Department of Computer Science & Engineering
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System Requirements Specification
CSE 4316: Senior Design I
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Positioning Partners
Positron Rover

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Revision History

Revision	Date	Author(s)	Description
1.0	10.24.2021	NF, DJ, KK, OM, DM	document first revision
1.1	05.08.2022	NF, DJ, KK, OM, DM	Final Document Revision

Contents

List of Figures

1 Product Concept

This section provides the purpose, use and intended audience of the Positron rover. The rover is intended to follow a path that can be set by the users and is able to complete a few simple tasks. Users of the Positron rover will be able to either spray dots of paint based on their input and use of a GPS tracker, or insert a stick of rebar into the ground with the same tracking.

1.1 Purpose and Use

We plan to be able to send signals to the robot, allowing it to move remotely along a GPS coordinate system that can be inputted by the user. The robot would move along and stop at coordinates, and perform a task. This task would either include spraying a dot onto the ground and then continuing moving forward, or sticking a stick of rebar into the ground at a desired level into the ground. We would expect it to be used in order to help with the act of driving rebar into the ground, and allowing for the intended audiences to be more safe when operating with it.

1.2 Intended Audience

The intended audiences would include the participants of an event that happens on Veterans Day. This event requires the driving of thousands of sticks of rebar into the ground in order to make flags in front of the tombstones of the veterans. This would help the participants with both speed and efficiency, allowing them to complete the event faster and safer. Another audience could be helping construction companies that could use the Positron rover in order to also help with the driving of the rebar into the frame of the house. Spraying the paint dots on the ground could also help with any planning or blueprints.

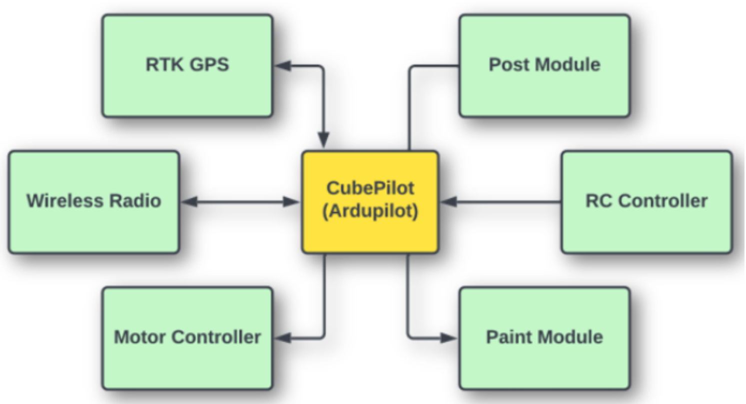

Figure 1: High Level System Diagram

2 Product Description

This section provides the reader with an overview of the Positron rover. The primary operational aspects of the product, from the perspective of end users, maintainers and administrators, are defined here. The key features and functions found in the product, as well as critical user interactions and user interfaces are described in detail.

2.1 Features & Functions

The rover will be able to use the post driving module to be able to drive in any direction, whether this be with the help of the GPS module or with the remote control. Using the pixhawk telemetry radio, we will be able to communicate back and forth with the rover giving us various details about where the rover is moving. The telemetry, RF, and cellular radio would all together in order to make the signal stronger and more precise, ensuring the movement of the rover is more accurate. The spray paint module would include an arm that would be attached to the front of the robot in order to hold the can, and a trigger that would be able to spray the can. The arm could also be used for the rebar module, which is not included with the diagram.

2.2 External Inputs & Outputs

Most of the external data flow would just be between the radio frequencies and the rover. These frequencies would help determine the rover's location, speed, altitude, etc. The GPS locations would also be able to help determine the rover's location, and coordinates that it needs to travel to. The coordinates would help determine the locations that the rover needs to go to in order to complete the tasks at hand. If the GPS option is not used, there is also a remote control that can be used to drive the rover around manually. The remote control would allow the same type of movements for the rover, allowing it to move in any direction that is needed.

2.3 Product Interfaces

Interfaces would include the software that is communicating with the pixhawk and is allowing the user to be able to see the statistics on the rover. The software would be determined at a later date to have a clear picture on what we will have. The second interface that the user would be able to have would just include the remote control for the rover. These controls would include the directional sticks that would move the rover in the direction desired. There are additional buttons on the controller that we hope to map in the future to do a few inputs. Some of these inputs could be changing the speed of the rover, stopping the rover entirely, or making it go to a specific location.

3 Customer Requirements

The Positron Rover is a modular robotic base capable of navigating treacherous and terrain as well as favorable conditions such as, dirt, grass and concrete. The Rover must also be able to be controlled by a remote device allowing a user to manually control the device. The Rover also must be able to perform automated tasks by being capable to navigate to GPS coordinates and perform actions at these locations. The Painting function should be fully automated with no need for user interaction and the Post function may require the use of a human to perform the task of drilling the post into the ground and have the robot only perform the positioning.

3.1 Autonomous Capabilities

3.1.1 Description

The rover shall be able to safely and accurately perform simple tasks and objectives without human intervention such as navigation, obstacle avoidance and usage of modular apparatuses.

3.1.2 Source

Sponsor: Christopher D. McMurrough, Ph.D

3.1.3 Constraints

Accurate autonomous navigation is subject to adequate satellite coverage and range from an RTK station.

3.1.4 Standards

The usage of GPS shall be implemented within the RTCM 10402.3 standard.

3.1.5 Priority

High Priority.

3.2 Manual Capabilities

3.2.1 Description

The rover shall be capable of manual or semi-autonomous control through the use of an RC (Radio Control) remote, supplying the user with critical navigation and on board system data and providing the pilot with a method to direct the robot while protecting it from collisions.

3.2.2 Source

Sponsor: Christopher D. McMurrough, Ph.D

3.2.3 Constraints

This functionality will be available only within range of the RC remote.

3.2.4 Standards

The RC functionality will rely on the LoRaWANÂ® Specification v1.1

3.2.5 Priority

Critical Priority

3.3 Terrain

3.3.1 Description

The rover shall be capable of navigating on many different surfaces, both ideal and non-ideal, such as grass, dirt, and concrete.

3.3.2 Source

Sponsor: Christopher D. McMurrough, Ph.D

3.3.3 Constraints

The rover must be used on Earth not Mars. The rover shall be expected to work on inclines of maximum 25% grade.

3.3.4 Standards

Non applicable for the requirement.

3.3.5 Priority

High priority.

3.4 Paint Module

3.4.1 Description

The rover shall have a removable module capable of spraying lines and dots using a downward firing spray paint can at predetermined location as well as done manually.

3.4.2 Source

Sponsor: Christopher D. McMurrough, Ph.D

3.4.3 Constraints

The rover will be designed to use a downward firing survey spray paint.

3.4.4 Standards

Non applicable for the requirement.

3.4.5 Priority

High Priority.

3.5 Post Driving Module

3.5.1 Description

the rover shall have a removable module capable of inserting a rebar stake into the ground through the aid of a hammer drill.

3.5.2 Source

Sponsor: Christopher D. McMurrough, Ph.D

3.5.3 Constraints

This operation must be performed semi-autonomously at the hands of an assistant to operate an insert the rebar into the ground. The rover will only be responsible for aligning the location.

3.5.4 STANDARDS

Non applicable for the requirement.

3.5.5 PRIORITY

Moderate Priority.

4 Packaging Requirements

In addition to the standard rover requirements Positron will also have several packaging requirements. Positron will be delivered to the customer in an encased form with all parts securely attached. Positron will come with both a remote and laptop control device as well as an RTK tower. These control platforms will come with preconfigured with control software and hardware.

4.1 Positron Packaging

4.1.1 Description

Positron will be delivered to the customer as one rover in an enclosed framework where all parts and components are properly secured to the chassis. The chassis should allow Positron to safely operate in changing envoirnments.

4.1.2 Source

Project Charter

4.1.3 Constraints

Packaging must be sturdy and able to protect Positron from less than optimal enviornments.

4.1.4 Standards

Positron will be delivered to the customer fully functional with the requirements documented here. Packaging will meet rover industry standards for both safety and quality. All software and parts will be used as recommended by the manufacturer.

4.1.5 Priority

High Priority

4.2 Positron Control Devices

4.2.1 Description

Positron will be delivered to the customer with a preconfigured remote control device as well as a laptop equipped for control capabilities. These control devices will be heavily tested and fully functional with Positron upon delivery.

4.2.2 Source

Project Charter

4.2.3 Constraints

Remote control devices must be configured to existing or new rover internal control devices.

4.2.4 Standards

Positron will be delivered to the customer fully functional with the requirements documented here. Control devices will meet rover industry standards for both safety and quality. All software and parts will be used as recommended by the manufacturer.

4.2.5 Priority

High Priority

4.3 Positron RTK Tower

4.3.1 Description

Positron will be delivered to the customer with a preconfigured RTK tower that provides centimeter accuracy to the rover's GPS. This tower will be heavily tested and fully functional with Positron upon delivery.

4.3.2 Source

Project Charter

4.3.3 Constraints

The RTK tower must be configured to existing or new GPS components.

4.3.4 Standards

Positron will be delivered to the customer fully functional with the requirements documented here. The RTK tower will meet rover industry standards for both safety and quality. All software and parts will be used as recommended by the manufacturer.

4.3.5 Priority

High Priority

4.4 Positron Control Software

4.4.1 Description

Positron will be delivered to the customer with preconfigured control software on all control devices as well as the rover and RTK tower. This software will be heavily tested and fully functional upon delivery.

4.4.2 Source

Project Charter

4.4.3 Constraints

Control software can be difficult to port and configure on certain platforms.

4.4.4 Standards

Positron will be delivered to the customer fully functional with the requirements documented here. Control software will meet rover industry standards for both safety and quality. All software and parts will be used as recommended by the manufacturer.

4.4.5 Priority

High Priority

4.5 Positron Decal

4.5.1 Description

Positron will be delivered to the customer with a custom rover logo on its chassis.

4.5.2 Source

Project Charter

4.5.3 Constraints

Decals require extra time and machinery that our team may not have access to.

4.5.4 Standards

Positron will be delivered to the customer fully functional with the requirements documented here. Decals will meet rover industry standards for both safety and quality. All software and parts will be used as recommended by the manufacturer.

4.5.5 Priority

Low Priority

5 Performance Requirements

In addition to standard rover requirements Positron will also have several performance requirements. Positron will be delivered to the customer with the ability to operate at several speeds. Positron will be able to start and stop activities within a specific time frame. Positron will be able to operate for an extended period of time. Positron will be able to locate a position with centimeter accuracy.

5.1 Operational Speed

5.1.1 Description

Positron will be delivered to the customer with the ability to operate at several speeds. Speeds will depend on operator input and no speed will exceed system capabilities. Speed changes will be heavily tested and fully functional upon delivery.

5.1.2 Source

Project Charter

5.1.3 Constraints

Speed can be difficult to balance and control.

5.1.4 Standards

Positron will be delivered to the customer fully functional with the requirements documented here. Speeds will meet rover industry standards for both safety and quality. All software and parts will be used as recommended by the manufacturer.

5.1.5 Priority

High Priority

5.2 Operational Time

5.2.1 Description

Positron will be delivered to the customer with the ability to operate for several hours, but no more than 24 hours straight. Battery life will be heavily tested and fully functional upon delivery.

5.2.2 Source

Project Charter

5.2.3 Constraints

Batteries have a short lifespan and drain quickly.

5.2.4 Standards

Positron will be delivered to the customer fully functional with the requirements documented here. Batteries will meet rover industry standards for both safety and quality. All software and parts will be used as recommended by the manufacturer.

5.2.5 Priority

High Priority

5.3 Setup Time

5.3.1 Description

Positron will be delivered to the customer fully functional and requiring minimum setup. Any setup that Positron will require would consist of delivering the rover to its starting location and powering it on as well as its control devices. All setup will be heavily tested and fully functional upon delivery.

5.3.2 Source

Project Charter

5.3.3 Constraints

Setup and configuration for Positron could be complicated.

5.3.4 Standards

Positron will be delivered to the customer fully functional with the requirements documented here. Setup will meet rover industry standards for both safety and quality. All software and parts will be used as recommended by the manufacturer.

5.3.5 Priority

High Priority

5.4 Startup Time

5.4.1 Description

Positron will be delivered to the customer with the ability to startup right away, however the rover's control devices may require startup time not to exceed 10 minutes. Startup will be heavily tested and fully functional upon delivery.

5.4.2 Source

Project Charter

5.4.3 Constraints

Software and hardware can freeze during boot up.

5.4.4 Standards

Positron will be delivered to the customer fully functional with the requirements documented here. Startup will meet rover industry standards for both safety and quality. All software and parts will be used as recommended by the manufacturer.

5.4.5 Priority

High Priority

5.5 Shutdown Time

5.5.1 Description

Positron will be delivered to the customer with the ability to shutdown right away, however the rover's control devices may require shutdown time not to exceed 10 minutes. Shutdown will be heavily tested and fully functional upon delivery.

5.5.2 Source

Project Charter

5.5.3 Constraints

Software and hardware can freeze during shutdown.

5.5.4 Standards

Positron will be delivered to the customer fully functional with the requirements documented here. Shutdown will meet rover industry standards for both safety and quality. All software and parts will be used as recommended by the manufacturer.

5.5.5 Priority

High Priority

5.6 Location Accuracy

5.6.1 Description

Positron will be delivered to the customer with the ability to find a given location with up to centimeter accuracy. The accuracy of the rover will be heavily tested and operational upon delivery.

5.6.2 Source

Project Charter

5.6.3 Constraints

Centimeter accuracy is difficult to achieve.

5.6.4 Standards

Positron will be delivered to the customer fully functional with the requirements documented here. Accuracy will meet rover industry standards for both safety and quality. All software and parts will be used as recommended by the manufacturer.

5.6.5 Priority

High Priority

6 Safety Requirements

Various safety protocols should be followed while working with the autonomous robot. It includes following the federal or state guidelines, and safety towards interaction with the robot. For the post driving robot, it should not be exposed to toxic chemicals because the batteries used in it can react with other chemicals and can explode, the electrical connection should be grounded to prevent the possible shock, and devices that emit radioactive signals should be kept away from it because it can interfere with the RTK-GPS station.

6.1 Laboratory equipment lockout/tagout (LOTO) procedures

6.1.1 Description

Any fabrication equipment provided used in the development of the project shall be used in accordance with OSHA standard LOTO procedures. Locks and tags are installed on all equipment items that present use hazards, and ONLY the course instructor or designated teaching assistants may remove a lock. All locks will be immediately replaced once the equipment is no longer in use.

6.1.2 Source

CSE Senior Design laboratory policy

6.1.3 Constraints

Equipment usage, due to lock removal policies, will be limited to availability of the course instructor and designed teaching assistants.

6.1.4 Standards

Occupational Safety and Health Standards 1910.147 - The control of hazardous energy (lockout/tagout).

6.1.5 Priority

Critical

6.2 National Electric Code (NEC) wiring compliance

6.2.1 Description

Any electrical wiring must be completed in compliance with all requirements specified in the National Electric Code. This includes wire runs, insulation, grounding, enclosures, over-current protection, and all other specifications.

6.2.2 Source

CSE Senior Design laboratory policy

6.2.3 Constraints

High voltage power sources, as defined in NFPA 70, will be avoided as much as possible in order to minimize potential hazards.

6.2.4 Standards

NFPA 70

6.2.5 Priority

Critical

6.3 RIA robotic manipulator safety standards

6.3.1 Description

Robotic manipulators, if used, will either housed in a compliant lockout cell with all required safety interlocks, or certified as a "collaborative" unit from the manufacturer.

6.3.2 Source

CSE Senior Design laboratory policy

6.3.3 Constraints

Collaborative robotic manipulators will be preferred over non-collaborative units in order to minimize potential hazards. Sourcing and use of any required safety interlock mechanisms will be the responsibility of the engineering team.

6.3.4 Standards

ANSI/RIA R15.06-2012 American National Standard for Industrial Robots and Robot Systems, RIA TR15.606-2016 Collaborative Robots

6.3.5 Priority

Critical

6.4 Safety on operating the batteries

6.4.1 Description

The post-driving robot will use a stick of rebar to drive into the ground at marked locations. The drill attached consumes lots of power to operate which sometimes can create overload and overheat to batteries and finally explode.

6.4.2 Source

Positioning Partners Team

6.4.3 Constraints

It can be avoided by using better batteries which can hold a lot more charge for operating the rebar.

6.4.4 Standards

IEC 60086

6.4.5 Priority

High

6.5 Safety towards the spray paint leakage

6.5.1 Description

The robot will contain an arm that grips a paint can. The robot will localize a pre-determined path and trigger that paint and make a mark in the ground. There is a very minor possibility of getting leakage in the spray paint can. The leakage can create a short circuit in the system.

6.5.2 Source

Positioning Partners Team

6.5.3 Constraints

Frequent observation and use of strong paint grip can used to avoid it.

6.5.4 Standards

N/A

6.5.5 Priority

Low

6.6 Maintain safe distance with the robot

6.6.1 Description

The three laws of robotics [Isaac Asimov, 1942] ensure the robot should not harm human beings at any cost. For the post-driving robot, it needs outdoor testing and people should maintain at least 2-3 feet of distance from the robot for safety towards the possible hazards. For example: while driving the robot, it can go unexpected location due to possible radio input failure.

6.6.2 Source

Society for Laboratory Automation and Screening (SLAS)

6.6.3 Constraints

Demonstration should be done maintaining at least 2-3 feet from the audience.

6.6.4 Standards

N/A

6.6.5 Priority

High

6.7 RTK-GPS station safety

6.7.1 Description

The position reported by a GPS antenna may not be absolute because many factors affect the GPS signal like satellite clock errors, atmospheric interference, and propagation delay.

6.7.2 Source

Larry E. Daniel, Lars E. Daniel

6.7.3 Constraints

Any radio emitting devices should be kept away from the RTK-base station for the possible bad signal accuracy.

6.7.4 Standards

Global Positioning System (GPS) Standard Positioning Service (SPS)

6.7.5 Priority

High

7 Maintenance & Support Requirements

Positioning Partners shall design the rover in a way such that repair and maintenance of the robot shall be easily performed by protecting the device from possible damage, selecting parts that are easy to source and replace, and by supplying proper documentation and source code to allow for adequate troubleshooting and modifications.

7.1 User Manual

7.1.1 Description

The user manual will collect all specification of the product where the system design will be accessible to the end user with a detailed description of parts and their locations, alongside with any software and accessibility.

7.1.2 Source

Sponsor: Christopher D. McMurrough, Ph.D

7.1.3 Constraints

Any legal reasons that will constrain Positioning Partners from releasing design details, including parts of source code.

7.1.4 Standards

Documentation will be provided in the standardized form of *Read the Docs*.

7.1.5 Priority

This has a low priority as this would be needed for the release of the final product.

7.2 Ingress Protection

7.2.1 Description

The rover shall be built such that it sufficiently protects against fine dust and particles from entering sensitive areas. This is so maintenance and cleaning of the rover can be performed without the need of dismantling the robot.

7.2.2 Source

Positioning Partners Team.

7.2.3 Constraints

Within manufacturing and mechanical constraints.

7.2.4 Standards

This will be accomplished by using the IP(IN60529) Ingress Protection standards.

7.2.5 Priority

Moderate Priority.

7.3 Part Replaceability

7.3.1 Description

The rover shall be designed such that all parts are easily sourced from manufacturers allowing for easy upgrade and repair.

7.3.2 Source

Positioning Partners Team.

7.3.3 Constraints

In the event that a product is unable to be sources for a part, one may be created custom given that the part is either sold and supported by Positioning Partners and/or the design for the part is published.

7.3.4 Standards

This will be accomplished using the EN45554 standard.

7.3.5 Priority

High Priority.

8 Other Requirements

This section specifies anything else that is required for the rover to be complete. These requirements are related to the rover architecture/design such as the portability of the rover's software and the modularity of it's hardware functionalities.

8.1 Software Portability

8.1.1 Description

The rover's source code has been tested and only works on Windows 10.

8.1.2 Source

Positioning Partners Team

8.1.3 Constraints

Drivers must be supported for the platform being used at the end user's expense.

8.1.4 Standards

The rover shall follow the ROS 2 standards to ensure all software is portable on different OS platforms.

8.1.5 Priority

Moderate Priority.

8.2 Modularity

8.2.1 Description

The rover shall be designed such that tools can be easily swapped out for others to provide additional functionality.

8.2.2 Source

Positioning Partners Team

8.2.3 Constraints

Modules must fit within a specified size and weight as well as be compatible with the robot's electrical systems.

8.2.4 Standards

The rover will be designed such that it follows EN45554 standard to improve device functionality and environmental impact.

8.2.5 Priority

Moderate Priority.

9 References

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