The 20TH Annual Intelligent Ground Vehicle Competition (IGVC)

June 8th - 11TH, 2012
Oakland University
Rochester, Michigan

In memory of Paul Lescoe

New Items:
Autonomous & Navigation Challenges fully Integrated into the Auto-Nav Challenge
Course length 1000ft, 10 min
Two vehicles on course at once, starting 5 minutes apart
Slow vehicles will have to yield with judges call
Obstacle Driving Clearance reduced to 5 feet
Maximum vehicle with reduced to 4 feet

Student teams are invited to display their vehicles at The Association for Unmanned Vehicle Systems International's Unmanned Systems North America 2012 Symposium & Exhibition Held at LasVegas Nev 7-10 August , 2012

December 19th, 2011 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 2011 and June 2012.

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.

Schools are encouraged to have more than one entry; but are limited to a maximum of three per school, and each vehicle must have a separate team of students and a distinct design report. 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 form must be **TYPED** and accompanied with a $250.00 non-refundable registration fee made payable to *Oakland University*. Intention to compete must be received no later than **February 28, 2012**, by mailing your application form to:

Gerald C. Lane
C/O Dr. Ka C. Cheok
102A SEB
SECS-ECE Dept.
Oakland University
Rochester, MI 48309-4478

If you have any questions, please contact Andrew Kosinski by telephone at (586) 282-9389, fax: (586) 282-8684 or e-mail: andrew.d.kosinski.civ@mail.mil.

I.2 VEHICLE CONFIGURATION

The competition is designed for a small semi-rugged outdoor vehicle. Vehicle chassis can be fabricated 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. or hovercraft.
- **Length**: Minimum length three feet, maximum length seven feet.
- **Width**: Minimum width two feet, maximum width five 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 ten miles per hour (10 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 Auto-Navevent, the wireless E-stop will be held by the 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 18" 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: 18 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 event. 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 and when the vehicle is running in autonomous mode, the light goes from solid it 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 ten 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, 2012**. 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 AUTO-NAV CHALLENGE COMPETITION

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 an average course speed of one mph, a minimum of speed of one mph over a section and a maximum speed limit of ten mph, remaining within the lane, negotiating flags 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 VEHICLE CONTROL

Vehicles must be unmanned and autonomous. They must compete based on their ability to perceive the course 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 is allowed. Teams are encouraged to map the course and use that information to improve their performance on the course.

II.3 OBSTACLE COURSE

The course will be laid out on grass over an area of approximately 500 feet long by 240 feet wide and minimum of 1000 feet in length. 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.

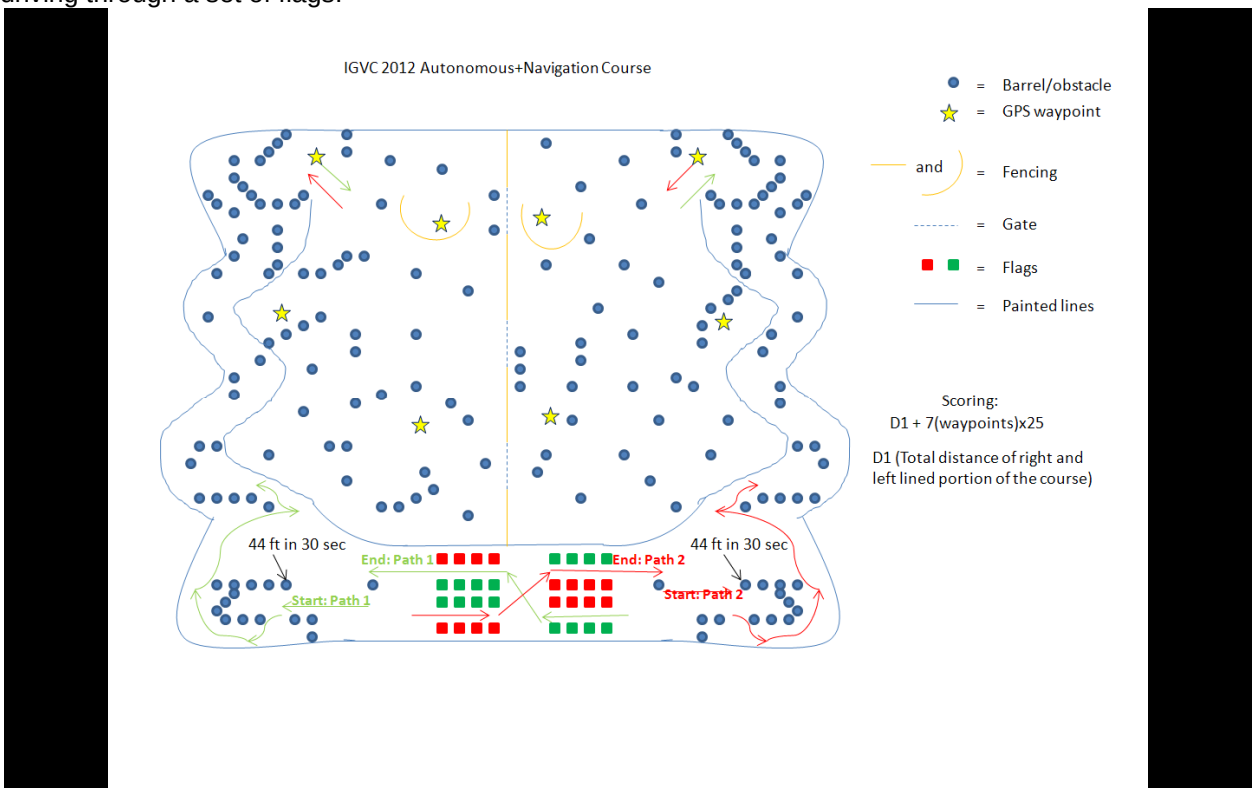
The course outer boundaries will be designated by continuous or dashed white lane markers (lines) approximately three inches wide, painted on the ground. Track width will be approximately ten feet wide with a turning radius not less than five feet. Alternating side-to-side dashes will be 15-20 feet long, with 10-15 feet separation. A minimum speed will be required of one mph and will be a requirement of Qualification and verified in each run of the Autonomous 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 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.

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. Also on the course there will be complex barrel arrangements with switchbacks and center islands. These will be adjusted for location between runs. Direction of the obstacle course will change between heats.

Alternating red (right) flags (Grainger part no.3LUJ1) and green (left) flags (Grainger part no.3LUJ6) will be placed on the later part of the course. Flags will have a minimum passage width between them of six feet; i.e., if the flag is near the edge of the course then between the flag and the line will be six feet of driving space. Flags are not obstacles and vehicles can touch flags to increase speed

and optimized route, vehicles are not allowed to go over flags. The objective is for the vehicle to stay to the left of the red flags and to the right of the green flags. Flags can be staggered or the vehicle could be driving through a set of flags.



Example Auto-Nav Challenge Layout

Auto-Nav Challenge will contain eight Global Positioning System (GPS) waypoints, one at each entry and exit and three on each side of the navigation no-man's land separated by a fence with three alternating gates Distance achieved will be totaled by adding straightline distances between waypoints and added to total distance driving on lined portion of the course. The open space between the navigation waypoints will contain a mix of obstacles which must be avoided while staying with-in the course.
The exact waypoint locations will be marked on the grass for use by the judges, but there will be no standup markers to indicate those positions. Construction barrels, barricades, fences, and certain other obstacles will be located on the course in such positions that they must be circumvented to reach the waypoints. These may be randomly moved between runs.

The course will be divided into two areas by a fence with a two meter wide opening located somewhere along it (no coordinates are provided). The opening will be randomly relocated along the fence at the start of each run. waypoints will have two meter circles around them.

Auto-Nav Course direction will change for each run of a Heat.

II.4 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 the up to two runs (time permitting) in each of three heats.

- Judges/officials will assign a designated starting order. 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 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.
    - Five minutes have passed after the vehicle run has started.
    - 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.
- Each vehicle will be given 10minutes per attempt to complete the course, if the vehicle has not completed the course in the 10 minute time period, the attempt will 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. 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.5 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	- 5 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	Wrong Side of Flag	-5 Feet	No	No
11	Run over Flag	-10 Feet	Yes	Yes
12	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 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 outside 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. Rocking/Tilting an obstacle with no permanent displacement is not considered obstacle displacement.
- **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.
- **Wrong Side of Flag:** Vehicles must remain on the left side of red flags and the right side of green flags.
- **Run over Flag:** Vehicles drive over the top of a red or green flag will results in End of Run.
- **Too Slow:** If the vehicle does not maintain 1 mph minimum average speed limit throughout the course this run is disqualified.

II.6 PRACTICE COURSE

All teams that have qualified will be given three tokens. Each token represent one opportunity to use the Auto-Nav Challenge Practice Course. The course will be open daily for use from the time a team Qualifies till the start of the third heat of the Autonomous Challenge. The course will focus on the no-mans land portion of the Autonomous Challenge with the same rules and similar obstacles, fence & gates. One token allows a maximum of five minutes (one minute at the start point and five minutes for the run) on the Autonomous Challenge Practice Course. In that time you must position your vehicle at the start, prep the vehicle for the judge to start, and can continue to run as long as you do not break any of the rules of the Autonomous Challenge. If so, your run and remaining time will be ended. All teams will still have unlimited access to the regular practice fields.

II.7 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 five minute 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 passing the money barrel. The money barrel location is determined by the judges during the final/actual course layout. 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 10 minute mark.

II.8 GROUNDS FOR DISQUALIFICATION

- Judges will disqualify any vehicle which appears to be a safety hazard 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. DESIGN COMPETITION

All teams must participate in the Design Competition.

III.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 follow 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.

Design innovation is a primary objective of this competition and will be given special attention by the judges. Innovation is considered to be a technology (hardware or software) that has not ever been used by this or any other vehicle in this competition. The innovation needs to be documented, as an innovation, clearly in the written report and emphasized in the oral presentation.

III.2 WRITTEN REPORT

The report should not exceed 15 letter-sized pages, including graphic material and all appendices, but not including the title page. Reports will lose 5 points in scoring for each page over 15. Line spacing must be at least 1.5, with at least a 10 point font (12 is preferred). Each vehicle must have a distinct and complete report of its own (a report cannot cover more than one vehicle). Participants are required to submit four hard copies of the report and an electronic copy in PDF format on a CD; failure to submit either of these will result in ***disqualification***. 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. The certification should also include a brief description of the areas in which changes have been made to a vehicle from a previous year. Everything must be mailed so as to arrive by **May 10, 2012**, addressed to:

Bernard Theisen
21281 Curie Avenue
Warren, MI 48091-4316

Written reports arriving after that date will lose 10 points in scoring for each business day late, electronic copies arriving after that date will lose 5 points in scoring for each business 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 changes 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.

The paper should present the conceptual design of the vehicle and its components. Especially important to highlight are any unique innovative aspects of the design and the intelligence aspects of the vehicle. Also included must be descriptions of:

electronics	design planning process
electrical system	signal processing
actuators	plan for path following
software strategy	(both solid & dashed lines)
sensors	plan for control decisions
computers	system integration plan
mapping	high speed operations

Design of the lane following and obstacle detection/avoidance systems must be specifically described. Along with how the vehicle uses mapping techniques to perceive and navigate through its environment. Describe how the system uses GPS for waypoint navigation and localization.

Components acquired ready-made must be identified, but their internal components need not be described in detail. The steps followed during the design process should be described along with any use of Computer-Aided Design (CAD). How considerations of safety, reliability, and durability were addressed in the design process should be specifically described, as well as problems encountered in the design process and how they were overcome. The analysis leading to the predicted performance of the vehicle should be documented, specifically:

- Speed
- Ramp climbing ability
- Reaction times
- Battery life
- Distance at which obstacles are detected
- How the vehicle deals with complex obstacles including switchbacks and center islands dead ends, traps, and potholes
- Accuracy of arrival at navigation waypoints
- Comparison of these predictions with actual trial data is desirable.

Although cost itself is not a factor in judging (these are considered research vehicles), the report should include a cost estimate (not counting student labor) for the final product if it were to be duplicated. A breakdown of the cost by component is helpful.

The team organization and the names of all members of the design team, with academic department and class, should be included along with an estimate of the project's total number of person-hours expended.

Vehicles that have been entered in IGVC in earlier years and have not had significant changes in design are ineligible in either the design or performance events. Vehicles that have been changed significantly in design (hardware or software) from an earlier year are eligible, but will require a completely new design report (15 pages or less) treating both the old and new features, thus describing the complete vehicle as if it were all new.

Judges will score the written reports as follows:	**Maximum Points**
1. Conduct of the design process and team organization (including decision-making & software development)	50
2. Completeness of the documentation	50
3. Quality of documentation (English, grammar, and style)	50
4. Effective innovation represented in the design (as described above)	150
5. Description of mapping technique	100
6. Description of electronic design	100
7. Description of software strategy	150
8. Description of systems integration Descriptions to include: lane following, obstacle detection/ avoidance, and waypoint navigation (GPS or other)	150
9. Efficient use of power and materials	50
10. Attention given to safety, reliability, and durability	50
Total	**900**

III.3 ORAL PRESENTATION

The technical talk should relate the highlights of the written report described above and include any updates of the design since the written report. Audio or video tape presentations of the text 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 and should last not more than 10 minutes. A penalty of 5 points will be assessed for each minute or fraction thereof over 11 minutes. After the presentation, judges only may ask questions for up to 5 minutes. The audience should be considered as a senior management group of generally knowledgeable engineers upon whom the project is dependent for funding and the team is dependent for their employment. Scoring will be as follows:

Judges will score the oral presentations as follows:	**Maximum Points**
1.Clear and understandable explanation of the innovations	50
2. Logical organization of the talk	25
3. Effective use of graphic aids	25
4. Articulation	20
5. Demonstrated simulation of vehicle control in performance events	10
6. Response to questions	10
7. Salesmanship	10
Total	**150**

Effective use of graphic aids includes not blocking the view of the screen by the presenter and simple enough graphics that are large enough to read (block diagrams rather than detailed circuit diagrams). Articulation refers to the clarity and loudness of speaking. 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 may 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 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.

III.4 EXAMINATION OF THE VEHICLE

The vehicle must be present and will be examined by the judges preferably immediately after the oral presentation or at another convenient time the time during the competition. Software is not included in this judging. Judging will be as follows:

Judges will score the vehicle examinations as follows:	**Maximum Points**
1. Packaging neatness, efficient use of space	20
2. Serviceability	20
3. Ruggedness	20
4. Safety	20
5. Degree of original content in the vehicle (as opposed to ready-made)	50
6. Style (overall appearance)	20
Total	**150**

III.5 FINAL SCORING

The number of points awarded by the individual judges will be averaged for each of the 23 judging areas above, and these results will be offered to each participating team for their edification. The total of the average scores over all 23 areas (max 1200) will be used to determine the ranking.

When two teams of judges are used (due to a large number of entries) each judging team will determine the top three winners in their group, and the resulting six contestants will participate in a runoff of oral presentations and vehicle examinations judged by all judges to determine an overall Design Winner. The six teams will be judged in random order.

For the Finals competition four criteria from the written report judging will be added to the normal oral presentation scoring shown above for preliminary judging. Thus, the Finals Oral presentation scoring will have maximum points as below:

Judges will score the final presentations as follows:	**Maximum Points**
1.Clear explanation of the innovations	50
2. Description of mapping technique	30
3. Description of Electronic Design	30
4. Description of Software Strategy	30
5. Description of System Integration	30
6. Logical organization of the talk	50
7. Effective use of graphic aids	25
8. Articulation	25
9. Demonstrated Simulation of Vehicle Control	10
10. Response to questions	10
11. Salesmanship	10
Total	**300**

The vehicle examination scoring will be the same as in the preliminary judging, as shown above.

IV. JAUS Challenge

Participation in the JAUS Challenge is recommended.

IV.1 TECHNICAL OVERVIEW

Each entry will interface with the Judge's COP providing information as specified below. The general approach to the JAUS interface will be to respond to a periodic status and position requests from the COP. This requires the support of the JAUS Transport Specification (AS5669A) and the JAUS Core Service Set (AS5710). The JAUS Transport Specification supports several communication protocols, the competition will use only the Ethernet based JUDP. The Core services required for the competition include the discovery, access control, and management services. The JAUS Mobility Service Set (AS6009) or JSS-Mobility defines the messaging to be used for position communications and waypoint based navigation.

IV.2 COMMON OPERATING PICTURE

The COP will provide a high level view of the systems in operation that successfully implement the JAUS protocol as described above. This software is a simple validation, reporting and recording tool for the Judges to use while verifying student implementations of the JAUS standard. It provides a graphical display of the operational area in relative coordinates. Primitive graphics are loaded in the display of the COP to add perspective. Each reported status is displayed on the COP user interface and recorded for future reference. For competitions and systems reporting positional data, a 2-D map on the COP display is annotated with the updated position as well as track marks showing the previous position of the system for the current task.

IV.3 COMMUNICATIONS PROTOCOLS

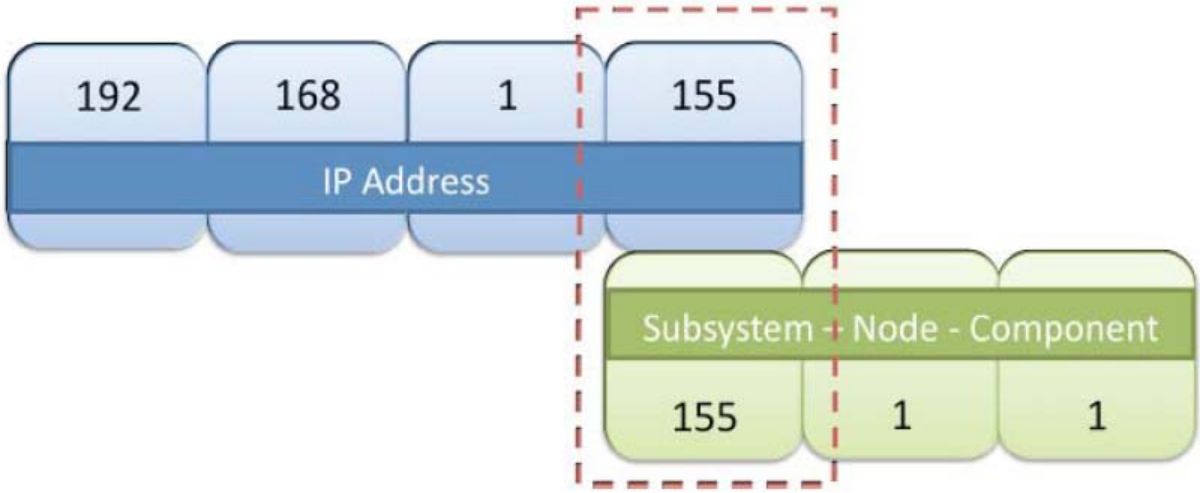
The teams will implement a wireless 802.11b/g or hardwired Ethernet (RJ-45) data link. The interface can be implemented at any point in the student team's system including the control station or mobility platform.

The Internet Protocol (IP) address to be used will be provided at the competition. For planning purposes, this address will be in the range of 192.168.1.100 to 192.168.1.200. The Judge's COP will have both hard-wire and 802.11b/g capabilities where the IP address of the COP will be 192.168.1.42. All teams will be provided an IP address to be used during the competition. The last octet of the IP address is significant, as it will also be used as the subsystem identifier in the team's JAUS ID. The port number for all JAUS traffic shall be 3794.

IV.4 JAUS SPECIFIC DATA

The JAUS ID mentioned above is a critical piece of data used by a JAUS node to route messages to the correct process or attached device. As indicated above each team will be provided an IP address in which the last octet will be used in their respective JAUS ID. A JAUS ID consists of three elements, a Subsystem ID, a Node ID and a Component ID. The Subsystem ID uniquely identifies a major element that is an unmanned system, an unmanned system controller or some other entity on a network with unmanned systems. A Node ID is unique within a subsystem and identifies a processing element on which JAUS Components can be found. A Component ID is unique within a Node represents an end-point to and from which JAUS messages are sent and received. The last octet of the assigned IP address will be used as the team's JAUS Subsystem ID. So for the team assigned the IP address of 192.168.1.155, the completed JAUS ID of the position-reporting component might be 155-1-1 where the

node and component are both assigned the IDs of 1. This is shown in the IP and JAUS ID Assignment Figure below. The Node ID and Component ID are discussed further in the JAUS Service Interface Definition Language standard (AS5684). The COP software will be programmed with the assumption that all services required by the specific competition are implemented on a single component.



IP and JAUS ID Assignment

In summary, each team will be assigned an IP address by the judges. The last octet of that IP address will be the team's subsystem identifier. The COP will be a subsystem as will each team's entry in the competition. The COP will have a JAUS ID of 42:1:1 and an IP address of 192.168.1.42. The port number shall be 3794.

IV.5 COMPETITION TASK DESCRIPTION

Messages passed between the COP and the team entries will include data as described in the task descriptions below. The COP will initiate all requests subsequent to the discovery process described as Task 1. A system management component is required of all teams. This interface will implement several of the messages defined by the Management Service defined in the JSS-Core. This service inherits the Access Control, Events and Transport services also defined by the JSS-Core document. The implementation of the Access Control interfaces will be necessary to meet the JAUS Challenge requirements; however no messages from the Events service will be exercised. The sequence diagram in Discovery and System Management Figure shows the required transactions for discovery including the access control setup and system control protocol. This interaction is required for every task.

The judges will evaluate each team's ability to meet the Interoperability Challenge for the tasks described below in accordance with the scoring chart.

Judges will score the task as follows:	**Maximum Points**
1. Transport Discovery	10
2. Capabilities Discovery	10
3. System Management	10
4. Velocity State Report	10
5. Position and Orientation Report	10
6. Waypoint Navigation	10
Total	**60**

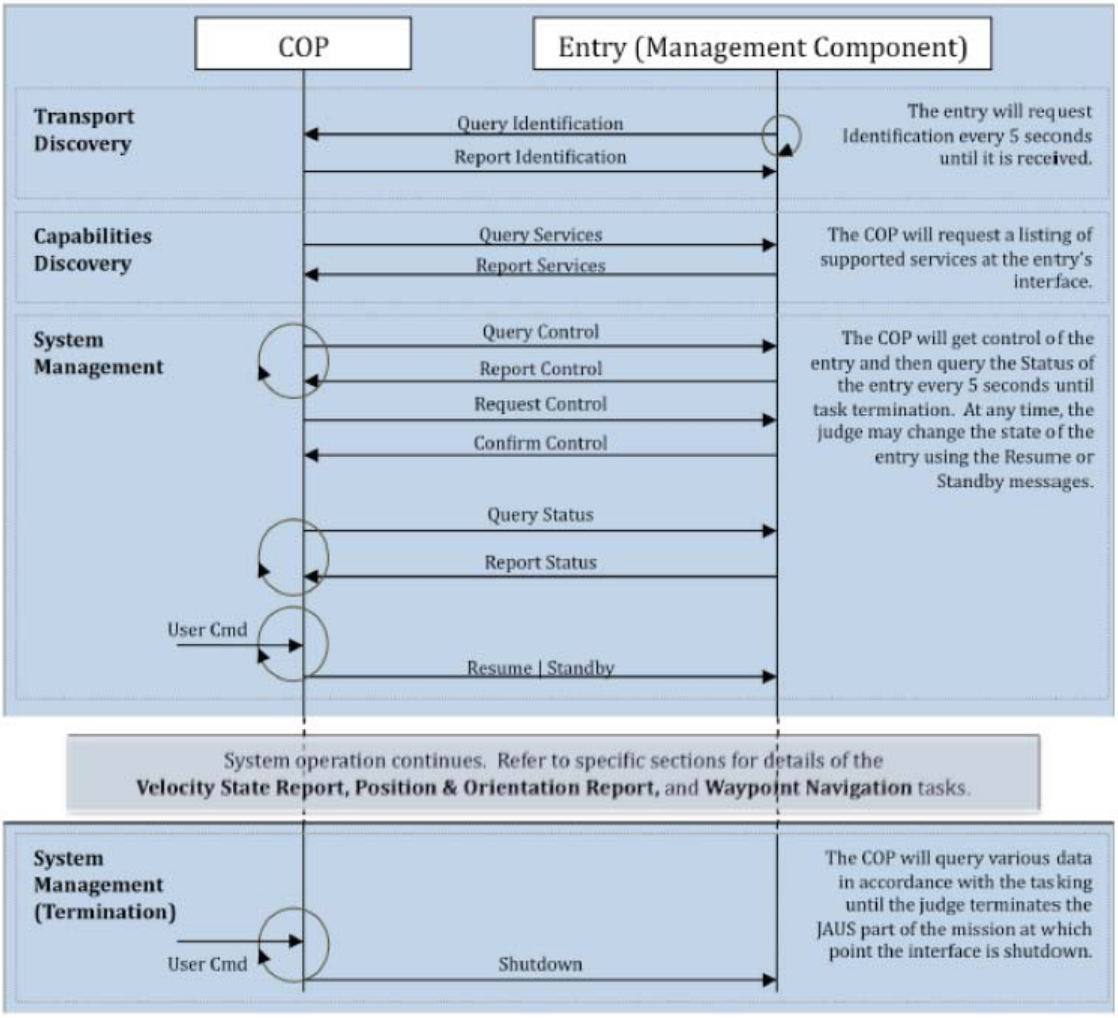
IV.6 TRANSPORT DISCOVERY

For any two elements in the system to communicate meaningful data there must first be a handshake to ensure both sides use the same protocols and are willing participants in the interaction. For the sake of simplicity, the team's entry shall initiate the discovery protocol with the Judge's COP, and the IP address and JAUS ID of the COP shall be fixed. The IP address and JAUS ID of the Judge's COP are defined as:

COP IP ADDRESS:	192.168.1.42:3794
COP JAUS ID:	42-1-1 (Subsystem-Node-Component)

The discovery process, in Discovery and System Management Figure, will occur at the application layer. The student team's JAUS element will send a request for identification to the COP once every 5 seconds. The COP will respond with the appropriate informative message and request identification in return from the team's JAUS interface. After the identification report from the COP, the team entry will stop repeating the request. This transaction will serve as the basic discovery between the two elements.

The COP software will be programmed with the assumption that all services required by the specific competition are provided at the single JAUS ID. Furthermore, as per the AS5669A Specification, the team's entry shall receive JUDP traffic at the same IP address and port number that initiated the discovery protocol. Teams should note that this is different from common UDP programming approaches in which the outbound port for sent messages is not bound.



Discovery and System Management

The following table shows the messages sent from the COP to the team's entry, along with the expected response and minimal required fields to be set using the presence vector (PV) if applicable, required to complete this portion of the challenge:

Input Messages	Expected Response	Required Fields (PV)
Query Identification	Report Identification	N/A

IV.7 CAPABILITIES DISCOVERY

Following the completion of the Transport Discovery handshake the COP will query the entry for its capabilities. The Query Services message and Report Services message are defined in the AS5710 document and require the inheritance of the Transport service. The COP will send a Query Services message to a student team entry. Upon receipt of the message the student team entry shall respond with a properly formed Report Services message.

The following table shows the messages sent from the COP to the team's entry, along with the expected response and minimal required fields to be set using the presence vector (PV) if applicable, required to complete this portion of the challenge:

Input Messages	Expected Response	Required Fields (PV)
Query Identification	Report Identification	N/A

IV.8 SYSTEM MANAGEMENT

The implementation of the status report is required. This interoperability task, like the discovery tasks above, is also a prerequisite for all other tasks. The task begins with the discovery handshake as described above and continues for an indeterminate period of time. The protocol is given in Discovery and System Management Figure. The following table shows the messages sent from the COP to the team's entry, along with the expected response and minimal required fields to be set using the presence vector (PV) if applicable, required to complete this portion of the challenge:

Input Messages	Expected Response	Required Fields (PV)
Query Control	Report Control	N/A
Request Control	Confirm Control	N/A
Query Status	Report Status	N/A
Resume	<none>	N/A
Standby	<none>	N/A
Shutdown	<none>	N/A

IsaV.9 VELOCITY STATE REPORT

In the Velocity State Report task the COP will query the entry for its current velocity state. The COP will send a Query Velocity State message to a student team entry. Upon receipt of the message the student team entry shall respond with a properly formed Report Velocity State message.

The following table shows the messages sent from the COP to the team's entry, along with the expected response and minimal required fields to be set using the presence vector (PV) if applicable, required to complete this portion of the challenge:

Input Messages	Expected Response	Required Fields (PV)
Query Velocity State	Report Velocity State	Velocity X, Yaw Rate & Time Stamp [320 Decimal, 0140h]

V.10 POSITION AND ORIENTATION REPORT

For performing the task Position and Orientation Report, the discovery and status protocols described above are also required. In addition to the COP queries for status, the vehicle systems will also be required to respond correctly to local position queries. The reports will be validated for relative position and with respect to a relative time offset to ensure the time contained within each position report is valid with respect to some timer within the entry's system. In other words, the position reports must show that the travel occurred at a reasonable speed and not instantaneously. Additional variation in the position reporting using the available presence vectors is allowed. Minimally, all entries must report X, Y and Time Stamp.

The following table shows the messages sent from the COP to the team's entry, along with the expected response and minimal required fields to be set using the presence vector (PV) if applicable, required to complete this portion of the challenge:

Input Messages	Expected Response	Required Fields (PV)
Set Local Pose	<none>	X, Y & Yaw [67 Decimal, 0043h]
Query Local Pose	Report Local Pose	X, Y & Time Stamp [259 Decimal, 0103h]

V.11 WAYPOINT NAVIGATION

The team entry shall implement the Local Waypoint List Driver service from the JAUS Mobility Service Set (AS6009). From a starting point in the JAUS challenge test area the student entry will be commanded to traverse, in order, a series of 4 waypoints. Time will be kept and will start at the moment that the student entry exits the designated start box. Upon leaving the start box the student entry will proceed to the first waypoint in the list. Upon satisfactorily achieving each waypoint the team will be credited with 2.5 points. Time is kept for each waypoint achieved. The shortest overall time taken to achieve this task will determine the winner in the event of a tie.

The following table shows the messages sent from the COP to the team's entry, along with the expected response and minimal required fields to be set using the presence vector (PV) if applicable, required to complete this portion of the challenge:

Input Messages	Expected Response	Required Fields (PV)
Set Element	Confirm Element Request	N/A
Query Element List	Report Element List	N/A
Query Element Count	Report Element Count	N/A
Execute List	<none>	N/Speed (value of 1)
Query Active Element	Report Active Element	N/A
Query Travel	Report Travel Speed	N/A
Query Local Waypoint	Report Local Waypoint	X & Y (value of 3)

VI. AWARDS AND RECOGNITION

All schools are only eligible to win award money once per event (Autonomous Challenge, Design Competition, and JAUS Challenge); if more then one team from the same school places in the same event, only the highest placing team will be placed in a standing and receive money for that event.

VI.1 AUTO-NAV CHALLENGE COMPETITION

Autonomous Competition Standard Awards

1ST Place	$25,000
2ND Place	$5,000
3RD Place	$4,000
4TH Place	$3,000
5TH Place	$2,000
6TH Place	$1,000

Nominal Award Money
(Vehicle did not pass Money Barrel)

1ST Place	$3,000
2ND Place	$2,000
3RD Place	$1,000
4TH Place	$ 750
5TH Place	$ 500
6TH Place	$ 250

VI.2 VEHICLE DESIGN COMPETITION

Design Competition Standard Awards

Dr William G. Agnew Award	1ST Place	$3,000
	2ND Place	$2,000
	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

IVI.5 JAUS CHALLENGE

JAUS Competition Standard Awards

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

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

IVI.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 (for this year the team would be eligible if they haven't competed since the thirteenth IGVC in 2006). 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 Qualification, in the Autonomous Challenge you must pass the Rookie Barrel and in the Navigation Challenge you must make three waypoints. 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.

VI.6 GRAND AWARD

The Grand Award trophies will be, presented to the top three teams that perform the best overall (combined scores per below), in all three competitions. For each competition, points will be awarded to each team, below is a breakdown of the points:

Autonomous Challenge	Passed Money Barrel	Short of Money Barrel
First Place	48	24
Second Place	40	20
Third Place	32	16
Fourth Place	24	12
Fifth Place	16	8
Sixth Place	8	4

Design Competition	Vehicle Qualified	Vehicle Failed to Qualify
First Place	24	12
Second Place	20	10
Third Place	16	8
Fourth Place	12	6
Fifth Place	8	4
Sixth Place	4	2

JAUS Competition	Vehicle Qualified	Vehicle Failed to Qualify
First Place	24	12
Second Place	20	10
Third Place	16	8
Fourth Place	12	6
Fifth Place	8	4
Sixth Place	4	2

VI.7 PUBLICATION AND RECOGNITION

International recognition of all participating teams through AUVSI and SAE publications.

Student Teams are Invited to Display Their Vehicles at The Association for Unmanned Vehicle Systems International's Unmanned Systems North America 2012 Symposium & Exhibition Held in Las Vegasl teams are invited to display the winning vehicles in the AUVSI exhibit halls.

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

If you have any questions, please feel free to contact any of the following IGVC Officials:

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Bernard Theisen	2006-2011
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Dan Maslach	2003-2004
Bernard Theisen	2001-2003
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Scot Wheelock	1999-2000
Geoff Clark	1998-1999
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Jerry Lane, Paul Lescoe and Ka C. Cheok	1992-1996

IGVC Rules Editors

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