33rd Annual Intelligent Ground Vehicle Competition(IGVC)

AutoNav, Self Drive & Design

May 29th– June 1st, 2026

Oakland University

Rochester, Michigan

http://www.igvc.org/rules.htm

New in 2026

Top Performer Award added for top three teams competing in AutoNav & Self Drive
Design reports emphasize discussion of Autonomous Subsystems for AutoNav & Self Drive
HBCU Award continued
Self Drive Challenge times extended to permit dual challenge running with AutoNav

All questions and concerns should be e-mailed to IGVCquestions@yahoo.com.

30 June 25 Version

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I. COMPETITION INFORMATION

I.1 TEAM ENTRIES

Teams may be comprised of undergraduate and graduate students, and must be supervised by at least one faculty advisor. Interdisciplinary (Electrical, computer, mechanical, systems engineering, etc.) teams are encouraged. Students must staff each team. Only the student component of each team will be eligible for the awards. Faculty supervisor will certify that all team members are bonafide students on application form and will also provide contact information (telephone number and e-mail address) for him and the student team leader on the form. Business/Non-Engineering students are encouraged to join teams to promote marketing, sponsorships, and other program management functions. For a student to be eligible to compete as a team member, they are required to have attended at least one semester of school as a registered student between June 2025 and June 2026.

Team sponsors are encouraged. Sponsors' participation will be limited to hardware donation and/or funding support. Sponsors logos may be placed on the vehicle and may be displayed inside of the team maintenance area. Teams should encourage sponsor attendance at the IGVC.

Universities are encouraged to have more than one entry; but are limited to a maximum of three per university, and each vehicle must separately registered, have a separate team of students and a design report in a defined format.See design rules for format. Each entry must be based on a different chassis and software and must be documented by a separate application form and design report, submitted in accordance with all deadlines. All entries must have a team name and each application will be accompanied with a $500.00 non-refundable (after 1 March) registration.

Continued for 2026 , A team(one vehicle) registering for both AutoNav and Self Drive will receive a 50% discount on the second registration,.

Registrations will be accepted on a first come first served basis. Register early to assure a confirmed team entry. Registrations are being accepted beginning 1 July 2025 and not later than** February 28, 2026**, by registering online see registration link at** https://igvc.secs.oakland.edu/registration.htm **.Questions regarding registration should be directed to OU PACE at Professional and Continuing Education (PACE) <oupace@oakland.edu

International Teams Note

International(Non-United States Teams) requiring Visa Invitation letters must limit team participation to a maximum of six students & two faculty. Changes and additions to original submission entry are not permitted after March 30th, 2026. All requests for VISA letters must be submitted by March 30th 2026 to insure adequate time for preparation

Team Award Payments

After the IGVC Award ceremony each team should contact their University Accounting or other payment office and notify them to prepare the appropriate tax document: a W9 (US schools) or W8 (for foreign schools). These documents will be required by either Oakland University or RoboNation for award checks to get checks processed. !

All battery chargers must be 3 prong grounded plug compatible United States 110V duplex plugs. No voltage converters are allowed between battery chargers and IGVC supplied electrical plugs! No exceptions!

I.2 VEHICLE CONFIGURATION for Autonomous Navigation (AutoNav) & Self Drive (SD)

Vehicles must be unmanned and autonomous. They must compete based on their ability to perceive thecourse environment and avoid obstacles. Vehicles cannot be remotely controlled by a human operator during competition. All computational power, sensing and control equipment must be carried on board the vehicle. No base stations allowed for positioning accuracy Mapping or course position memorization is not allowed. Judges will adjust course between runs to nullify any mapping/memorization

In 2025 both AutoNav and SD competitions will use the same type of a small semi-rugged outdoor vehicle. Vehicle chassis can befabricated from scratch or commercially bought. Entries must conform to the following specifications:

- **Design**: Must be a ground vehicle (propelled by direct mechanical contact to the ground such as wheels, tracks, pods, etc.)
- **Length**: Minimum length three feet, maximum length seven feet.
- **Width**: Minimum width two feet, maximum width four feet.
- **Height**: Not to exceed 6 six feet (excluding emergency stop antenna).
- **Propulsion**: Vehicle power must be generated onboard. Fuel storage or running of internal combustion engines and fuel cells are not permitted in the team maintenance area (tent/building).
- **Average Speed:** Speed will be checked at the end of a challenge run to make sure the average speed of the competing vehicle is above one (1) mph over the course completed. Vehicle slower than the minimum average speed will be disqualified for the run.
- **Minimum Speed:** There will be a stretch of about 44 ft. long at the beginning of a run where the contending vehicle must consistently travel above 1 mph. A vehicle slower than this speed is considered to “hold-up traffic” and will be disqualified.
- **Maximum Speed:** A maximum vehicle speed of five miles per hour (5 mph) will be enforced. All vehicles must be hardware governed not to exceed this maximum speed. No changes to maximum speed control hardware are allowed after the vehicle passes Qualification.
- **Mechanical E-stop location**: The E-stop button must be a push to stop, red in color and a minimum of one inch in diameter. It must be easy to identify and activate safely, even if the vehicle is moving. It must be located in the center rear of vehicle at least two feet from ground, not to exceed four feet above ground. Vehicle E-stops must be hardware based and not controlled through software. Activating the E-Stop must bring the vehicle to a quick and complete stop.
- **Wireless E-Stop:** The wireless E-Stop must be effective for a minimum of 100 feet. Vehicle E-stops must be hardware based and not controlled through software. Activating the E-Stop must bring the vehicle to a quick and complete stop. During the competition performance events (AutoNav Challenge and SD Challenge) the wireless E-stop will be held bythe Judges.
- **Safety Light:** The vehicle must have an easily viewed solid indicator light which is turned on whenever the vehicle power is turned on. The light must go from solid to flashing whenever the vehicle is in autonomous mode. As soon as the vehicle comes out of autonomous mode the light must go back to solid.
- **Payload**: Each vehicle will be required to carry a 20-pound payload. The shape and size is approximately that of an 16" x 8" x 8" cinder block. Refer to section I.3 Payload.

I.3 PAYLOAD

The payload must be securely mounted on the vehicle. If the payload falls off the vehicle during a run, the run will be terminated. The payload specifications are as follows: 16 inches long, 8 inches wide, 8 inches high and a weight of 20 pounds.

I.4 QUALIFICATION

All vehicles must pass Qualification to receive standard award money in the Design Competition and compete in the Auto Nav performance events. To complete Qualification the vehicle must pass/perform all of the following criteria.

- **Length**: The vehicle will be measured to ensure that it is over the minimum of three feet long and under the maximum of seven feet long.
- **Width**: The vehicle will be measured to ensure that it is over the minimum of two feet wide and under the maximum of four feet wide.
- **Height**: The vehicle will be measured to ensure that it does not to exceed six feet high; this excludes emergency stop antennas.
- **Mechanical E-stop**: The mechanical E-stop will be checked for location to ensure it is located on the center rear of vehicle a minimum of two feet high and a maximum of four feet high and for functionality.
- **Wireless E-Stop:** The wireless E-Stop will be checked to ensure that it is effective for a minimum of 100 feet. During the performance events the wireless E-stop will be held by the Judges.
- **Safety Light:** The safety light will be checked to ensure that when the vehicle is powered up the light is on and solid. When the vehicle is running in autonomous mode, the light goes from solid

to flashing, then from flashing to solid when the vehicle comes out of autonomous mode.

- **Speed:** The vehicle will have to drive over a prescribed distance where its minimum and maximum speeds will be determined. The vehicle must not drop below the minimum of one mile per hour and not exceed the maximum speed of five miles per hour. Minimum speed of one mph will be assessed in the fully autonomous mode and verified over a 44 foot distance between the lanes and avoiding obstacles. No change to maximum speed control hardware is allowed after qualification. If the vehicle completes a performance event at a speed faster than the one it passed Qualification at, that run will not be counted.
- **Lane Following:** The vehicle must demonstrate that it can detect and follow lanes.
- **Obstacle Avoidance:** The vehicle must demonstrate that it can detect and avoid obstacles.
- **Waypoint Navigation:** Vehicle must prove it can find a path to a single two meter navigation waypoint by navigating around an obstacle.

During the Qualification the vehicle must be put in autonomous mode to verify the mechanical and wireless E -stops and to verify minimum speed, lane following, obstacle avoidance and waypoint navigation. The vehicle software cannot be reconfigured for waypoint navigation qualification. It must be integrated into the original autonomous software. For the max speed run the vehicle may be in autonomous mode or joystick/remote controlled. Judges will not qualify vehicles that fail to meet these requirements. Teams may fine tune their vehicles and resubmit for Qualification. There is no penalty for not qualifying the first time. Vehicles that are judged to be unsafe will not be allowed to compete. In the event of any conflict, the judges' decision will be final.

I.5 INDEMNIFICATION AND INSURANCE

Teams will be required to submit an Application Form prior to **February 28, 2026**. The Application Form can be downloaded from www.igvc.org.

Each Team's sponsoring institution will also be required to submit a Certificate of Insurance at the time the Application Form is submitted. The certificate is to show commercial general liability coverage in an amount not less than $1 million.

In addition, each individual participating at the competition will be required to sign a Waiver of Claims when they arrive at site and before they can participate in the IGVC events.

NOTE: *The IGVC Committee and Officials will try to adhere to the above official competition details, rules and format as much as possible. However, it reserves the right to change or modify the competition where deemed necessary for preserving fairness of the competition. Modifications, if any, will be announced prior to the competition as early as possible.*

II AutoNav CHALLENGE

All teams must pass Qualification to participate in this event.

II.1 Objective

A fully autonomous unmanned ground robotic vehicle must negotiate around an outdoor obstacle course under a prescribed time while maintaining a minimum of speed of one mph over a section and a maximum speed limit of five mph, remaining within the lane, and avoiding the obstacles on the course.

Judges will rank the entries that complete the course based on shortest adjusted time taken. In the event that a vehicle does not finish the course, the judges will rank the entry based on longest adjusted distance traveled. Adjusted time and distance are the net scores given by judges after taking penalties, incurred from obstacle collisions and boundary crossings, into consideration.

II.2 AutoNav COURSE

The Auto-Nav Challenge is on asphalt pavement. The Course will be approximately 500 feet long in an area 120 feet wide and 100 feet deep. This distance is identified so teams can set their maximum speed to complete the course pending no prior violations resulting in run termination. Track width will vary from ten to twenty feet wide with a turning radius not less than five feet.

Outer boundaries will be designated by continuous or dashed white lines approximately three inches wide, taped on the asphalt. Track width will be approximately ten feet wide. A minimum speed will be required of one mph and will be a requirement of Qualification and verified in each run of the Auto-Nav Challenge. If the vehicle does not average one mph for the first 44 feet (30 seconds) from the starting line, the vehicle run will be ended. The vehicle will then need to average over one mph for the entire run.

Competitors should expect natural or artificial inclines (ramps) with gradients not to exceed 15% and randomly placed obstacles along the course. The course will become more difficult to navigate autonomously as vehicle progresses. Obstacles on the course will consist of various colors (white, orange, brown, green, black, etc.) of construction barrels/drums that are used on roadways and highways. Natural obstacles such as trees or shrubs and manmade obstacles such as light posts or street signs could also appear on the course. The placement of the obstacles may be randomized from left, right, and center placements prior to every run. Simulated potholes of 2 foot diameter, solid white circles may be inserted. These simulated pot holes must be avoidedor an end of run will occur.

There will be a minimum of five feet clearance, minimum passage width, between the line and the obstacles; i.e., if the obstacle is in the middle of the course, then on either side of the obstacle will be five feet of driving space. Or if the obstacle is closer to one side of the lane then the other side of the obstacle must have at least five feet of driving space for the vehicles.

The Course will be primarily sinusoidal curves with series of repetitive barrel obstacles. Two waypoint pairs for the course will be provided prior to competition. One waypoint pair will be the entrance and exit of the course in No Man's Land. The two additional waypoints in No-Man's Land will guide the vehicles to the ramp entrance in either direction.

Six (6) minutes will be allowed for course driving/negotiation.


Chicane
N
Start
S
Ramp
+ Navigation
Waypoint-4
Barricade
Min Speed barrel

II.3 COMPETITION RULES & PROCEDURES

- The competition will take place in the event of light rain or drizzle but not in heavy rain or lightning.
- Each qualified team will have up to two runs (time permitting) in each of five heats.
- Starting order will be based on order of qualification. Teams will setup on-deck in that order. Failure to be on-deck will place you at the end of the order for the run and may forfeit you final (second) run in a heat based on heat time completion.
- No team participant is allowed on the course before the team's first run, and only one student team member is allowed on the course during a run. This shall in no case be the faculty advisor.
- At the designated on-deck time, the competing team will be asked to prepare their vehicle for an attempt. On-deck teams start in the order they arrive in the starting area unless they give way to another team.
- A Starting Official will call teams to the starting line. The Starting Official's direction is final. The Starting Officials may alter the order to enhance the competition flow of entries; e.g. slower vehicles may be grouped together to allow successive running of two vehicles on the course simultaneously.
- A team will have one minute in the starting point to prep the vehicle at the starting line and point out to the Competition Judges the buttons to start and stop the vehicle,
- The Competition Judge will start the vehicle by a one touch motion; i.e. pushing a remote control button, hitting the enter key of a keyboard, a left mouse click, lifting the e-stop up, flipping a toggle switch, etc. The Competition Judge will also carry the E-Stop.
- An attempt will be declared valid when the Competition Judge initiates the start signal at the designated competing time. An attempt will continue until one of the following occurs:
- The vehicle finishes the course.
- The vehicle was E-Stopped by a judge's call.
- The team E-Stops the vehicle.
- The vehicle has not started after one minute after moving to the start line or at the judges' discretion.
- Time for each heat will be strictly observed.
- Tactile sensors will not be allowed.
- Based on the above allowable run times, if the vehicle has not completed the course in the **6** minute time period, the attempt will be ended by a judge's choice E-stop, with no additional penalty for that run.
- Each vehicle must navigate the course by remaining inside the course boundaries and navigating around course obstacles. Crossing internal lines is not allowed and will be judged an E-Stop end of run with penalty. For the following Traffic Violations, the appropriate ticket will be issued and deducted from the overall distance or time score. Refer to section II.5 Traffic Violation Laws.

II.4 TRAFFIC VIOLATION LAWS

	Traffic Violations	Ticket Value	E-Stop	Measurement
1	Hold-up Traffic	End of Run	Yes	>60 secs. to 88 ft
2	Leave the Course/Scene	- 10 Feet	Yes	Yes
3	Crash/Obstacle Displacement	- 10 Feet	Yes	Yes
4	Careless Driving	- 5 Feet	No	No
5	Sideswipe/Obstacle Touch	- 5 Feet	No	No
6	Student's Choice E-Stop	- 10 Feet	Yes	Yes
7	Judge's Choice E-Stop	0 Feet	Yes	Yes
8	Blocking Traffic	- 5 Feet	Yes	Yes
9	Loss of Payload	0 Feet	Yes	Yes
10	Too slow, did not average 1 mph	Disqualified	No	No

- **Hold-up traffic:** Must maintain 1 mph, there will be a speed check at 44/88 foot mark of the course, will result in end of run with time recorded
- **Leave the scene\course**: All portions of the vehicle cross the boundary. The overall distance will be measured from the starting line to the furthest point where the final part of the vehicle crossed the boundary edge.
- **Crash**: The overall distance will be measured from the starting line to the collision point with the obstacle.
- **Careless Driving**: Crossing the boundary while at least some part of the vehicle remains in bounds.
- **Student E-Stop**: Student e-stop is used if the team feels that there may be damaged caused to their vehicle or they know that it is stuck and want to end their time.
- **Judge E-Stop**: The overall distance will be measured from the starting line to the front of the vehicle or where the final/furthest remaining part of vehicle if stopped, crossed the boundary outside edge.
- **Obstacle Displacement**: Defined as displacing permanently the obstacle from its original position. Slightly rocking/Tilting an obstacle with no permanent displacement is not considered obstacle displacement. An obstacle that rocks or tilts significantly but with no displacement will still be considered a end of run. Judges calls are final.
- **Blocking Traffic**: Vehicles stopping on course for over one minute will be E-Stopped and measured.
- **Loss of Payload**: If the payload falls of the vehicle the run will be ended.
- **Too Slow:** If the vehicle does not maintain 1 mph minimum average speed limit throughout the course this run is disqualified.

II.5 HOW COMPETITION WILL BE JUDGED

- A team of judges and officials will determine compliance with all rules.
- Designated competition judges will determine the official times, distances and ticket deductions of each entry. At the end of the competition, those vehicles crossing the finish line will be scored on the time taken to complete the course minus any ticket deductions. Ticket values will be assessed in seconds (one foot = one second) if the vehicle completes the course within the run time.
- The team with the adjusted shortest time will be declared the winner.
- In the event that no vehicle completes the course, the score will be based on the distance traveled by the vehicle minus the ticket deductions. The team with the adjusted longest distance will be declared the winner.
- For standard award money consideration, entry must exhibit sufficient degree of autonomous mobility by completing the Auto-Nav course. If a tie is declared between entries, the award money will be split between them.
- If your vehicle is overtaken by a faster vehicle you will be commanded to stop and your time will be recorded and allowed to be restarted with remaining time after the faster vehicle passes. Total distance will be assessed at the 6-minute mark of runtime(driving) from start.

II.6 GROUNDS FOR DISQUALIFICATION

- Judges will disqualify any vehicle which appears to be a safety hazard, degrades the course or violate the safety requirements during the competition.
- Intentional interference with another competitor's vehicle and/or data link will result in disqualification of the offending contestant's entry.
- Damaging the course or deliberate movement of the obstacles or running over the obstacles may result in disqualification.
- Actions designed to damage or destroy an opponent's vehicle are not in the spirit of the competition and will result in disqualification of the offending contestant's entry.

III. Self Drive Challenge

III.1 OBJECTIVE

The purpose of Self Drive is to develop student, faculty and university skills and experience in high level “Rules of the Road Autonomy” which encompasses those required to develop automotive smart driving cars or defense intelligent vehicle systems compatible with current roadways and future intelligent highway systems. Those capabilities include camera vision systems, lane following obstacle and pedestrian avoidance, roadway and parking driving maneuvers, road network navigation, road sign understanding and other traffic functions. Components and subsystems currently used in smart driving vehicles are the preferred approach.

Self Drive Competition is focused on AutoNav class vehicles defined in Part 1.2 and examples below

Figure 1: Examples of Self Drive AutoNav vehicles

III.2 COURSE

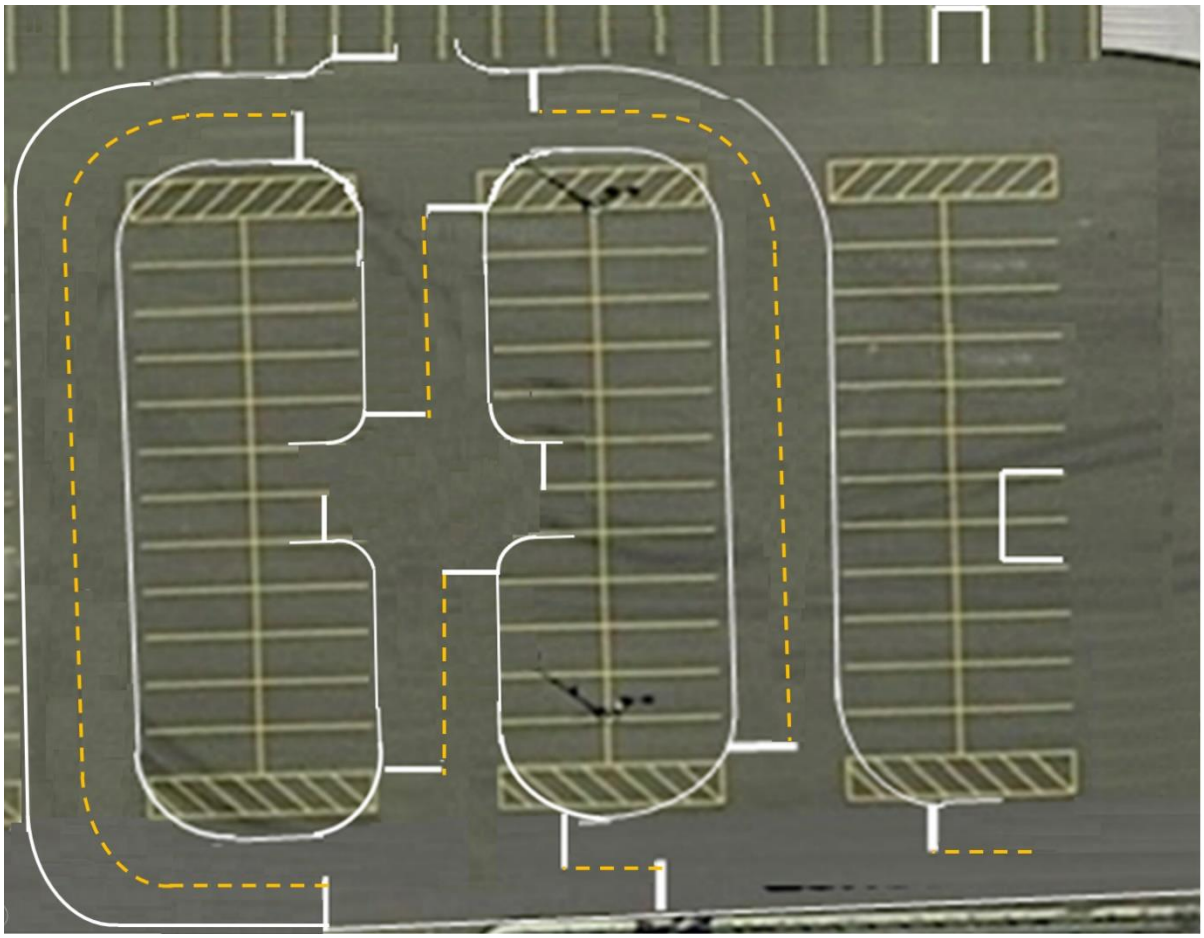


Figure 2: Self Drive Course Parking Lot 37, Oakland University

III.3 SELF DRIVE Challenge RULES AND PROCEDURES

The Self Drive competition aims to mimic highway and urban driving at the lower speeds for level five autonomy. The competition expects to attract future professionals interested in Deep learning, machine learning, algorithm development, simulation, clean code development, feature and system requirements development and implementation.

At the Self Drive, teams are asked to test their vehicles similar to how automotive suppliers and manufactures test their features (here called function tests) at the test ground facilities. In addition, teams are asked to perform systems test, where all features are tied together (here called Full Course test).

All tests are conducted on the paved test track with an open sky environment. The course will be two lanes wide and each lane will have a width of 10 ft. No other vehicles or unauthorized personal shall be present when the tests are active. The vehicle's speed is limited to 5 mph.

First, a team needs to pass AutoNav Qualifications Testing requirements below. There are unlimited number of trials available.

- **Parameters check:**
    - 3 feet < Length < 7 feet
    - 2 feet < Width < 4 feet
    - Height < 6 feet **without emergency stop antennas**
- **Mechanical E-Stop:**
    - Location - Center rear of the vehicle
    - 2 feet < Height < 4 feet
    - Functional
- **Wireless E-Stop:**
    - Range >= 100 feet
- **Safety Light:**
    - Light is **Solid** when vehicle is powered up
    - Light is **Flashing** during autonomous mode
    - Light is **Solid** when vehicle comes out from autonomous mode
- **Speed – verified in fully autonomous mode over 44-foot distance between the lanes and obstacles**
    - 1 mph < speed < 5 mph
    - No change to max speed control hardware is allowed after qualifications
- **Lane following** – can detect and follow lanes
- **Obstacle Avoidance** – can detect and avoid obstacles
- **Waypoint Navigation – not applicable if qualifying for Self Drive only**

Next, a team is ready for Self Drive Qualification Tests outlined below. Qualification tests represent the basic requirements needed for any team to be successful at the competition. It is highly recommended to test those features ahead of the competition in both inside and outside environments, with various lighting conditions present. It is also recommended to develop software tests for testing your code's methods or functions in order to avoid simple bugs. There are unlimited number of trials to pass Self Drive Qualification Tests.

The detailed testing procedures could be found in Appendix A.

Table 1: Qualification Test Data Sheet

Test Type	Test ID	Name	# of Runs
Qualification	Q.1	Lane Keeping (Go Straight)	Unlimited
Qualification	Q.2	Lines Detection	Unlimited
Qualification	Q.3	Left Turn	Unlimited
Qualification	Q.4	Right Turn	Unlimited

After passing both Self Drive Qualifications Tests, a team is eligible to compete in Functions Tests and Self Drive Challenge Full Course.
There are unlimited trials available for each function, with the maximum score of 100 points per function. The team is allowed to keep the best score out of unlimited number of attempts. The team could choose to complete any function at random. Functions Testing have the following independent tests, outlined in the table below. For more information on Functions Testing, see Appendix B.

Table 2: Functions Test Data Sheet

Test Type	Test ID	Name	# of Runs	Total Penalty Points	Total Points Possible
Function	I.1	Pedestrian Detection	Unlimited	-25	100
Function	I.2	Tire Detection	Unlimited	-25	100
Function	II.1	Stop Sign Detection	Unlimited	-25	100
Function	III.1	Lane Keeping	Unlimited	-25	100
Function	III.2	Left Turn	Unlimited	-25	100
Function	III.3	Right Turn	Unlimited	-25	100
Function	IV.1	Parking. Pull Out	Unlimited	-25	100
Function	IV.2	Parking. Pull In	Unlimited	-25	100
Function	IV.3	Parking. Parallel	Unlimited	-25	100
Function	V.1	Unobstructed STATIC Pedestrian Detection	Unlimited	-25	100
Function	V.2	Obstructed DYNAMIC Pedestrian Detection	Unlimited	-25	100
Function	V.3	STATIC Pedestrian Detection. Lane Changing	Unlimited	-25	100
Function	V.4	Obstacle Detection. Lane Changing	Unlimited	-25	100
Function	VI.1	Curved Road Evaluation. Lane Keeping	Unlimited	-25	100
Function	VI.2	Curved Road Evaluation. Lane Changing	Unlimited	-25	100
Function	VII.1	Pothole Detection	Unlimited	-25	100
Total					**1600**

Self Drive Challenge Full Course has all or most function tests tied together in a single run. Each completed step earns up to 100 points for the team.

This System test is intended to evaluate a vehicle's performance to stay in lane, change lane, detect and avoid obstacles, detect signs, merge into loop and park at the specified locations. During the official run, any sensor fusion combination is acceptable to detect any static/dynamic obstacles and signs. Fake signs might be present on the course. Below is an example of a tentative 2025 Self Drive Challenge Full Course. See Appendix C for more details.

Table 3: Self Drive Challenge Full Course

	Test Type	**Name**	**Total Penalty Points**	**Total Points Possible**
1	Function	Right Turn at Intersection	-25	100
2	Function	Lane Keeping	-25	100
3	Function	Curved Road Evaluation. Lane Keeping	-25	100
4	Function	Obstacle Detection. Lane Changing	-25	100
5	Function	Lane Keeping	-25	100
6	Function	Obstacle Detection. Lane Changing	-25	100
7	Function	Lane Keeping	-25	100
8	Function	Stop Sign Detection	-25	100
9	Function	Right Turn at Intersection	-25	100
10	Function	Lane Keeping	-25	100
11	Function	Obstructed DYNAMIC Pedestrian Detection	-25	100
12	Function	Lane Keeping	-25	100
13	Function	Curved Road Evaluation. Lane Keeping	-25	100
14	Function	Lane Keeping	-25	100
15	Function	Pothole Detection	-25	100
16	Function	Lane Keeping	-25	100
17	Function	Tire Detection. Lane Changing	-25	100
18	Function	Curved Road Evaluation. Lane Keeping	-25	100
19	Function	Stop Sign Detection (Fake/Real Sign)	-25	100
20	Function	Left Turn at Intersection	-25	100
21	Function	Parking. Pull In	-25	100
	Total			**2100**

The following signs and obstacles may be present on the track during Functions Testing and Main Course.

Table 4: Traffic Signs and Obstacles specifications

Sign / Obstacle	Dimensions
"Stop"	24" H x 24" H minimum height from ground is 5 feet
Mannequin	71.7" height, 18.1" width shoulder to shoulder, 37.4" chest, 29.9" waist, 37.8" hips
Barrel(s)	39.7"H x 23.5"W Weight: 8 lbs
Pothole	2' diameter solid white circle or plastic mirror
Tire	Standard sedan's tire between 14" and 21" inches in diameter

The location of the barrels and/or tires on the course will be marked with the duct's tape.

The evaluation will be completed with two judges, who will track the vehicle through each test. Evaluation points and comments will be marked in the Self Drive Evaluation Worksheet. After the test completion, the test score will be reviewed with a team representative. The Judge(s) and a team representative will initial the evaluation sheet upon finished discussion.

III.4 Scoring Criteria

All schools are only eligible to win award money once per Self Drive; if more than one team from the same school places in the event, only the highest placing team will be placed in a standing and receive money for Self Drive.

The total score is determined by combining the total scores for functions and system testing. In case of the tie, the winner will be determined by the system's testing best time.

Table 5: Self Drive Cumulative Scoring System Example

Results	Team's score	Max possible points
Functions Testing	cumulative score	1600
Full Course	cumulative score	2100
Final Score	total	3700

III.5 APPENDIX A. Unique SELF DRIVE QUALIFICATION TESTING

Qualification Test Descriptions

Test Q.1 Lane Keeping (Go Straight)

1. Test Goal

This test is intended to evaluate if the vehicle is able to stay within lane boundaries, without wheels crossing the line or driving on the line.

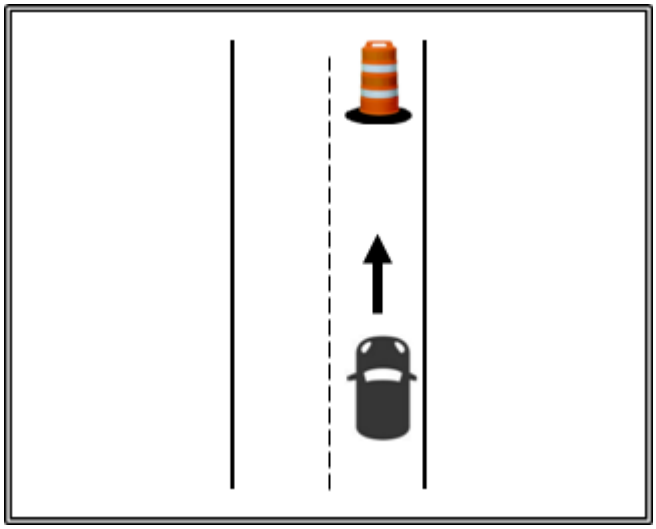


Figure 3: Qualification Testing. Lane Keeping. Go Straight

2. Test Setup

The following items shall be placed on the road:

- **Barrel 1 on the side of the road** to indicate a starting point at which vehicle is stationary
- **Barrel 2** about 50 ft away to indicate an ending point.
- A duct tape's mark placed 3 ft from the **Barrel 2**

3. Test Script

1. Begin test run
2. Judge pushes 'start' button
3. Vehicle takes off from full stop at **Barrel 1**
4. Vehicle maintains the target speed (between 4 – 5 mph)
5. Vehicle reaches full stop within 3 ft from the **Barrel 2**
6. End test run

4. Evaluation

Pass Criteria - vehicle stays within lane boundaries without wheels crossing the lines or hitting a barrel. Vehiclereaches full stop within 3 ft from Barrel 2.

Test Q.2 Lines Detection

1. Test Goal

This test is intended to evaluate detection of white and yellow lines using traditional Machine Vision algorithms. There are NO PENALTIES for crossing or moving over a line. A GUI interface with extracted white and yellow lines MUST be present during a run. This test could be performed as a stationary test per judges discretion.

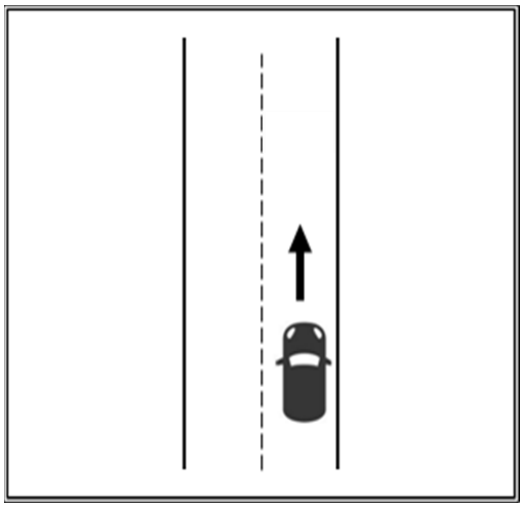


Figure 4: Qualification Testing. Lines Detection

2. Test Setup

The following items shall be placed on the road:

- **Barrel 1** to indicate a starting point at which vehicle is stationary

3. Test Script

1. Begin test run
2. Judge pushes 'start' button
3. The white and yellow lines must be present on the screen.
4. End test run

4. Evaluation

Pass Criteria – GUI interface is present during the run, correct identification of the lines in front of the vehicle

Test Q.3 Left Turn

1. Test Goal

This test is intended to evaluate if a vehicle is able to make a left turn across the traffic, merge into expected lane and drive within this lane until an obstacle is detected.

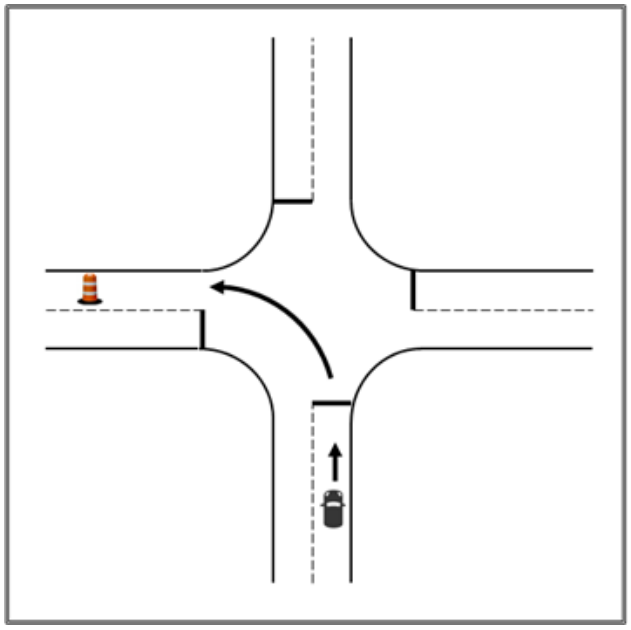


Figure 5: Qualification Testing. Left Turn

2. Test setup

The following items shall be placed on the road:

- **Barrel 1** to indicate a starting point at which vehicle is stationary. The Barrel 1 could be placed near the stop bar, or several feet away from the stop bar per judges' decision.
- **Barrel 2** to indicate an ending point. The barrel is placed about 30 ft away from the stop bar in the right lane.
- A duct tape's mark placed 3 ft from the **Barrel 2**

3.Test Script

1. Begin test run
2. Judge pushes 'start' button
3. Vehicle takes off from full stop at Barrel 1
4. Vehicle maintains the target speed (between 3 – 5 mph)
5. Vehicle turns left across the traffic and merges into correct lane
6. Vehicle maintains the target speed (between 3 – 5 mph)
7. Vehicle reaches full stop within 3 ft from the Barrel 2
8. End test run

4. Evaluation

Pass Criteria - vehicle is able to turn left, merge into correct lane and stop without hitting a barrel or crossing boundaries

Test Q.4 Right Turn

1. Test Goal

This test is intended to evaluate if the vehicle is able to make a right turn, merge into the lane and drive within a lane until an obstacle is detected.

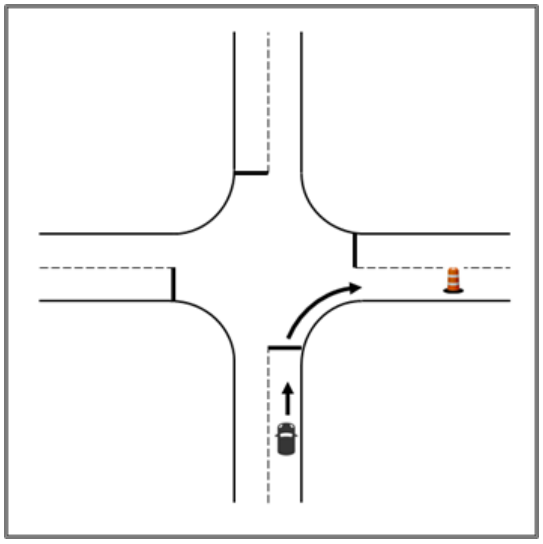


Figure 6: Qualification Testing. Right Turn

2. Test Setup

The following items shall be placed on the road:

- **Barrel 1** to indicate starting point at which vehicle is stationary. The Barrel 1 could be placed near the stop bar, or several feet away from the stop bar per judges' decision.
- **Barrel 2** to indicate an ending point. The barrel is placed about 30 ft away from the stop bar in the right lane
- A duct tape's mark placed 3 ft from the **Barrel 2**

3. Test Script

1. Begin test run
2. Judge pushes 'start' button
3. Vehicle takes off from full stop at Barrel 1
4. Vehicle maintains the target speed (between 3 – 5 mph)
5. Vehicle makes right turn and merges into correct lane
6. Vehicle maintains the target speed (between 3 – 5 mph)
7. Vehicle reaches full stop within 3 ft from the Barrel 2
8. End test run

4. Evaluation

Pass Criteria - vehicle is able to turn right, merge into correct lane and stop without hitting a barrel or crossing boundaries

III.6 APPENDIX B. FUNCTIONS TESTING

Traditional machine vision and signs detection tests require GUI interface with displayed results during the test. The Stop Sign detection test shall display a relevant classification as “Stop Sign” or “Unknown

I. Traditional Machine Vision Tests

The goals of the traditional Machine Vision tests are to foster object detection primarily based on shape and color. Traditional machine vision and signs detection tests **require** GUI interface with displayed results during the test.

Test FI.1 Static Pedestrian Detection

1. Test Goal

This test is intended to evaluate detection of a mannequin using traditional Machine Vision algorithms. A mannequin wears ORANGE construction vest. A GUI interface with extracted orange blob MUST be present during a run. There are NO PENALTIES for crossing or moving over a line.

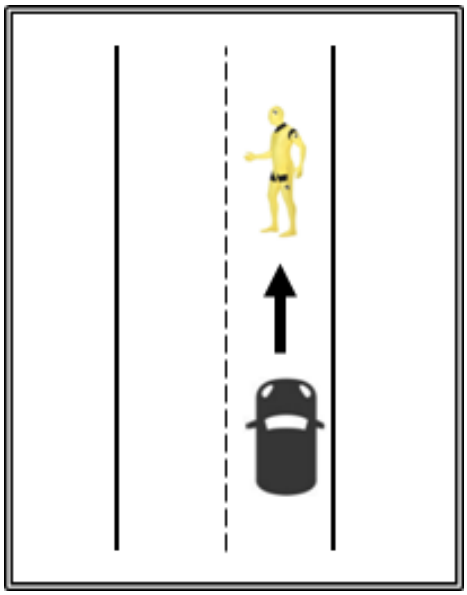


Figure 7: Machine Vision Tests. Static Pedestrian Detection

2. Test Setup

The following items shall be placed on the road:

- **Barrel 1** to indicate starting point at which vehicle is stationary

3. Test Script

1. Begin test run
2. Judge pushes 'start' button
3. The extracted orange blob is present on the screen.
4. End test run

4. Evaluation

Fail Criteria – no GUI interface is present during the run, incorrect identification of the shape/object

Penalties – no penalties for crossing or moving over the lines, in case if vehicle is moving during the test

Test FI.2 Tire Detection

1. Test Goal

This test is intended to evaluate detection of a small item present in a current lane using traditional Machine Vision algorithms. A GUI interface with extracted shape of a tire MUST be present during a run. There are NO PENALTIES for crossing or moving over a line.

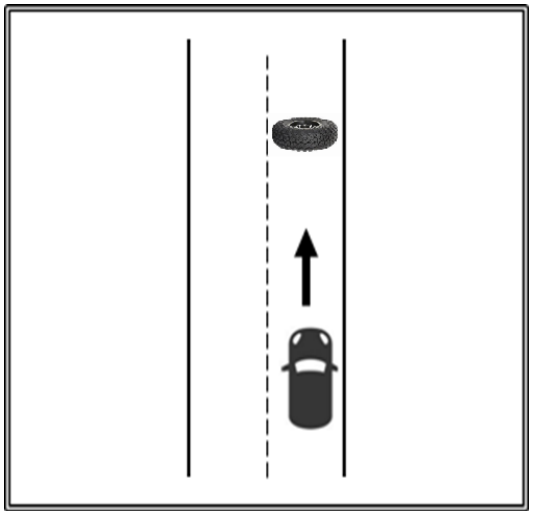


Figure 8: Machine Vision Tests, Tire Detection

2. Test Setup

The following items shall be placed on the road:

- **Barrel 1** to indicate starting point at which vehicle is stationary

3.Test Script

1. Begin test run
2. Judge pushes 'start' button
3. The extracted tire is present on the screen
4. End test run

4. Evaluation

Fail Criteria – no GUI interface is present during the run, incorrect identification of the tire
Penalties – no penalties for crossing or moving over the lines, if vehicle is moving during the test

II. Traffic Sign Tests

Test FII.1 Stop Sign Detection

1. Test Goal

This test is intended to evaluate Stop Sign classification detection and accuracy. Any type of algorithm could be used for this test. Before test, a RANDOM picture might be put on top of a STOP sign. A forgery sign could be red in color with random letters, be a different color with same letters, or be a different picture. Examples used in the previous years: “Soup” and “IGVC” signs. A GUI interface shell display a relevant classification as “Stop Sign” or “Unknown”. There are NO PENALTIES for crossing or moving over a lane.

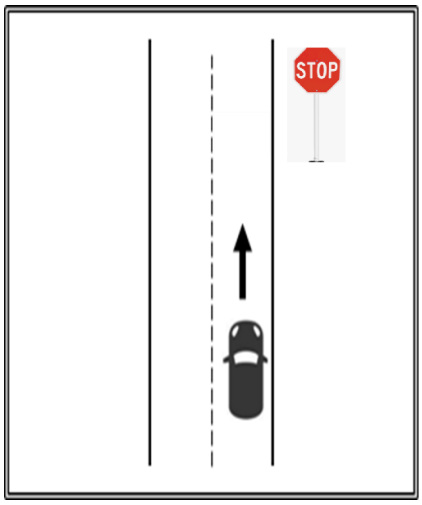


Figure 9: Functions Testing. Stop Sign Detection

2. Test Setup

- **Barrel 1** to indicate starting point at which vehicle is stationary
- **3 different “Stop” signs are being tested randomly**

3. Test Script

1. Begin test run
2. The 1st judge inside of the vehicle pushes a 'start' button
3. The extracted sign is shown on the screen with a correct identification
4. The 2nd judge removes a current sign, and puts a new “stop” sign. It could be a fake or a real sign.
5. The extracted sign is shown on the screen with a correct identification
6. The 2nd judge removes a current sign, and puts a new “stop” sign. It could be a fake or a real sign.
7. End test run

4. Evaluation

Fail Criteria – no GUI interface is present during the run, incorrect identification of any of 3 signs, keyboard touching between the sign changes. To pass the test, all 3 signs must be correctly identified.

Penalties – no penalties for crossing or moving over the lines, if vehicle is moving during the test

III. Intersection Tests

The goals of the Intersection tests are to evaluate vehicle's ability to maneuver at a road intersection.

Test FIII.1. Lane Keeping

1. Test Goal

This test is intended to evaluate if the vehicle is able maneuver within lane boundaries, without wheels crossing the line or driving on the line. Additionally, this test evaluates if the vehicle stops at the "Stop" sign at the intersection, goes straight through intersection, and stops before an obstacle placed on the road.

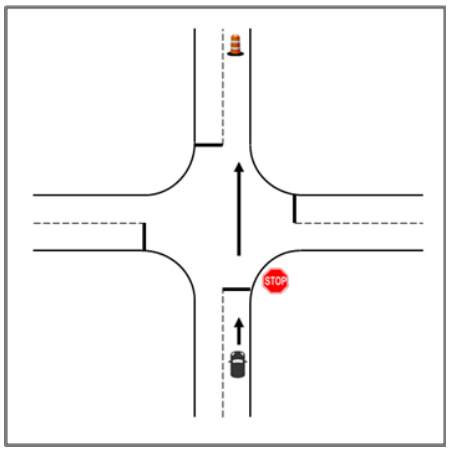


Figure 10: Intersection Tests, Lane Keeping

2. Test Setup

The following items shall be placed on the road:

- **Barrel 1** to indicate a starting point at which vehicle is stationary
- **'Stop'** sign
- **Barrel 2** to indicate an ending point
- Duct tape's dashed line to indicate 30 cm from the perpendicular line

3.Test Script

1. Begin test run
2. Judge pushes 'start' button
3. Vehicle takes off from full stop at **Barrel 1**
4. Vehicle maintains the target speed (between 4 – 5 mph)
5. Vehicle reaches full stop within 30 cm from perpendicular white line next to the "Stop" sign. A vehicle's bumper should be within two lines at the time when a vehicle reaches full stop.
6. Vehicle takes off from full stop
7. Vehicle maintains the target speed (between 4 – 5 mph)
8. Vehicle reaches full stop within 3 ft the **Barrel 2**
9. End test run

4. Evaluation

Fail Criteria – crosses white parallel lines, crosses perpendicular white line, stops further than 30 cm from a perpendicular line

Penalties – hits barrel at the end of the run (25 points), stops further than 3 ft from the barrel (10 points)

Test FIII.2. Intersection Testing. Left Turn

1. Test Goal

This test is intended to evaluate if a vehicle is able to stop at the 'Stop' traffic sign, make a left turn across the traffic, merge into expected lane and drive within this lane until an obstacle is detected.

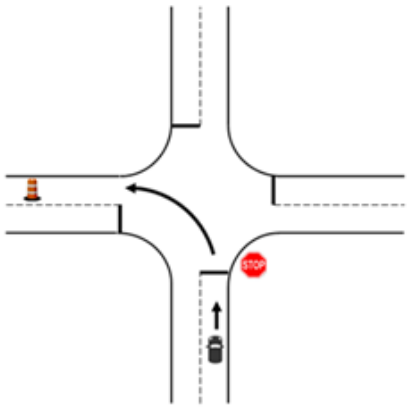


Figure 11: Intersection Testing. Left Turn

2. Test Setup

The following items shall be placed on the road:

- **Barrel 1** to indicate a starting point at which vehicle is stationary
- **'Stop'** sign
- **'One Way'** sign
- **Barrel 2** to indicate an ending point
- Duct tape's dashed line to indicate 30 cm from the perpendicular line

3. Test Script
   1. Begin test run
   2. Judge pushes 'start' button
   3. Vehicle takes off from full stop at Barrel 1
   4. Vehicle maintains the target speed (between 4-5 mph)
   5. Vehicle reaches full stop within 30 cm from perpendicular white line next to the "Stop" sign. A vehicle's bumper should be within two lines at the time when a vehicle reaches full stop.
   6. Vehicle takes off from full stop
   7. Vehicle turns left across the traffic and merges into correct lane
   8. Vehicle maintains the target speed (between 4 – 5 mph)
   9. Vehicle reaches full stop within 3 ft from the **Barrel 2**
   10. End test run

4. Evaluation

Fail Criteria – crosses white parallel lines, crosses perpendicular white line, makes a wrong turn, stops further than 30 cm from a perpendicular line

Penalties – hits barrel at the end of the run (25 points), stops further than 3 ft from the barrel (10 points)

Test FIII.3. Intersection Testing. Right Turn

1. Test Goal

This test is intended to evaluate if a vehicle is able to stop at the 'Stop' traffic sign, make a right turn, merge into the lane and drive within a lane until an obstacle is detected.

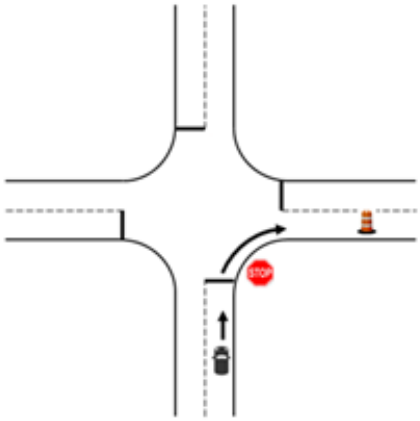


Figure 12: Intersection Testing. Right Turn

2. Test Setup

The following items shall be placed on the road:

- **Barrel 1** to indicate a starting point at which vehicle is stationary
- **'Stop'** sign
- **Barrel 2** to indicate an ending point
- Duct tape's dashed line to indicate 30 cm from the perpendicular line

3. Test Script

1. Begin test run
2. Judge pushes 'start' button
3. Vehicle takes off from full stop at **Barrel 1**
4. Vehicle maintains the target speed (between 4 – 5 mph)
5. Vehicle reaches full stop within 30 cm perpendicular white line next to the "Stop" sign. A vehicle's bumper should be within two lines at the time when a vehicle reaches full stop.
6. Vehicle takes off from full stop
7. Vehicle turns right and merges into correct lane
8. Vehicle maintains the target speed (between 4 – 5 mph)
9. Vehicle reaches full stop within 3 ft from the **Barrel 2**
10. End test run

4. Evaluation

Fail Criteria – crosses white parallel lines, crosses perpendicular white line, makes a wrong turn, stops further than 30 cm from a perpendicular line
Penalties – hits barrel at the end of the run (25 points), stops further than 3 ft from the barrel (10 points)

IV. Parking Tests

Test FIV.1 Parking. Pull Out

1. Test Goal

This test is intended to evaluate if a vehicle is able to reverse out (or pull out) of the representativeparking space. The direction of pull out (right-turn-pull-out or left-turn-pull-out) is selected by the judges. The same direction is repeated for all 3 attempts.

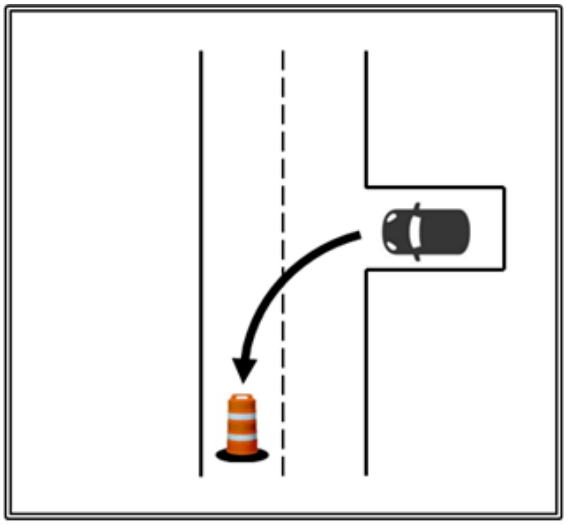


Figure 13: Parking. Pull Out

2. Test Setup

The following items shall be placed on the road:

- **Barrel 1** to indicate a starting point at which vehicle is stationary
- **Barrel 2** to indicate an ending point

3. Test Script

1. Begin test run
2. Judge pushes 'start' button
3. Vehicle takes off from full stop at Barrel 1
4. Vehicle slowly pulls out from the parking spot
5. Vehicle reaches full stop within 3 ft from the Barrel 2
6. End test run

4. Evaluation

Fail Criteria – vehicle crosses solid white lines
Penalties – hits barrel at the end of the run (25 points), stops further than 3 ft from the barrel (10 points)

Test FIV.2. Parking. Pull In

1. Test Goal

This test is intended to evaluate if a vehicle is able to pull into a representative parking space. The direction of pull in (right-turn-pull-in or left-turn-pull-in) is selected by the judges. The same direction is repeated for all 3 attempts.

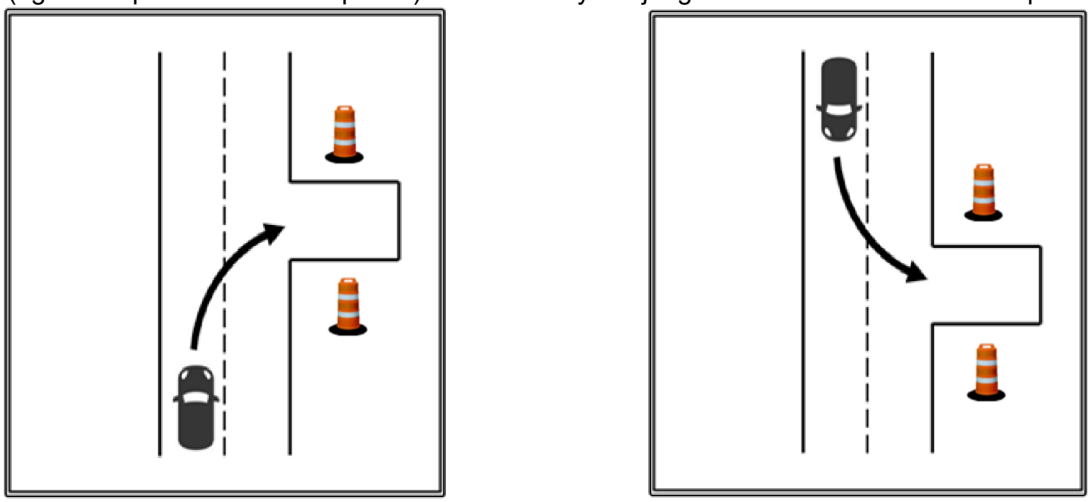


Figure 14(a,b): Functions Testing. Parking. Pull In

2. Test Setup

The following items shall be placed on the road:

- **Barrel 1** to indicate starting point at which vehicle is stationary

3. Test Script

1. Begin test run
2. Judge pushes 'start' button
3. Vehicle takes off from full stop at **Barrel 1**
4. Vehicle slowly pulls into the parking spot
5. Vehicle reaches full stop. It should be fully in the box without crossing any lines
6. End test run

4. Evaluation

Fail Criteria – vehicle crosses solid white lines

Test FIV.3. Parking. Parallel

1. Test Goal

This test is intended to evaluate if a vehicle is able to parallel park into the representative parking space. The direction of parallel parking (to the right or to the left) is selected by the judges. The same direction is repeated for all attempts.

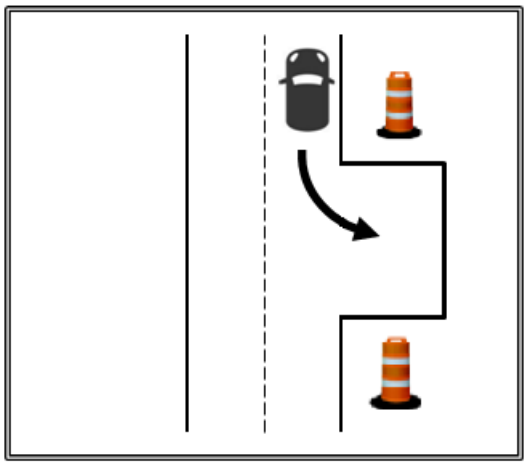


Figure 15: Functions Testing. Parking. Parallel

2. Test Setup

The following items shall be placed on the road:

- **Barrel 1** to indicate starting point at which vehicle is stationary

3. Test Script

1. Begin test run
2. Judge pushes 'start' button
3. Vehicle backs off from full stop at Barrel 1
4. Vehicle slowly pulls into the parking spot
5. Vehicle reaches full stop. It should be fully in the box without crossing any lines.
6. End test run

4. Evaluation

Fail Criteria – vehicle crosses solid white line

V. VRU (Vulnerable Road User) and Obstacle Tests

Test FV.1 Unobstructed STATIC pedestrian detection

1. Test Goal

This test evaluates ability of Ego vehicle to stop if a pedestrian is detected within boundaries of a current lane.

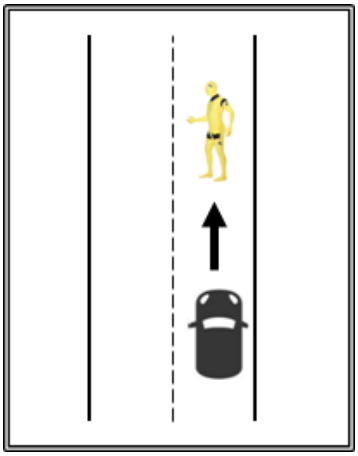


Figure 16: Functions Testing. Unobstructed Static Pedestrian Detection

2. Test Setup

The following items shall be placed on the road:

- **Barrel 1** to indicate a starting point at which vehicle is stationary
- **Mannequin**

3. Test Script

1. Begin test run
2. Judge pushes 'start' button
3. Vehicle takes off from full stop at Barrel 1
4. Vehicle maintains the target speed (between 4 – 5 mph)
5. Vehicle reaches full stop within a range from 7 ft to 5 ft from the Mannequin
6. End test run

4. Evaluation

Fail Criteria – stops further than 7 ft from the mannequin, or hits mannequin
Penalties – hits barrel at the end of the run (25 points), stops closer than 5 ft from the mannequin (10 points)

Test FV.2 Obstructed DYNAMIC pedestrian detection

1. Test Goal

This test evaluates ability of Ego vehicle to stop if an obstructed by barrel pedestrian (mannequin) suddenly starts crossing an Ego's vehicle lane.

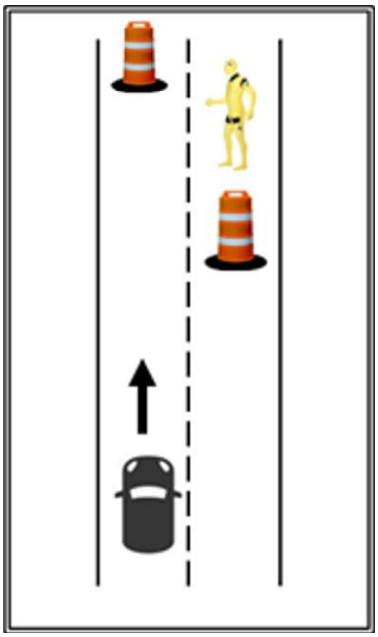


Figure 17: Functions Testing. Obstructed Dynamic Pedestrian Detection

2. Test Setup

- **Barrel 1** to indicate a starting point at which vehicle is stationary
- **Barrel 2** placed in adjacent lane, with Mannequin behind it
- **Barrel 3** to indicate an ending point
- **Mannequin**

3. Test Script

1. Begin test run
2. Judge 1 pushes 'start' button
3. Vehicle takes off from full stop at Barrel 1
4. Vehicle maintains the target speed (between 3 – 5 mph)
5. Judge 2 rolls out Mannequin from behind Barrel 2 and stops Mannequin in Ego's vehicle lane
6. Vehicle reaches full stop within a range from 7 ft to 5 ft from the Mannequin
7. Judge 2 pulls back Mannequin behind Barrel 2
8. Vehicle takes off from the full stop
9. Vehicle maintains the target speed (between 3 – 5 mph)
10. Vehicle reaches full stop within 3 ft from the Barrel 2
11. End test run

4. Evaluation
Fail Criteria - stops further than 7 ft from the mannequin, or hits mannequin
Penalties – hits barrel at the end of the run (25 points), stops closer than 5 ft from the Mannequin (10 points)

Test FV.3 STATIC Pedestrian Detection. Lane Changing

1. Test Goal

This test imitates a situation of a broken vehicle in a current lane with STATIC pedestrian standing in FRONT of barrel(s) in the same lane as Ego vehicle. Ego vehicle must slow down, and safely change into an adjacent lane.

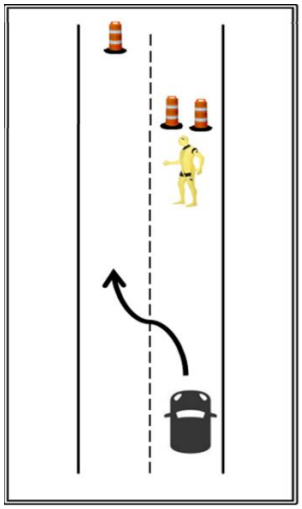


Figure 18: Functions Testing. Pedestrian Detection. Lane Changing

2. Test Setup

There will be a distance of approximately 85 ft between the mannequin/barrel when mannequin will start crossing the road.

The following items shall be placed on the road:

- **Barrel 1** to indicate starting point at which vehicle is stationary
- **Mannequin** to indicate obstacle
- **Barrel 1 and Barrel 2 to indicate a broken vehicle in a current lane**
- **Barrel 3** to indicate end of a run

3. Test Script

1. Begin test run
2. Judge pushes 'start' button
3. Vehicle takes off from full stop at **Barrel 1**
4. Vehicle maintains the target speed (between 3 -5 mph)
5. Vehicle detects **Mannequin**
6. Vehicle performs full transition into the next lane within a range from 13 ft to 10 ft away from the Mannequin
7. Vehicle maintains the target speed in the new lane (between 3-5 mph)
8. Vehicle reaches full stop within 3 ft from the obstacle (**Barrel 3**)
9. End test run

4. Evaluation

Fail Criteria –hits mannequin, crosses white solid line, lane change completed further than 13 ft away from mannequin

Penalties – hits barrel at the end of the run (25 points), lane change completed closer than 10 feet from the obstacle (10 points)

Test FV4. Obstacle detection. Lane Changing

1. Test Goal

This test evaluates Ego vehicle's ability to safely change lane if a stationary object is present within a current lane.

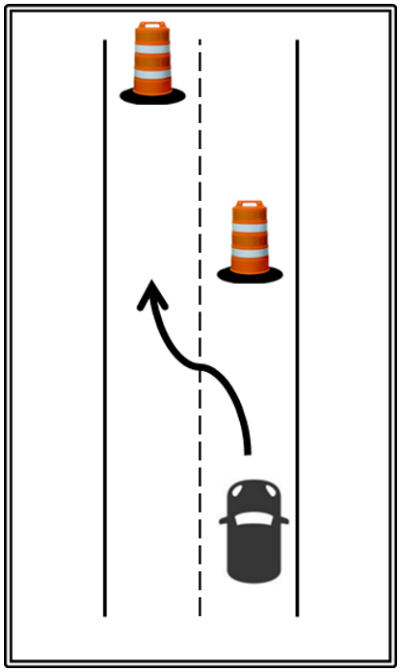


Figure 19: Functions Testing. Obstacle Detection. Lane Changing

2. Test Setup

The following items shall be placed on the road:

- **Barrel 1** to indicate a starting point at which vehicle is stationary
- **Barrel 2** to indicate obstacle
- **Barrel 3** to indicate an ending point

3. Test Script

1. Begin test run
2. Judge pushes 'start' button
3. Vehicle takes off from full stop at **Barrel 1**
4. Vehicle maintains the target speed (between 3 – 5 mph)
5. Vehicle fully moves into the next lane within a range from 13 ft to 10 ft away from the **Barrel 2**
6. Vehicle maintains the target speed in the new lane (between 3 – 5 mph)
7. Vehicle reaches full stop within 3 ft from the obstacle (**Barrel 3**)
8. End test run

4. Evaluation

Fail Criteria –hits Barrel 2, crosses white solid line, lane change completed further than 13 ft away from Barrel2

Penalties – hits Barrel 3 at the end of the run (25 points), lane change completed closer than 10 feet from the obstacle (10 points)

VI. Curved road Evaluation Tests

The minimum inside curve radius is 10 meters (32.8084 feet).

Test FVI.1 Curved Road Evaluation. Lane Keeping

1. Test Goal

This test is intended to evaluate Ego vehicle's ability to stay in the lane on a curved road, and be able to stop at the obstacle within a current lane. This test consists of 4 possible case scenarios: driving in right lane on the left curve, driving in left lane on the left curve, driving in right lane on the right curve and driving in left lane on the right curve. Any of above scenarios could be chosen at judges' discretion.

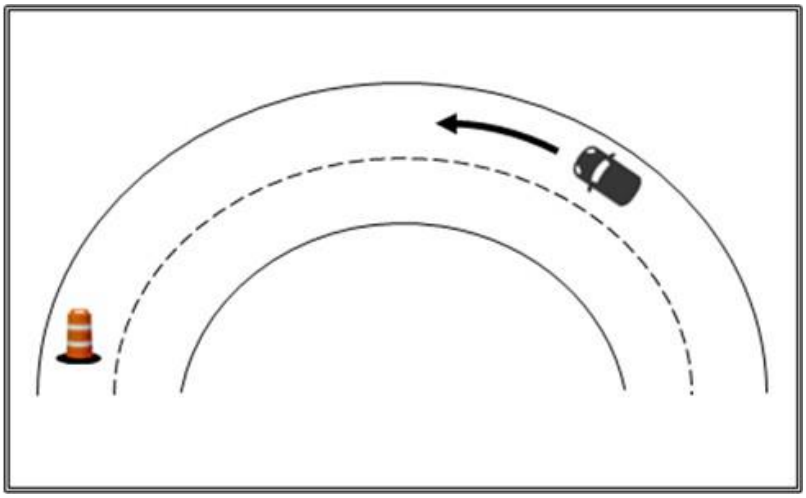


Figure 20: Functions Testing. Curved Road Evaluation. Lane Keeping

2. Test Setup

The following items shall be placed on the road:

- **Barrel 1** to indicate a starting point at which vehicle is stationary
- **Barrel 2** to indicate an ending point

3. Test Script

1. Begin test run
2. Judge pushes 'start' button
3. Vehicle takes off from full stop at **Barrel 1**
4. Vehicle maintains the target speed (between 3 – 5 mph)
5. Vehicle reaches full stop within 3 ft from the **Barrel 2**
6. End test run

4. Evaluation

Fail Criteria – crosses white solid line

Penalties – hits barrel at the end of the run (25 points), stops further than 3 ft to the Barrel 2 (10 points)

Test FVI.2 Curved Road Evaluation. Lane Changing

1. Test Goal

This test is intended to evaluate if a vehicle is able to perform a lane change on the curved road if obstacles are detected. This test consists of 4 possible case scenarios: changing right lane on the left curve, changing left lane on the left curve, changing right lane on the right curve and changing left lane on the right curve. Any of above scenarios could be chosen as this year's test.

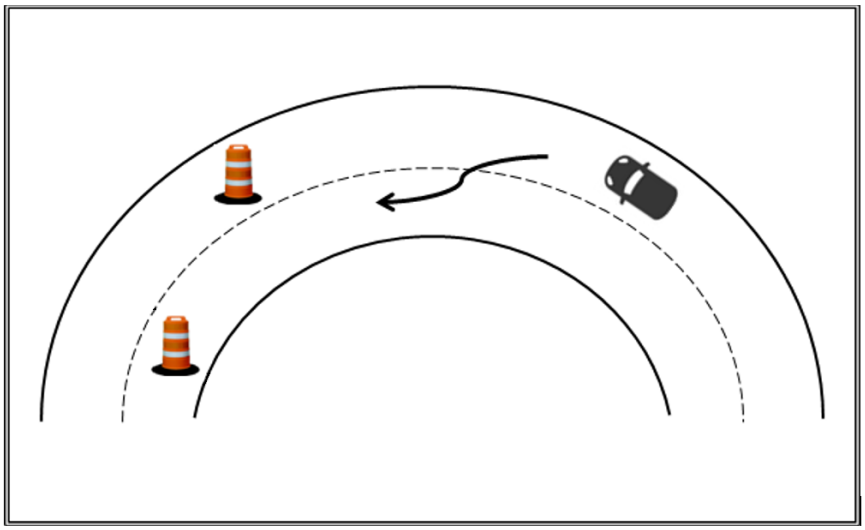


Figure 21: Functions Testing. Curved Road Evaluation. Lane Changing

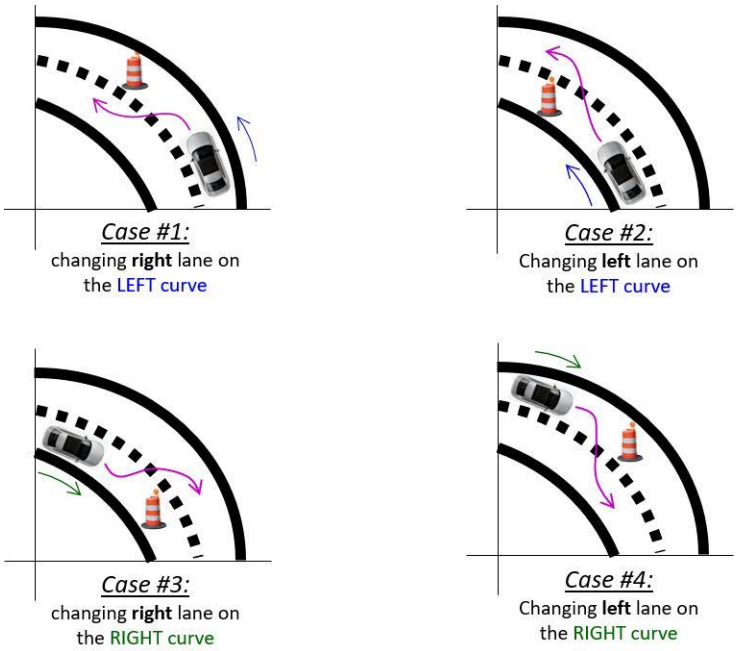


Figure 22: Types of Curved Road Evaluation scenarios

2. Test Setup

The following items shall be placed on the road:

- **Barrel 1** to indicate a starting point at which vehicle is stationary
- **Barrel 2** to indicate an obstacle in current lane
- **Barrel 3** to indicate an ending point

3. Test Script

1. Begin test run
2. Judge pushes 'start' button
3. Vehicle takes off from full stop at **Barrel 1**
4. Vehicle maintains the target speed (between 3 – 5 mph)
5. Vehicle detects obstacle (**Barrel 2),** and safely moves into the next lane
6. Vehicle maintains the target speed in the new lane (between 3 – 5 mph)
7. Vehicle reaches full stop within 3 ft from the obstacle (**Barrel 3**)
8. End test run

4. Evaluation

Fail Criteria – crosses white solid line, hits Barrel 2

Penalties - hits Barrel 3 at the end of the run (25 points), stops further than 3 ft to the Barrel 2 (10 points)

VII. Other Tests

Test FVII.1 Pothole Detection

1. Test Goal

This test is intended to evaluate Ego vehicle's ability to detect a pothole and safely change lane.

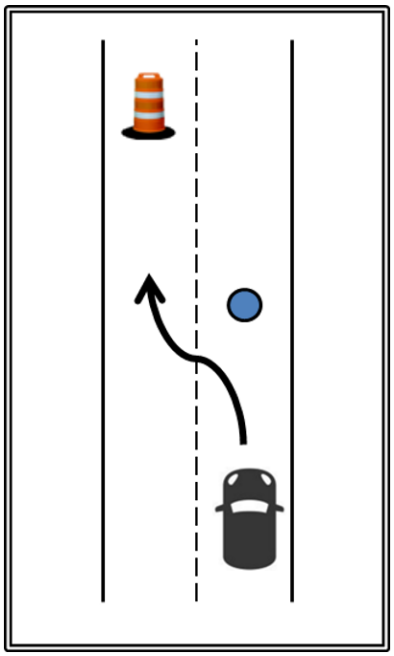


Figure 23: Functions Testing. Pothole Detection

2. Test Setup

The following items shall be placed on the road:

- **Barrel 1** to indicate a starting point at which vehicle is stationary
- **Pothole** (2 feet diameter solid white circle or plastic mirror)
- **Barrel 2** to indicate an ending point

3. Test Script

1. Begin test run
2. Judge pushes 'start' button
3. Vehicle takes off from full stop at **Barrel 1**
4. Vehicle maintains the target speed (between 4 – 5 mph)
5. Vehicle detects pothole and safely moves into the next lane
6. Vehicle maintains the target speed in the new lane (between 4 – 5 mph)
7. Vehicle reaches full stop within 3 ft from the **Barrel 2**
8. End test run

4. Evaluation

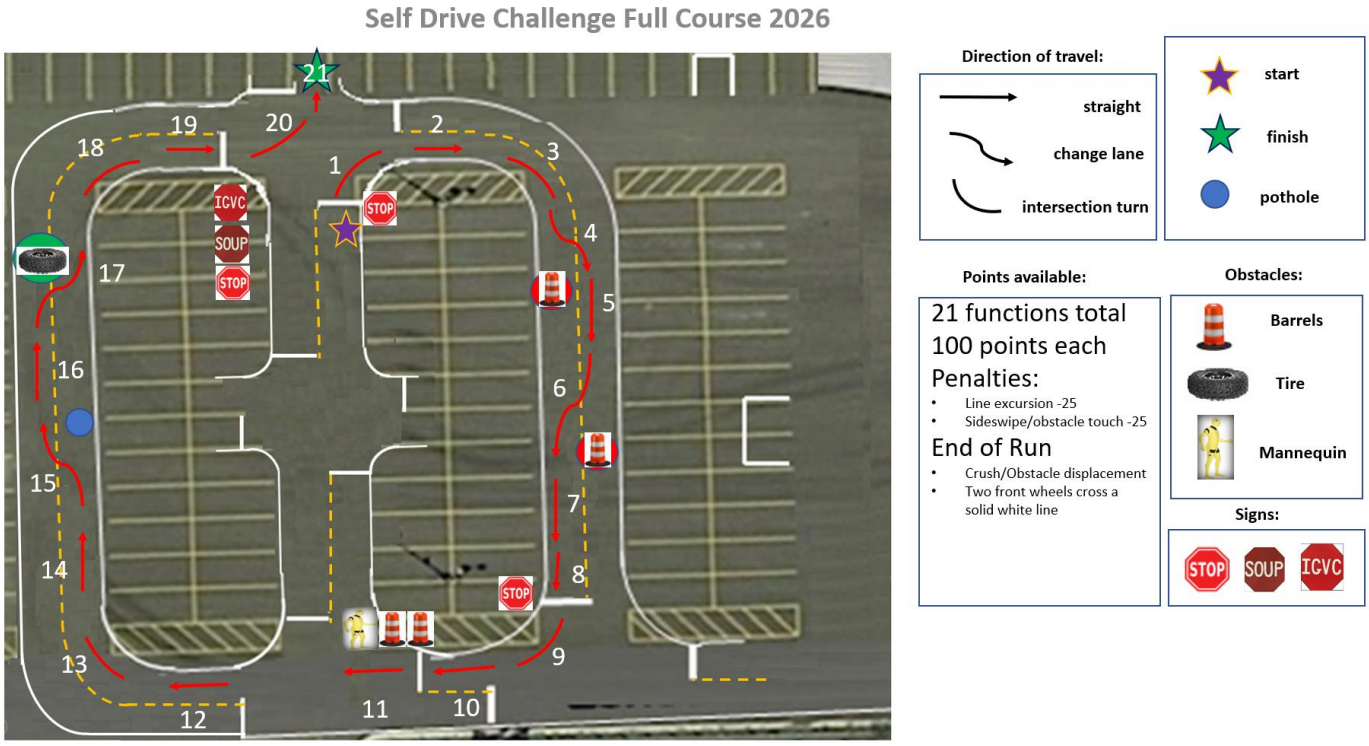
Fail Criteria – run over the pothole

Penalties - hits barrel at the end of the run (25 points), stops further than 3 ft to the Barrel 2 (10 points)

III.7 APPENDIX C. SELF DRIVE CHALLENGE FULL COURSE TESTING

The Full Course setup varies from year to year, and it is usually announced 1 week prior to the competition. Below is tentative Self Drive Challenge Full Course. It has 21 functions run consecutively and autonomously. No course mapping is allowed. The obstacles positions may vary each run. 100 points are awarded for each successfully completed function. As part of the challenge, there is a probability to have fake sign on the road. Before each run, each team draws out the sign. The course ends if the vehicle's 2 wheels cross a solid white line, or vehicle displaces an obstacle. In the case of line excursion or an obstacle touch, 25 points penalty is applied to relative function.

Figure 25: Self Drive Challenge Full Course Example



Test Setup

The following items shall be placed on the road:

- **Small and/or large barrels** to indicate starting and ending point of the course
- **Barrels on the course**
- **Mannequin**
- **Signs**
- **Pothole**
- **Tire**

III.8 REFERENCES

[1]. “Automated Driving Systems 2.0: A vision for safety”. U.S. Department of Transportation, NHTSA, September 2017

https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/13069a-ads2.0_090617_v9a_tag.pdf

IV. DESIGN Challenge for AutoNav and Self Drive

All teams must participate in the Design Competition, including submitting a design report in the mandatory format described in this section, and providing an oral presentation.

IV.1 OBJECTIVE

Although the ability of the vehicles to negotiate the competition courses is the ultimate measure of product quality, the officials are also interested in the design strategy and process that engineering teams followed to produce their vehicles. Design judging will be by a panel of expert judges and will be conducted separate from and without regard to vehicle performance on the test course. Judging will be based on a written report, an oral presentation, and examination of the vehicle.

Demonstrating each vehicle's performance on the course(s) is the culmination of the weekend competition, and this design challenge is structured following a sequence that the competition organizers have seen lead to strong performance in past years. In particular, taking the time to read the rules for your targeted course(s) while noting key limits and features of the course(s), considering those limits and course features during your HW/EE/SW design and build process, and taking the time to test and confirm that your vehicle achieves the targets you identified from the rules is a strong path to success. Measuring performance aspects of your vehicle early is especially important so there is time to make improvements.

The Design Challenge has three aspects: the written submitted in advance, the oral presentation with Q&A from the judges, and the judges examining the vehicle and asking more questions at the end of the oral session. Generally, the teams are divided into three groups with a team of 2 to 3 judges assigned to each group. The preliminary oral presentations generally occur on Saturday of the competition weekend, with each team giving their oral presentation to the judging team that read and scored their written report in advance. The score from each judge will be the sum of their scores for the written report, the oral presentation, and examination of the vehicle. The independent scores from each judge will be combined to compute the final team score.

Typically, the top two scoring teams from each group are asked to return for the finals on Sunday of the competition weekend. All the judges will join as the audience for these final presentations, so even though the format is the same as in the preliminaries, most of the judges will not have read your report so your briefing should be different. There is additional guidance below to guide structuring your presentations for the finals. The judges will score all aspects of the finals independently of your previous efforts, scoring solely based on what happens during the finals. The score from each judge will be the sum of their scores for the oral presentation and examination of the vehicle during the finals. The independent scores from each judge will be combined to compute the final event score. The top scoring teams in the final event will be the winners for the design competition.

IV.2 WRITTEN REPORT

The IGVC report shall use a Sans Serif font of at least 11 points in size, with page margins a minimum of 1 inch top, bottom, right and left, and the content divided into sections that follow the outline below in Section III.3.

Each vehicle must be documented with its own unique and complete report. That is, a report cannot cover more than one vehicle, and multiple reports cannot contain duplicated material. Design reports must be newly written each year, and documents that were submitted to IGVC in past years, even with minor updates, are ineligible. The originality of each year's report is important to the educational

objectives of IGVC. Reports from returning teams will be reviewed for duplications and scored appropriately! It is not allowed to copy material from past reports into this year's report, and violations will cause the report to not be scored!

Vehicles that have competed in IGVC before and have not had significant changes in design are ineligible in either the design or performance events. Vehicles that have been significantly changed in design (hardware or software) from an earlier year are eligible but will require a completely new design report treating both the old and new features, thus describing the complete vehicle as if it were all new.

All reports, both for new vehicles and for earlier vehicles with design changes, must include a statement signed by the faculty advisor certifying that the design and engineering of the vehicle (original or changes) by the current student team has been significant and equivalent to what might be awarded credit in a senior design course.

Participants are required to submit an electronic copy in PDF format along with a scanned copy of the faculty signed statement in PDF format by **May 15, 2026.** Everything must be e-mailed along with any questions to IGVCquestions@yahoo.com. Reports arriving after that date will lose **100 points** in scoring for each day late, statements arriving after that date will lose **25 points** in scoring for each day late. Teams are encouraged to submit reports even several weeks early to avoid the last-minute rush of preparing vehicles for the competition, and there will be no penalty for last minute differences in the vehicle from the design reported. The electronic copy of the report will be posted on the competition's web site in PDF format after the completion of the competition.

Teams entered in only one performance challenge (AutoNav or Self Drive) shall keep their report to a maximum of 15 pages, while teams entered in both challenges shall keep their report to a maximum of 18 pages. In either case the cover page and an optional table of contents page will not be counted towards the page limit. All other pages shall count towards the page limit, including all figures, appendixes, and other attachments. Teams exceeding this limit shall receive a 250-point deduction and the excess pages shall not be read or considered in the judge's scoring.

IV.3 DESIGN REPORT MANDATORY FORMAT – for both AutoNav & Self Drive

1. Cover Page [Not counted towards page limit]
    - University/College Name
    - Vehicle/Team Name
    - Vehicle Photo/Sketch/Symbol
    - Team Captain's Name, E-Mail, and phone number (main point of contact)
    - Key Team Member's Name, E-Mail, and phone number (secondary point of contact)
    - Faculty Advisor's Name, E-mail, and phone number (tertiary point of contact)
    - Clearly state which challenges(s) you are targeting (AutoNav and/or Self Drive)
    - Scan of Faculty Advisor's Signed Statement of Integrity. [Or submit separate pdf document]

2. Optional Table of Contents [Not counted towards page limit]
    - Optional - not required

3. System and Subsystem Requirements [Start counting and/or numbering pages here with page 1]
    - Describe the system engineering process you followed to identify important System and Subsystem Requirements
    - List at least 2 requirements each for: (a) the mechanical design of your vehicle, (b) safety, (c) the electrical/electronic components
    - For each challenge you are targeting (AutoNav and/or SelfDrive), list at least 2 requirements that

guided your design for each of: (a) perception, (b) driving logic, and (c) key performance indicators
- For each requirement you listed (12 for one course, 18 if both) explain what in these rules or elsewhere drives that requirement, describe how you will quantifiably measure the requirement, and set a target value.

4. Mechanical Design
    - Describe the mechanical design of your robot, including CAD or other drawings of your vehicle
    - Describe significant decisions on the frame structure, housing, and/or overall design
    - Describe significant components of your vehicle's drive system, electrical power system, and the control system that enables computer-controlled motion. Components acquired ready-made must be identified, but their internal components need not be described in detail.
    - Describe the significant mechanical components, including the frame, structure, suspension, housing, and weather proofing
    - Clearly identify the aspects of your mechanical design that are driven by each mechanical system requirement you listed.
    - For each mechanical requirement you listed, compare the target value with the most recently measured actual value, and discuss what this tells you about your vehicle

5. Safety
    - Describe the robot's safety aspects while being transported, parked, and charging.
    - Describe the robot's safety aspects while operating on the course(s), including the mechanical and wireless ESTOP systems.
    - Clearly identify the aspects of your safety efforts that are driven by each safety requirement you listed.
    - For each safety requirement you listed, compare the target value with the most recently measured actual value, and discuss what this tells you about your vehicle

6. Electrical/Electronic Design
    - Describe significant power, electrical, and electronic components in your vehicle, including electronics, computers, sensors, and motor controllers
    - Describe significant decisions made in designing/selecting the electrical and electronic components
    - Describe the power distribution system's capacity, max. run time, recharge time, and safety
    - Clearly identify the aspects of your electrical and electronic components that are driven by each electrical/electronic components system requirement you listed.
    - For each electrical/electronic components system requirement you listed, compare the target value with the most recently measured actual value, and discuss what this tells you about your vehicle

7. Perception
    - If you are targeting both challenges, you must include separate discussions of how your perception system matches each course.
    - Describe processing of the sensor data to identify course features and items around the vehicle, including obstacles and lane markings, and the use of machine vision to perceive the environment.
    - If targeting AutoNav, describe how the system identifies lanes and obstacles.

- If targeting SelfDrive, describe how the vehicle senses pedestrians, stop signs, and road obstacles.
- Describe the internal representation of the course built from the perception data which is used by the driving logic. This might be a sophisticated internal representation of the environment or a simple list of features. Include a discussion of how it is created and updated as the robot moves.
- Clearly identify how your design of the sensor data processing system was driven by the perception requirements you listed.
- For each perception requirement you listed, compare the target value with the most recently measured actual value, and discuss what this tells you about your vehicle

8. Driving Logic
    - If you are targeting both challenges, you must include separate discussions of how your driving logic matches each course.
    - Design of the lane following and obstacle avoidance systems must be specifically described, along with how the vehicle navigates through its environment. Describe how the system uses GPS for waypoint navigation and localization.
    - If targeting AutoNav, describe how your robot uses the perception system's output and other information to follow lanes, detect and avoid obstacles, climb the ramp, and navigate to the GPS waypoints. Include how vehicle motion is generated and monitored to move the vehicle through the course, including how it deals with complex obstacles including switchbacks and center islands dead ends, traps, and potholes.
    - If targeting SelfDrive, describe how the vehicle uses the perception system's output and other information to follow the rules of the road while navigating the course that includes pedestrians, stop signs, road obstacles, and other items.
    - Clearly identify how your design was driven by the driving logic requirements you listed.
    - For each driving logic requirement you listed, compare the target value with the most recently measured actual value, and discuss what this tells you about your vehicle

9. Key Performance Indicators
    - If you are targeting both challenges, you must include separate discussions for each course.
    - Describe how you will measure each of the key performance indicators you selected to check that your robot is competitive on the target course(s), what value/result you are targeting, and how you selected that value/result for the KPI.
    - For each KPI requirement you listed, compare the target value with the most recently measured actual value, and discuss what this tells you about your vehicle

10. Analysis of Complete Vehicle
    - Describe lessons learned during construction and system integration
    - Identify key mechanical and electrical components that have failed during testing and discuss what changes you made to prevent repeat failures. Did your changes prevent repeat failures?
    - Describe your software testing, bug tracking, and version control processes
    - Describe your simulation-based testing process (*e.g.,* Gazebo, *etc.*)
    - Describe physical testing to date (mechanical, electronic, indoors, real world, etc.) and identify key differences in actual performance compared to predictions from simulation.

11. Cyber Security Analysis
    - Modern robotic and human driven vehicles are network-connected, contain large amounts of

software from multiple vendors, and are an inviting target for cyber-attacks.

- List 3 cyber vulnerabilities present in your vehicle and discuss what steps should be taken to harden/remove them before it enters series production and is widely deployed.

IV.4 DESIGN REPORT Scoring

A team of judges will be assembled to individually read and independently score your design reports. These judges will use the scoring guide listed in the table below.

WRITTEN REPORT Scoring	Max Points per Section
1. Title Page content and clarity	50
2. Discussion of the system engineering process followed and the identified System and Subsystem Requirements	100
3. Mechanical Design	100
4. Safety	100
5. Electrical/Electronic Design	100
6. Perception	200
7. Driving Logic	200
8. Key Performance Indicators	100
9. Analysis of Complete Vehicle	100
10. Cyber Security Analysis	100
11. Overall grammar, style, content, and quality of the document	100
12. The document provides the reader with a clear understanding of the team's design choices, how the vehicle perceives and navigates the course(s), and robustness/performance improvements driven by testing	150
TOTAL	**1400**

IV.5 Preliminary Oral Presentation

The same team of judges that read and scored your design reports will be the audience for your preliminary oral presentation. These judges will use the scoring guide in the table below.

Please structure your presentation following the concept that you are presenting the final report for your year-long project to your manager, who has read your design report but is not otherwise aware of your project. You should provide an overview of your project using highlights from the written report. Highlight the key points in your written report, your successes, the challenges you overcame, and any updates since the report was written. You are trying to convince your manager that the project was a success, your vehicle is awesome, and you deserve a raise. Some polish and salesmanship will help!

Notify the judges before you start your presentation which challenge(s) your team is targeting.

Audio or video tape presentations of the text instead of a live speaker are not allowed,but graphic aids may be presented by video, slide projection, computer projection, overhead transparencies, or easel charts. The presentation must be made by one or more student members of the team to the judges and other interested members of the audience. The presentation must be not more than 10 minutes for teams

targeting a single challenge and not more than 12 minutes for teams targeting both challenges. A grace period of 59 seconds will be granted, with a penalty of 100 points assessed for each minute or fraction thereof for presentations lasting 11 minutes or longer targeting a single challenge or 13 minutes or longer for teams targeting both challenges. Scoring will be as follows:

Judges will score the preliminary oral presentations as follows:	Maximum Points
1. Logical organization, subject matter, and quality of the presentation, including effective use of drawings, photos, and videos	100
2. Discussion of the system engineering process followed and the identified System and Subsystem Requirements	100
3. Description of the mechanical design and components	100
4. Description of the design aspects and processes ensuring safety	100
5. Description of the Electrical/Electronic Design and Components	100
6. Description of the Perception software system	100
7. Description of the Driving Logic software system	100
8. Description of Key Performance Indicators	100
9. Describe process for testing software in simulation and share test results	100
10. Analysis of the Complete Vehicle	100
11. Cyber Security Analysis	100
12. Speaker's clarity, articulation, eye contact, salesmanship, and polish	100
13. Overall salesmanship during the presentation	100
14. Response to questions	100
15. The presentation provided the judge with a clear understanding of the team's design choices, how the vehicle perceives and navigates the course(s), and robustness/performance improvements driven by testing	100
Total	**1,500**

The "effective use of drawings, photos, and videos" includes readability of the diagrams and drawings. The "Speaker's clarity, articulation, eye contact, salesmanship, and polish" includes the presenter not blocking the view of the screen. Articulation refers to the clarity and loudness of speaking. Eye contact refers to speaking to the audience and judges and not reading notes or screen or looking above the audience's heads. Response to questions means short answers that address only the question. Salesmanship refers to the enthusiasm and pride exhibited (why this vehicle is the best).

Participants are responsible for providing their own visual aids and related equipment (the vehicle itself must be displayed). A computer-connected projector will be made available. Projectors may also be supplied by the participants.

During the oral presentation, the following question period and the examination of the vehicle, team members sitting in the audience may participate by assisting the oral presenters, but at no time is the faculty advisor to participate in this part of the design competition.

IV.6 Finals Oral Presentation

The full team of judges will be assembled as the audience for the design competition's Finals oral presentations. These judges will use the scoring guide in the table below.

The concept is you are now presenting the final report for your year-long project to the upper management in your company, who have NOT read your design report. You should provide an overview of your project using highlights from the written report. Highlight your design innovations, your successes, the challenges you overcame, and any updates since the report was written. You are trying to convince your upper management that the project was a success, and your vehicle is awesome. Sell it!

Notify the judges before you start your presentation which challenge(s) your team is targeting.

Audio or video tape presentations of the text instead of a live speaker are not allowed, but graphic aids may be presented by video, slide projection, computer projection, overhead transparencies, or easel

charts. The presentation must be made by one or more student members of the team to the judges and other interested members of the audience. The presentation must be not more than 15 minutes for teams targeting a single challenge and not more than 17 minutes for teams targeting both challenges. A grace period of 59 seconds will be granted, with a penalty of 100 points assessed for each minute or fraction thereof for presentations lasting 16 minutes or longer targeting a single challenge or 18 minutes or longer for teams targeting both challenges. Scoring will be as follows:

Judges will score the final oral presentations as follows:	Maximum Points
1. Logical organization, subject matter, and quality of the presentation, including effective use of drawings, photos, and videos	100
2. Discussion of the system engineering process followed and important System and Subsystem Requirements	100
3. Description of the mechanical design and components	100
4. Description of how safety is ensured	100
5. Description of the Electrical/Electronic Design and Components	100
6. Description of the Perception software system	100
7. Description of the Driving Logic software system	100
8. Description of Key Performance Indicators	100
9. Describe process for testing software in simulation and share test results	100
10. Analysis of the Complete Vehicle	100
11. Cyber Security Analysis	100
12. Speaker's clarity, articulation, eye contact, salesmanship, and polish	100
13. Overall salesmanship during the presentation	100
14. Response to questions	100
15. The presentation delivered an understanding of the vehicle's mechanical and electrical systems, how it perceives and navigates the course(s), and a convincing explanation of why it will perform well in the challenge(s).	100
Total	**1,500**

The "effective use of drawings, photos, and videos" includes readability of the diagrams and drawings. The "Speaker's clarity, articulation, eye contact, salesmanship, and polish" includes the presenter not blocking the view of the screen. Articulation refers to the clarity and loudness of speaking. Eye contact refers to speaking to the audience and judges and not reading notes or screen or looking above the audience's heads. Response to questions means short answers that address only the question. Salesmanship refers to the enthusiasm and pride exhibited (why this vehicle is the best).

Participants are responsible for providing their own visual aids and related equipment (the vehicle itself must be displayed). A computer-connected projector will be made available. Projectors may also be supplied by the participants.

During the oral presentation, the following question period and the examination of the vehicle, team members sitting in the audience may participate by assisting the oral presenters, but at no time is the faculty advisor to participate in this part of the design competition.

IV.7 EXAMINATION OF THE VEHICLE AFTER EACH ORAL PRESENTATION

After your oral presentation concludes (both the preliminaries and finals), the judges will examine your vehicle. These judges will review the directions in this section and use the scoring guide in the table below.

Judging will be as follows:

Judges will score the vehicle examinations as follows:	Maximum Points
1. Packaging neatness and efficient use of space	50
2. Physical Serviceability	50
3. Mechanical and Electrical ruggedness	100
4. Effectiveness of autonomy components/subsystem integration	100
5. Safety (sharp edges, exposed belts/chains, loose connections)	100
6. Degree of original content in the vehicle for returning vehicles	50

7. Style (overall appearance)	50
Total	**500**

V. AWARDS AND RECOGNITION

All schools are only eligible to win award money once per event (AutoNav Challenge, Design Challenge and Self Drive Challenge); if more than one team fromthe same school places in the same event, only the highest placing team will beplaced in a standing and receive money for that event.

V.1 AUTONAV CHALLENGE

Standard Award Money

(Vehicle must complete AutoNav course)

1ST Place	$ 3,000
2ND Place	$ 2,000
3RD Place	$ 1,500
4TH Place	$ 1,000
5TH Place	$ 750
6TH Place	$ 500

Nominal Award Money

(AutoNav must attain one ramp waypoint in No Man;s Land & Self drive Vehicle must qualify and successfully complete minimum of four Function Tests)

1ST Place	$ 1,000
2ND Place	$ 800
3RD Place	$ 600
4TH Place	$ 500
5TH Place	$ 400
6TH Place	$ 300

V.2 SELF DRIVE CHALLENGE

Standard Award Money

(Vehicle must complete All functions and entire Self Drive course autonomously

autonomous)

1ST Place	$ 3,000
2ND Place	$ 2,000
3RD Place	$ 1,500
4TH Place	$ 1,000
5TH Place	$ 750
6TH Place	$ 500

Less than six teams competing

1ST Place	$ 2,000
2ND Place	$ 1,500
3RD Place	$ 1,000

Nominal Award Money

Vehicle must qualify and successfully complete Function Tests 1-4)

1ST Place	$ 1,000
2ND Place	$ 800
3RD Place	$ 600

V.3 TOP PERFORMER Award to the vehicle with best combined AutoNav & Self-Drive rankings (ties in combined rankings will be decided by highest design score)

1ST Place	$ 2,000
2ND Place	$ 1,500
3RD Place	$ 1,000

V.4 VEHICLE DESIGN Challenge – Dr. William G. Agnew Award

Design Competition Standard Awards

1ST Place	$ 2,000
2ND Place	$ 1,500

3RD Place	$ 1,000
4TH Place	$ 750
5TH Place	$ 500
6TH Place	$ 250

Nominal Award Money

(Vehicle did not pass Qualification)

1ST Place	$ 600
2ND Place	$ 500
3RD Place	$ 400
4TH Place	$ 300
5TH Place	$ 200
6TH Place	$ 100

V.5 ROOKIE-OF-THE-YEAR AWARD

The Rookie-of-the-Year Award will be given out to a team from a new school competing for the first time ever or a school that has not participated in the last five competitions. To win the Rookie-of-the-Year Award the team must be the best of the eligible teams competing and perform to the minimum standards of the following events. In the Design Competition you must pass AutoNav Qualification, in the AutoNav Challenge you must pass the Rookie Barrel and in the Self Drive Challenge you must pass SD Qualification. The winner of the Rookie-of-the-Year Award will receive $1,000 in award money; in the case the minimum requirements are not met the best of the eligible teams competing will receive $500.

V.6 GRAND AWARDS

Two sets of Grand Award trophies will be, presented to the top three teams that perform the best overall in both AutoNav and Self Drive (combined with design scores per below).

Standard Grand Award Points*

Challenge AN or SD	First	Second	Third	Fourth	Fifth	Sixth
AutoNav-Self Dr	24	20	16	12	8	4
Design	12	10	8	6	4	2

Nominal Grand Award Points**

Challenge	First	Second	Third	Fourth	Fifth	Sixth
AutoNav-Self Dr	12	10	8	6	4	2
Design	6	5	4	3	2	1

* For Standard Grand Award Points, the team must complete the Auto-Nav or Self Drive courses
For the Standard Design Competition points the vehicle must qualify in AutoNav or Self Drive

** For Nominal Grand Award Points, the team must qualify to be eligible in the AutoNav or Self Drive Challenges and have their vehicle present for the Design Competition.

V.6 HBCU Top Flight AWARD

New $1000 award to the top performing HBCU student team with combined performance

and design scores in either AutoNav or Self Drive, minimum of three HBCU schools competing.

VI PUBLICATION AND RECOGNITION

Videos of the competition event will be distributed to sponsors, media and the public. All design reports, articles, videos and pictures will be posted on the IGVC website www.igvc.org.

Name	Years as Editor
Jerry Lane, Jane Tarakhovsky, Andrew Kosinski, & Dr Doug Mackenzie	2022-2025
Jerry Lane, Jane Tarakhovsky & Andrew Kosinski	2018-2022
Jerry Lane & Andrew Kosinski	2014-2018
Bernard Theisen	2013-2014
Jerry Lane	2011-2013
Bernard Theisen	2006-2010
Greg Gill	2005-2006
Bernard Theisen	2004-2005
Dan Maslach	2003-2004
Bernard Theisen	2001-2003
Stephen W. Roberts	2000-2001
Scot Wheelock	1999-2000
Geoff Clark	1998-1999
G. Edzko Smid	1997-1998
Candy McLellan and G. Edzko Smid	1996-1997
Jerry Lane, Paul Lescoe and Ka C. Cheok	1992-1996

IGVC Rules Editors

All questions and concerns should be e-mailed to IGVCquestions@yahoo.com.

VII "IGVC In Memory Of"

Paul Lescoe	TARDEC Robotics Engineer	IGVC Co-Founder & Co-Chair
Dr, James Overholt	TARDEC Chief Roboticist	IGVC 1993 student, Judge & Official
Dr. Nattu Natajaran	UofM Dearborn Professor	IGVC Faculty
Wayne Wheelock	Former TARDEC Director	IGVC Design Judge
Dr William G. Agnew	Former GM Research Lab Director	IGVC Design Challenge, Navigation Challenge, and Follow the Leader Challenge Founder
Hank Lewandowski	IGVC supporter	Printed IGVC T and Official shirts 1992-2001
Dr, CT Lin	CSU Northridge Professor	IGVC Faculty
Dr. Michael Polis	1st OU Dean for IGVC	Approved start of IGVC and initial OU IGVC staff
Sen Carl Levin	US Senator Michigan	Visited IGVC multiple years Staffers spoke at IGVC Welcomes
Len Brown	OU SECS Lab Manager	Provided Lab support for first decade of IGVC and designed & built ramps and replacements

30 June 2025 Version