



FAMU/FSU College of Engineering

Department of Mechanical Engineering

Operational Manual

Team 10 Autonomous ATV

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Functional Analysis

- *Overall ATV Function*

The end goal for this project is for the ATV to drive itself autonomously from waypoint to waypoint as well as follow a road. Last year actuators were installed onto the throttle, steering, brake and shifter. The ATV was then controlled by a human operator remotely with a controller. To achieve autonomous capability sensors were installed and algorithms were developed to replace the operator.

The first step is to power on the onboard and chase computers as well as all the sensors. The scripts that were written on the computers will then establish a connection between each other, the installed sensors, and the previously installed actuators. The system will then prompt to initialize the calibration of the steering encoders using the steering motor and wait for the GPS to acquire satellite communication. Once this is complete, the user will then select either road following or waypoint navigation on the chase computer. If road following is selected, the program will execute and the ATV will follow the forward road until told to stop. If waypoint navigation is selected, the ATV will move to the selected destination and stop when it arrives. The system can then be shut down after the program has run completely. To do this, the ATV engine must first be turned off. The onboard computer and the sensors are then turned off by the external switches.

If the ATV motion must be stopped at any point during the testing, there will be a person manning an RF cutoff switch at all times. There are also four safety cutoff switches located at the four corners of the vehicle which will turn off the ATV engine.

- *Communication*

The communication block diagram for the system is illustrated in Figure 1. The onboard Toughbook computer will communicate with the onboard QNX computer via serial communication. The Toughbook will then establish communication with all other sensors and the actuators. Once this process is complete, the chase computer will connect to the same network as the onboard computers through the router on the ATV. This will allow for the chase computer to mirror the screen of the Toughbook to allow remote controlling of the ATV's different autonomous modes.

- *Road Following*

The road following algorithm incorporates the encoders, lasers and all of the actuators. The encoder data will be used to give the ATV speed, distance traveled and acceleration. The lasers will scan the forward environment and send back accurate distance measurements of obstacles. It will also measure the curbs of the road. Based

on these readings, the throttle actuator and steering motor will be used to turn and move the ATV in the appropriate manner.

- *Waypoint Navigation*

The waypoint navigation algorithm will use the GPS and IMU as well as the encoders, lasers and all of the actuators. The GPS data will be used to give the global position of the ATV. Since the GPS frequency is slower than required, the IMU will be used to track the position of the ATV in between GPS readings. The lasers will be used for obstacle detection while the ATV is moving to the next waypoint. Using this data, the Toughbook computer will then send the proper commands to the actuators to move the ATV to the desired waypoint.

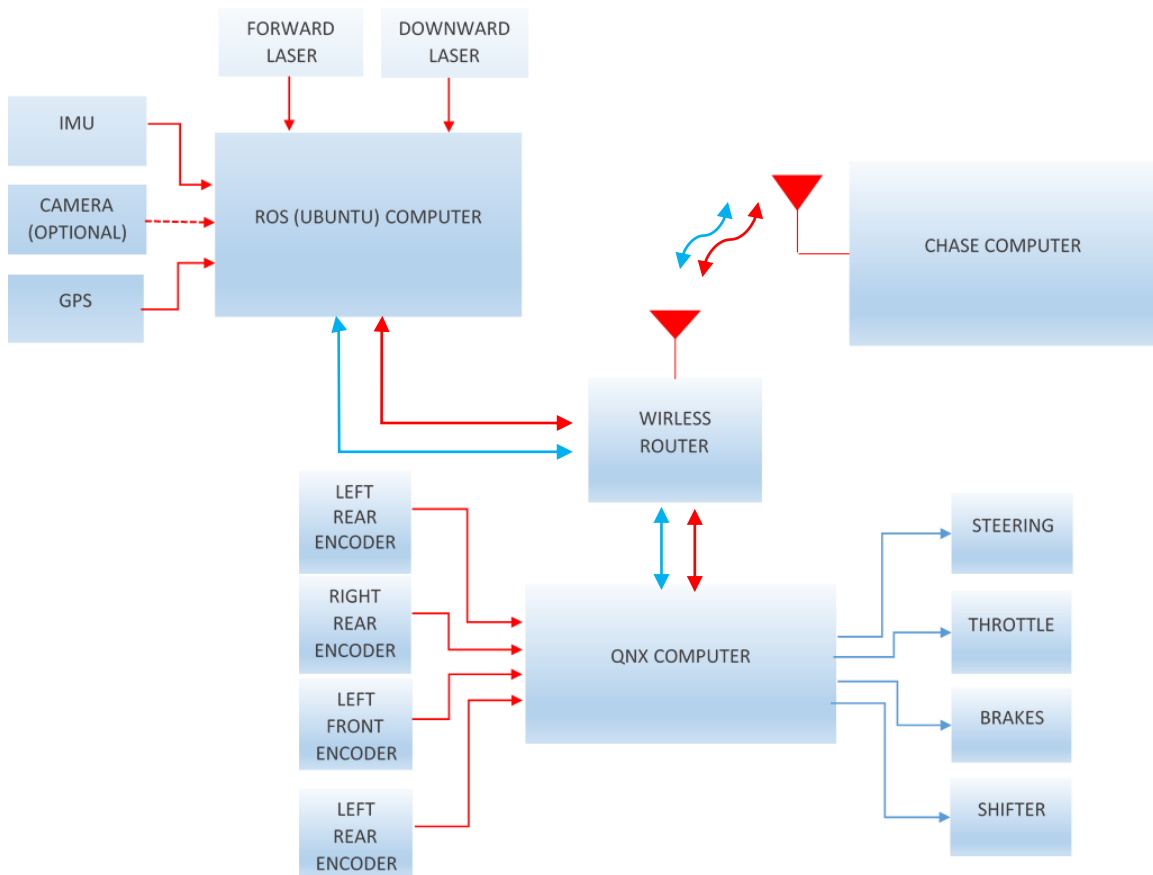


Figure 1: Block diagram of system communication and operation.

Product Specifications

- *SICK LMS-200 Laser Measurement System*

The lasers will be powered by the 24V battery at a maximum of 2A. They will send data via serial to USB to the onboard Toughbook computer at the specified baud rate. Each laser will scan at an angular resolution of 0.25° with an operating range between 0° and 180° . At each of those specified angles, the laser will output the distance to the measured objects with an accuracy of $\pm 1\text{cm}$. The operating range is between 0.1m and 80m.

- *Accu-Coder Model 725 Encoder*

Each encoder is powered by the QNX computer's data acquisition card at 5V and a maximum of 100mA. The encoder will output two square waves at a phase angle of 180° and there will be 30,000 outputs per revolution.

- *NovaTel Pro-Pak G2plus GPS*

The GPS will be powered by the 12V battery at a maximum of 200mA. The GPS will acquire satellite within a minute of startup and output an updated GPS location every one second in DMS (degrees minutes seconds).

- *Crossbow Inertial Measurement Unit (IMU)*

The supply voltage of the IMU will be 12V and consumes energy at a rate of 3W. It can measure an angular velocity of $\pm 100^\circ/\text{sec}$ with a resolution of $0.025^\circ/\text{sec}$. The IMU can measure linear accelerations of $\pm 2g$ with a resolution of less than 0.001g.

- *Polaris Sportsman 550 All-Terrain Vehicle and Actuators*

The product specifications of the ATV as well as the actuators installed can be found in the Operation Manual of the previous year's team.

Operational Instructions

The following is a step by step procedure to safely perform autonomous motion with the ATV:

1. Make sure ATV is in proper testing location before any initialization.
 - On an empty road for road following or in an open field for waypoint navigation.
2. Visually inspect the mechanical and electrical condition of the ATV.
 - Check fluid levels, tire pressures, electrical connections.
 - Make sure all safety buttons are not depressed.
 - Check suspension and battery charge level.
3. If Toughbook is not installed, place computer on the ATV, plug in the USB, and turn it on.
4. Make sure the ATV gear selector is in park.
 - **WARNING:** Changes done to the starting system will allow the engine to be started in any gear and may cause damage to the starter. Make sure vehicle is in park before starting.
5. Turn the ignition key to the run position. Do not start vehicle yet.
6. Power on the QNX computer, lasers, router, GPS, IMU, and cooling fans with each labeled switch on the outside of the trunk.
 - Wait 1 minute for QNX computer to boot, and the lasers' green light turns on.
 - **WARNING:** Make sure trunk lid is closed and locked before turning on fans.
7. Boot up chase computer and connect to the router on the ATV.
 - Use remote desktop to control the onboard Toughbook computer.
 - The QNX computer will automatically run the script to communicate with the data acquisition board to retrieve the encoder data and connect to the Toughbook computer.
8. Using the Chase computer run main.cpp
9. Program prompt the user to start the actuator calibration process.
 - Make sure any people are at a safe distance during calibration due to automatic steering.

10. Appoint a person to be the remote safety switch operator.
11. Start ATV engine.
12. Retreat all personnel to a safe distance from the ATV.
13. User will be prompted to select waypoint navigation or road following.
 - If road following is selected user will then input desired time or distance and then the program will start moving the ATV.
 - If waypoint navigation is selected, user will then input desired waypoint and then the program will start moving the ATV.
 - **WARNING:** ATV is now under autonomous control. Watch the direction and speed of the ATV at all times. If any undesired actions occur, immediately depress the remote safety button.
14. Once the ATV has reached desired location the program will safely bring the ATV to a stop.
15. The program will then prompt the user if another waypoint is desired or to continue road following.
16. Once testing is complete the user can exit the program from the prompt.
 - **WARNING:** Before approaching the ATV depress the emergency stop button.
17. Turn the ignition key into the off position.
18. Power down the QNX computer, lasers, router, GPS, IMU, and cooling fans with each labeled switch on the outside of the trunk.
19. Disconnect Toughbook computer from the trunk of the ATV.

Maintenance

1. Recharge batteries after each day of use.
2. Clean laser lenses as needed to keep them free of dust, dirt, and water.
3. Lubricate steering motor chain weekly to maintain life of chain and prevent rust.
4. Refer to Polaris Sportsman 550 Owners manual for all periodic ATV maintenance.

Repair/Replace Decision for Major Components

1. If any of the added sensory equipment breaks or fails the individual component must be replaced.
2. Cracked or broken mounting brackets should not be repaired and should be replaced.
3. If the ATV itself is damaged it should be repaired with exception of the frame.
4. The ATV should be thought of the same as any vehicle and any repair or part replacement should be done by certified Polaris technicians.
5. If any repair needs to be done, follow the steps in the supplied ATV service manual.

Spare Parts

For extended operation the following spare parts should be kept on hand,

- 12V batteries or recharger kit
- Unleaded gasoline
- Engine oil
- Engine coolant
- Gear lubrication
- Encoder belts
- backup computer