Team Juggernaut

DARPA Grand Challenge 2005 Technical Paper

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ABSRACT

Team Juggernaut developed a fleet of autonomous ground vehicles for DARPA's Grand Challenge 2005. The basis of the development is centered around COTS (Commercial-Off-The Shelf) technology in order to make the final product affordable, readily available and understandable by those reasonably skilled in the art. The electronics and software are platform independent in order to eliminate the need to customize the technology for the various military ground vehicles subject to retrofit.

1. Introduction

DesignJug, LLC believes that autonomous ground vehicles will be a viable and proven technology within a year. DesignJug research indicates that the capability exists today; it is a matter of marrying the various technologies currently available with the appropriate software to create an efficient and cost effective solution. The market exists to support these efforts – upwards of $10 billion over the next 10 years.

DesignJug has fully committed its resources to the sponsorship of the vehicle - Desert Juggernaut - as well as the team - Team Juggernaut - for its entry and execution of the DARPA Grand Challenge 2005. Team Juggernaut consists of full-time and part-time professionals with over 20 years of experience in ruggedized systems design and manufacture in a variety of industries. Their backgrounds include: systems design and development, project management, business management, software engineering, electrical engineering, mechanical engineering, electronic and mechanical assembly, sales and marketing, procurement, and strategic planning.

2. Vehicle Description

2.1 Vehicle

The Desert Juggernaut autonomous vehicle is not just one vehicle; it defines a fleet. These are: V'Ger: a 1997 Yamaha Kodiak all-terrain vehicle whose main purpose is platform development and proof of concept; Desert Buzzard: a 2005 Polaris Sportsman MV 7 (Military Vehicle) with its main purpose as a race vehicle and The Jean Marie: a 2004 Chevy Avalanche, both a race vehicle and mobile laboratory. All 3 vehicles have identical and complete electronics systems and sensors. All 3 vehicles receive software and hardware revisions as development continues. Redundancy assures that a vehicle will always be available for continuous development and for race day in the event of some unforeseen mishap.

For the actual GC'05 National Qualification Event and race, our military ATV was chosen over the 4-wheel drive truck for two reasons. First, the ATV manages washboard

type roads and other “vibration laden terrain” better at higher rates of speed compared to a 4 wheel drive truck. On this type of road an ATV is not as vulnerable as a truck to loss of traction. Second, due to the smaller footprint of the ATV, the vehicle is more forgiving in terms of lateral movement around objects or in the event of slight GPS error calculation.

V’Ger – a 1997 Yamaha Kodiak. Used for platform development and proof of concept

2.2 Unique Modifications

The military ATV will potentially be modified with a larger gasoline tank to accommodate the lengthy operational requirements of full day testing and for the GC’05 race day. In addition, a 200 pound steel plate was affixed to the bottom of the chassis to assist with keeping the vehicle from tipping adversely or rolling over. And finally, a roll bar system was added to protect the electronics, sensors and structural integrity of the vehicle in the event of a rollover. The mechanical design was such that the vehicle would be ‘forced’ to right itself and would not be able to ‘rest’ upside down.

3. Autonomous Operations

Our approach is based upon significant experience in delivering and fielding military and industrial systems for usage in very rugged environments using PC based technologies. The modularity of the systems and our COTS (commercial-off-the-shelf) orientation supports our platform independence approach, making it ideal for transition into retrofit production programs for the military. The commercial technologies include sensors, actuators and industrial computers; all available at affordable costs. Full cycle software integration has been implemented. In addition, robust mission planning software has been created.

4. Systems Information

Three (3) 1GHz Pentium computers, running Windows XP, comprise the basis of the computer system. USB 2.0 was chosen as the connection interface. The software languages used are based on stable Visual Studio 6 and ActiveX technology.

All data is presented to the various executables through data pipes and shared memory technology. Seven primary executables are used across two of three functioning PCs to process I/O, calculate solutions, and control the vehicle. Those executables are:

Messenger	- Delivers messages from sources to targets
Loader	- Receives all I/O streams into the memory architecture
Vehicle Ctrl	- Controls and monitors vehicle operation
DJImageWB	- Process all imaging information from sensors
Pathing	- Generates path solutions based upon situational awareness.

Three GPS systems, two cameras, and two compasses determine the orientation of the vehicle in its environment. All vehicle information is managed through the usage of a Mission Planning system. Routes from a variety of sources are converted to courses, assigned to vehicles generating a mission. Data flow is managed throughout the mission starting with delivery to the assigned vehicle prior to execution and recovery after execution.

The fleet of vehicles can be driven by a human without any modifications, special instructions or special requirements. All vehicles were driven by humans as needed throughout the course of development. The Chevy Avalanche truck is used on public roads on a daily basis.

4.1 System Tests

The Team has implemented a rigorous testing regime. Testing is done across the three vehicles to validate the robustness of the system. A field mobile laboratory supports lengthy and extensive road testing. An automated rotary table is used for in-house testing prior to field testing.

4.1.1 Testing strategy

The GC '04 course was driven in Spring 2005 to familiarize the team with the terrain and level of off-road driving difficulty involved. In addition, digital images of most of the course were recorded for software development purposes. Off-road and paved-road testing was performed in the western Utah desert, with terrain and temperatures similar to the GC '04 course.

4.1.2 Test results and key challenges

Heat was a significant problem when testing in the desert. The electronic systems did not shut down but computing power was compromised. Due to this, it took time to troubleshoot the issue back to the electronics and not to a potential software error. This challenge was resolved by installing healthy blowers in all three vehicles.

5. Summary

Additional information can be obtained by qualified parties upon execution of a non-disclosure agreement; in consideration of the significant investment by DesignJug, LLC.