Team Power Hawks Requirements (Programming & Controls)

Logo Motion Requirements

Prepared

Monday, 31 January 2011

Version 1.0 **FINAL**

Prepared by

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Programming Team Mentors

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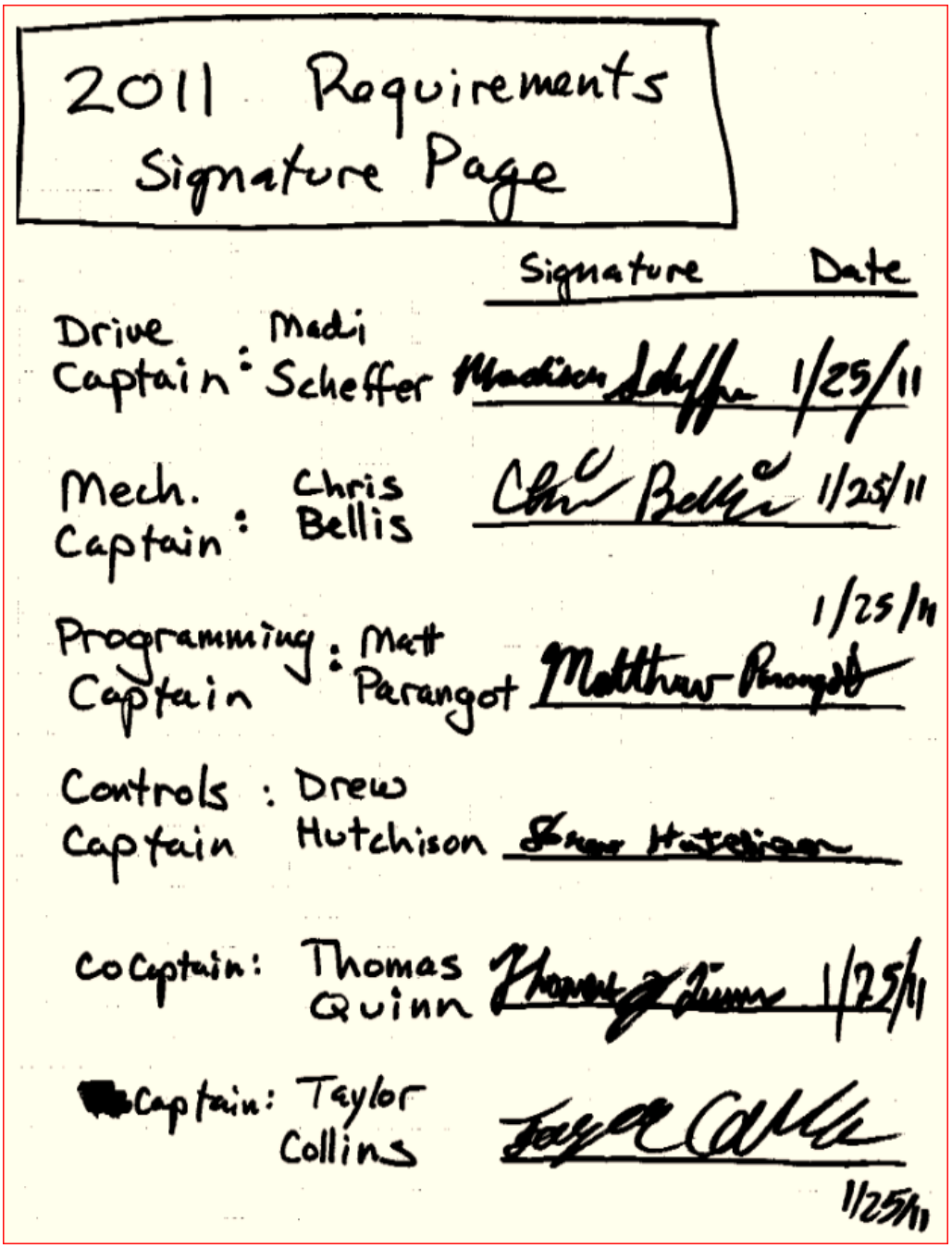
1 TEAM CAPTAINS SIGN OFF SHEET

On Tuesday, January 25, 2011, the various team captains listed below reviewed this document (Version v.03). They were asked to review the document to ensure that their requirements were articulated correctly and correctly received by the Programming and Controls Team Captains. They determined that the requirements, their priorities and the difficulty of achieving the requirement were adequately listed out for future review. Some changes were requested and thus, version v.04 has been produced. They signed the sheet below to indicate their acceptance. Should anyone have a question or issue with how a requirement was met, they should first review this document and then contact any or all of the people listed below.



2011 Requirements Signature Page

		Signature	Date
Drive Captain:	Madi Scheffer	Madison Scheffer	1/25/11
Mech. Captain:	Chris Bellis	Chris Bellis	1/25/11
Programming Captain:	Matt Parangot	Matthew Parangot	1/25/11
Controls Captain:	Drew Hutchison	Drew Hutchison	
CoCaptain:	Thomas Quinn	Thomas Quinn	1/25/11
[redacted] Captain:	Taylor Collins	Taylor Collins	1/25/11

2 REQUIREMENTS EXECUTIVE SUMMARY

This requirements document should be viewed as a contract between the various teams making requests of the Programming & Controls teams and the rest of the sub teams. When requirements are described verbally, they can be misinterpreted, not received correctly, etc. By writing the requirements into a document, both parties, those making the requirements and those fulfilling the requirements (Programming Team and/or Controls Team) can agree on them and then point to this document if and when disagreements occur.

Each requirement should have a designated priority (1, 2 or 3) assigned to it by the team submitting the requirements. Use a "1" to denote something of most importance. If a "1" is used, it should indicate Team Power Hawk's best chance for success if that requirement is fulfilled. A "3" should be used for ideas that would help the team to be successful in competition – but it's okay if it is not accomplished. A "3" would be placed next to "nice to have's". A "2" is the middle ground where it's important for the Programming or Controls team to accomplish, but should be worked on after the "1" requirements are met.

Additionally, each requirement should have a difficulty level assigned to it. The Programming and/or Controls team should review each requirement and assign a difficulty value of 1 to 3 to it. A difficulty value of 1 would indicate that the Programming team believes it will be easy to accomplish. Simple math is applied to create a score of each requirement [PRIORITY x DIFFICULTY = SCORE]. Scores that are low (1, 2, 3) are easiest to obtain according to the Programming team and best for the overall team. Scores that are high (6 or 9) are hardest to obtain and not as of interest to the team giving the requirement. Therefore, the Programming and/or Controls team will focus on the lower scored requirements.

Team Power Hawks is one team. It's structured into the following sub teams ('teams' going forward). The team captains are as follows:

	Sub Team	Sub Team Lead
1.	Programming Team	Matthew Parangot
2.	Drive Team	Madi Scheffer
3.	Mechanism Team	Chris Bellis
4.	Controls Team	Drew Hutchison
5.	Electrical Team	Krysta Rasmussen
6.	CAD Team	Sean Bruegman

The following table breaks requirements into those that come directly from a single sub-team (Drive, Mechanism and Controls) and areas of interest (Camera, Autonomous Period, Teleoperated Period).

Requirement-Type & Description	
DR	Drive Requirements
MR	Mechanism Requirements
KR	Camera Requirements
DC	Driver Game Controller – Controls Requirements
OC	Operator Game Controller – Controls Requirements
BC	Board Controls (Driver Station) – Controls Requirements
AR	Autonomous Period Requirements
TR	Teleoperated Period Requirements
MH	Minibot Requirements

It's expected that only two teams (Drive and Mechanism) are to give requirements to the Programming & Controls teams.

- Drive Requirements (denoted with prefix "**DR**") – The Drive Requirements section defines any requirements upon the Programming or Controls teams in the area of operating (driving) the Robot. No reference to HOW the Robot is to be controlled by the driver station (Driver or Operator) is to be placed in the requirement. The goal in this section is to understand how the wheels, swiveling/stirring, etc., are to work. Additionally, if there are controls or settings on the motors or devices controlling them that are of interest to the Drive Team, they should be documented in the Drive requirements.
- Mechanism Requirements (denoted with prefix "**MR**") – The Mechanism Requirements section defines any requirements upon the Programming or Controls teams in the area of operating the mechanisms themselves. No reference to HOW the mechanism is to be controlled by the driver station (Driver or Operator) is to be placed in the requirement. The goal in this section is to understand how individual mechanisms are to be operated, and what types of systems that power them (motors, pneumatics, etc.). Additionally, if there are controls or settings on the mechanisms or devices controlling them that are of interest to the Mechanism Team, they should be documented in the Mechanism requirements.
- Controls Requirements are broken down into three areas (denoted with prefix "**DC**", "**OC**" & "**BC**") – The Controls Requirements section defines any requirements upon the Programming or Controls teams in the area of how a Controller (Driver or Operator) would control the various mechanisms on the Robot from the driver station. Additionally, if there are indicators, inputs and/or outputs on the Driver Station board, they are to be documented here. Their viewpoint is in reference of controlling the movement of the Robot (Driver) as well as the operation of the various mechanisms (Operator).
    - **NOTE:** The Controls Team must be the advocate of the Driver and Operator of the Robot. Since Drivers and Operators will utilize their controls, the Controls team needs to have a thorough knowledge of how both the Driver and Operator intend to use their controls.

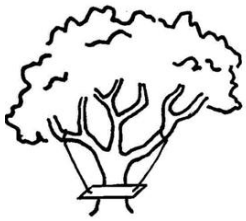
Each requirement has a unique identifier starting with the prefixes given above plus numbers. The idea here is that each team can refer to a specific requirement in verbal discussions, electronic and

otherwise. Please continue to use the unique identifiers as requirements are communicated between teams.

NOTE: Each requirement has a unique identifier. As a result, should a specific requirement be withdrawn, its unique identifier is to stay intact but crossed out and left as part of the document with an explanation of why it was withdrawn.

The following illustration is an example of what occurs when various groups don't communicate their ideas or if one group doesn't listen to its customer. The tree swing picture depicting a tire and rope swing in various states of dysfunctionality, illustrates the pitfalls of poor product design, or poor customer service, and the dangers of failing to properly listen to customers and interpret their needs.

The tree swing also demonstrates the dangers of departmental (read: sub-teams) barriers, and failures of departments to talk to each other, and to talk to customers (i.e. the sub teams giving the requirements).

The various 'thoughts' that each group had envisioned the solution.		**If the customer (Drive, Mech., Controls) wants a 'tree swing', build them a tree swing. Listen! Write it down.**
what marketing suggested	what management approved	as designed by engineering
		
what was manufactured	as maintenance installed it	what the customer wanted
		

3 DR: Drive Requirements

See **Section 1: Requirements Executive Summary** for the explanation of the Priority and Difficulty columns in the table as well as the description for Drive requirements.

NOTE: In 2011, the team determined to use the Mecanum Drive vs. Tank Drive.

NOTE: There are two items that may be of interest to the Programming team. One – Jaguars have jumpers that determine whether motors BRAKE or COAST. Jaguars also have the ability to program this determination at competition time. The Drive and Programming teams determined that the Jaguars are to be set to BRAKE.

NOTE: Each drive motor (or each side) will be outfitted with an Encoder device that allows for the speed of the wheels to be known (as well as figuring out how far the Robot will have rolled in a specific direction).

NOTE: Reference to "Button-11" and "Button-12" may be used here. For Mecanum wheels, ""Button-11" of a Game Controller controls the robot movement without changing orientation of the robot. "Button-12" controls rotation (orientation) of the robot only.

Req.	Priority (1-3)	Difficulty (1-3)	Drive Requirement Descriptions
DR 01	Prio-1	Diff-1	**Drive:** There will be four independent Mecanum wheels. Two on each side. Each one will have its own Jaguar. Controlling of wheels is described in the Control Requirements section.
DR 02	Prio-1	Diff-1	**Drive:** Using the Driver Controls (DC) – robot will drive forward and reverse without changing the orientation of the robot.
DR 03	Prio-1	Diff-1	**Drive:** Using the Driver Controls (DC) – robot will "strafe" to the left and to the right without changing the orientation of the robot. **NOTE: It has been determined that the use of the CAN (Controller Area Network) on the Jaguars may assist with issues in straight lateral movements. Investigation of the CAN network, its use and application in the LabVIEW language is underway.**
DR 04	Prio-1	Diff-1	**Drive:** Using the Driver Controls (DC) – robot will be able to make turns to the left or right.
DR 05	Prio-1	Diff-1	**Drive:** The Robot will stop moving when both driver controls (DC) are not used (engaged).

DR 06	Prio-2	Diff-3	**Drive:** A Gyro chip is to be added to the robot. The Gyro assists with unwanted excess rotation of the robot. See the Driver Controls (DC) section for how the Gyro is to be utilized and initialized. Also see Autonomous Requirements (AR) for its possible use in the Autonomous period.
DR 07	Prio-3	Diff-3	**Drive:** An Accelerometer chip is to be added to the robot. The accelerometer helps in avoiding drift as robot rolls in a straight line by comparing the X,Y angle of Button-11 (left hand joystick) and the X,Y angle of Accelerometer. In Autonomous, Accelerometer will not be used to control the outputs of the Jaguars connected to the Mecanum wheels. In Teleoperated Period, Accelerometer should modify the outputs to the Mecanum wheels when Button-11 (left hand joystick) is engaged by the Driver **NOTE: Use of the CAN network is mentioned in DR 03. The use of the Accelerometer may be another way of assisting with straight lateral movements.** **NOTE: At this time, this requirement is the ONLY requirement that mentions the use of an Accelerometer. It's currently not in any plans to be used for controlling the Drive or Mechanism aspects of the Robot**

4 MR: MECHANISM REQUIREMENTS

See **Section 1: Requirements Executive Summary** for the explanation of the Priority and Difficulty columns in the table as well as the description for Mechanism requirements.

Req.	Priority (1-3)	Difficulty (1-3)	Mechanism Requirement Descriptions
MR 01	Prio-1	Diff-1	**Minibot-Release:** Though not described by this document, some sort of mechanism is need to either (a) release a protective cover of the robot and cause a mechanism to deploy the Minibot to a pole, or (b) to only release a Minibot to the pole. Control of this is described in the Controls section of the document
MR 02	Prio-1	Diff-1	**Elevator:** Will have two motors that act together. Each motor will have its own Jaguar. Jaguars should NOT be controlled by the same connection from Sidecar/cRIO as the motors MAY end up rolling in opposite directions.
MR 03	Prio-2	Diff-2	**Elevator:** At the extreme ends of the elevator, a limit switch is planned to keep the Arm from going too high or too low.
MR 04	Prio-1	Diff-1	**Elevator:** Manual control of the elevator to go up or down will be provided by the Operators controller.
MR 05	Prio-1	Diff-2	**Elevator:** Encoder is necessary on the Elevator motor (just one motor) to allow Programming Team to measure 'height'.
MR 06	Prio-1	Diff-1	**Arm:** Will be controlled by one motor. Manual rotation of Arm up or down will be proved by the Operators controller.

MR 07	Prio-1	Diff-2	**Arm:** An Encoder is needed to assist with measuring the angle of the Arm. The encoder values will be used when any of the preset buttons are pressed. **NOTE:** Programming Captain indicated that the difficulty level is 2 for using the Encoder to acquire an angle of the Arm. However, the difficulty level is 3 for the PID portion of this requirement. In Autonomous, the Encoders will need to be initialized at the beginning of the match. http://en.wikipedia.org/wiki/PID_controller PID: A proportional–integral–derivative controller (PID controller) is a generic control loop feedback mechanism (controller) widely used in industrial control systems – a PID is the most commonly used feedback controller. A PID controller calculates an "error" value as the difference between a measured process variable and a desired setpoint. The controller attempts to minimize the error by adjusting the process control inputs. The PID controller calculation (algorithm) involves three separate parameters, and is accordingly sometimes called three-term control: the proportional, the integral and derivative values, denoted P, I, and D. Heuristically, these values can be interpreted in terms of time: P depends on the present error, I on the accumulation of past errors, and D is a prediction of future errors, based on current rate of change.[1] The weighted sum of these three actions is used to adjust the process via a control element such as the position of a control valve or the power supply of a heating element.
MR 08	Prio-2	Diff-2	**Arm:** The Arm will rotate within the range of two extreme points: Fully Down and Fully Up • Limit switches will be used to prevent Arm from extending past the expected rotation angles. • Limit switch to stop rotation in upward direction when the Fully Up position is acquired • Limit switch to stop rotation in downward direction when the Fully Down position is acquired

MR 09	Prio-1	Diff-2	**Arm / Elevator Combos:** When the robot is placed on the field BEFORE the Autonomous period, the Arm and Elevator positions will be such that they adhere to the rules of the game. Most likely the position will be such that the Arm is pointing inward towards the robot. This will be called the **Pre-Autonomous** position. When the robot is in play, the "normal" position of the Arm will be such that it's pointing outward from the robot. This will be called the **Default-Play** position. The Arm and Elevator starting positions MUST be the same from match to match in order for the Encoder values to be of any use. Before using the value of the Encoders of the Arm and Elevator, move the Arm/Elevator combination from the Pre-Autonomous position to the Default-Play position. Initialize the Encoder values and then proceed with the Autonomous programming.
MR 10	Prio-2	Diff-2	**Arm / Elevator Combos:** There are to be roughly eight preset positions. The Elevator and Arm will go into preset positions in regards to height (Elevator) and angle (Arm). 6-Scoring-Presets: To accommodate the six possible pole positions for the tubes. The required angle (Arm) and height (Elevator) for each position will not be part of this document. These values can be captured during testing and evaluation periods. Ground Catch: Move to the lowest positions for picking up Tubes off the playing field Feeder Slot: Move Arm and Elevator to a position that's easiest for a Human player to place tube into Claw (either type) from the Feeder Slot on the opposite side of the field. Use of the PID controller code will be needed here for improved precision control.

MR 11	Prio-1	Diff-2	**Claw:** Two rollers controlled by two motors will be at the ends of a Claw that allows for four types of actions determined by the Operator: • Catch: Both motors roll in • Release: Both motors roll out • Roll-up: Motors roll in the same direction – counter-clockwise to cause a tube to roll upward • Roll-down: Motors roll in the same direction – clockwise to cause a tube to roll downward
MR 12	Prio-3	Diff-1	**Claw:** Catch-AutoStop: Add limit switch at back of claw to not stop/control a motor. Rather, to set an LED indicator on the Driver Station board to indicate tube is fully acquired. **NOTE:** 3rd Roller with same type of motor as the other two rollers may be used only for rotating the tube up or down. This may be warranted should rotation of the tube with the original two motors causes the tube to accidentally be Released.

5 KR: CAMERA REQUIREMENTS

See **Section 1: Requirements Executive Summary** for the explanation of the Priority and Difficulty columns in the table.

Use of the camera falls into two main camps: Streaming for driving and streaming for Scoring. The priority of the camera is lower than the typical 'must haves' for Drive and Mechanism. However, it's a fairly good addition for difficult maneuvering when the robot cannot be seen by the Driver or Operator clearly to obtain the goal of the moment.

Overall priorities for Camera:

1. Stationary camera mounting should be easiest to accommodate
2. Tilting action (Y-axis) is preferred by the Operator compared to Panning action (X-axis)
3. Panning and Tilting together is desired by the Operator

NOTE: In 2011, the Mechanism Team has decided on an Elevator and Arm portions of their mechanisms. Camera location is likely to be the Elevator. Some thoughts have been to place the camera on the bar that the Arm is connected to the Elevator as another possible location.

Req.	Priority (1-3)	Difficulty (1-3)	Camera Requirement Descriptions
None			**NOTE: This is requirement OC11 in the Board Controls section. It's listed here for 'completeness' of this section on the camera.** **Camera On/Off Button:** Button on operator controller to turn on/off streaming of Camera. Should the camera output prove to lag too much or cause overall control of the robot to be sluggish, a simple button on the driver station should be sufficient to turn it off/on.
KR 01	Prio-2	Diff-1	**Camera:** Streaming: Acquire streaming of camera and output to Classmate in Driver Station.
KR 02	Prio-3	Diff-3	**Camera:** The Camera's "default" position (viewing wise) will be directly in front of the Robot. This is to be considered the center line and/or 0 degrees. This is true for both Pan (X-axis) and Tilt (Y-axis). A button on a game controller or the Control Board will be used to control when this is needed.
KR 03	Prio-3	Diff-3	**Camera:** The Camera will have the ability to TILT 45 degrees up/down on Y-axis.
KR 04	Prio-3	Diff-2	**Camera:** The Camera will be able to PAN 45 degrees on either side of the center line on the X-axis

6 CONTROLS REQUIREMENTS

Controls Requirements are broken down into three areas of Driver, Operator and Board (denoted with prefix of a "**DC**", "**OC**" or **"BC"** respectively**).** The Controls Requirements section defines any requirements upon the Programming and Controls teams in the area of how a Controller (Driver or Operator) would control the Mecanum wheels and the various mechanisms on the Robot from the Driver Station. Control requirements are to be based on interviews of a Driver and Operator of the Robot and how they intend to control it.

As of January 2011, both the Driver and Operator controllers will be Logitech 963292-0403 Dual Action Gamepad.

Driver Controls Quick List:

5, 6: If EITHER button is pressed, reduce robot speed by 50%

5, 6: If BOTH buttons are pressed, reduce robot speed by 75%

8: Disable Gyro while button pressed. Gyro value is to be used for Drive once button is released.

11: Steers robot in direction of tilt – robot orientation stays the same

12: Rotates robot (changes orientation), X-axis only, Y-axis ignored

Operator Quick List:

1: Claw: Catch tube

2: Claw: Angle tube down

3: Claw: Release tube

4: Claw: Angle tube up

5: Arm: Up

6: Elevator: Up

7: Arm: Down

8: Elevator: Down

9: Camera: On / Off

11: Camera: Pan Left / Right and Tilt Up / Down

11 (PRESSED): Resets Camera to "default" position

6.1 DC: Driver Game Controller – Controls Requirements

Where a requirement in another section is addressed by a requirement below, the requirement is placed at the end of the text in bold print.

Req.	Priority (1-3)	Difficulty (1-3)	DRIVER Controls Requirement Descriptions Answers: How is the Driver Controls Laid Out?
DC 01	Prio-1	Diff-1	**Driver Control:** Button-11 will cause the robot (Mecanum wheels) to move in the direction of the tilt of Button-11. **The orientation of the robot will not change.** X-axis and Y-axis are both used. **DR01, DR02, DR03, DR05**
DC 02	Prio-1	Diff-1	**Driver Control:** Button-12 will change the orientation of the robot. It will cause the robot (Mecanum wheels) to rotate in a clockwise or count-clockwise direction. I.e. change the robot's orientation. If Button-11 is NOT engaged, the robot will simply rotate in a circle without leaving the current floor position. Only X-axis is used. Y-axis movement is ignored NOTE: While Button-12 is engaged, constantly reset the Gyro. **DR01, DR04, DR05, DR06**
DC 03	Prio-3	Diff-1	**Driver Control:** Button-5 or Button-6 will cause the Mecanum wheel motors to all run at a reduced voltage. If EITHER button is pressed, power to wheel motors will be reduced 50%. If BOTH buttons are pressed, power to wheel motors will be reduced 75%. When both Button-5 and Button-6 are released, this reduction in voltage will be removed. **DR01**
DC 04	Prio-1	Diff-1	**Driver Control:** Button-8: Disable Gyro while button pressed. Gyro value is to be used for Drive once button is released. **DR06**

6.2 OC: Operator Game Controller – Controls Requirements

Where a requirement in another section is addressed by a requirement below, the requirement is placed at the end of the text in bold print.

Req.	Priority (1-3)	Difficulty (1-3)	OPERATOR Controls Requirement Descriptions Answers: How is Operator Controls Laid Out?
OC 01	Prio-3	Diff-1	**Operator Control:** Button-11 (left hand joystick): Pan and Tilt camera. **KR01, KR03, KR04**
OC 02	Prio-3	Diff-2	**Operator Control:** Button-11-PRESSED (left hand joystick): Return camera to the "default" position. **KR02**
OC 03	Prio-1	Diff-1	**Operator Control:** Button-5: Arm Rotation Rotate Arm upward. Once it's released, the Arm stops movement. **MR06, MR08**
OC 04	Prio-1	Diff-1	**Operator Control:** Button-7: Arm Rotation Rotate Arm downward. Once it's released, the Arm stops movement. **MR06, MR08**
OC 05	Prio-1	Diff-1	**Operator Control:** Button-6: Elevator Movement Move Elevator upward. Once it's released, Elevator stops movement. If Limit Switch is used and it's engaged, then Elevator stops movement. **MR03, MR04**
OC 06	Prio-1	Diff-1	**Operator Control:** Button-8: Elevator Movement Move Elevator downward. Once it's released, Elevator stops movement. If Limit Switch is used and it's engaged, then Elevator stops movement. **MR03, MR04**

OC 07	Prio-1	Diff-1	**Operator Control:** Button-1: Claw Catch tube. Both rollers roll inwards while button is pressed. Once it's released, the rollers stop movement. **MR11**
OC 08	Prio-1	Diff-1	**Operator Control:** Button-2: Claw Angle tube down. Both rollers roll in same direction to cause the tube to roll in the downward direction while button is pressed. Once it's released, the rollers stop movement. **MR11**
OC 09	Prio-1	Diff-1	**Operator Control:** Button-3: Claw Release tube. Both rollers roll outward while button is pressed. Once it's released, the rollers stop movement. **MR11**
OC 10	Prio-1	Diff-1	**Operator Control:** Button-4: Claw Angle tube up. Both rollers roll in same direction to cause the tube to roll in the upward direction while button is pressed. Once it's released, the rollers stop movement. **MR11**
OC 11	Prio-2	Diff-1	**Operator Control:** Button-9: Camera Streaming On/Off Should the camera output prove to lag too much or cause overall control of the robot to be sluggish, a simple button on the driver station should be sufficient to turn it on/off. **KR01**

6.3 BC: Board Control – Controls Requirements

Where a requirement in another section is addressed by a requirement below, the requirement is placed at the end of the text in bold print.

Board Controls represent controls placed on the Drive Station that are not on either the Driver's game controller or the Operator's game controller. In 2011, the driver station controls are documented in "The Arena" document (http://www.usfirst.org/roboticsprograms/frc/content.aspx?id=452). This document details what is allowed in the Player station area:

> **2.2.8 The PLAYER STATIONS**
>
> Attached to the ALLIANCE WALL are three aluminum shelves to support the OPERATOR CONSOLES for the three TEAMS on the ALLIANCE. The support shelf measures approximately 60 inches wide by 12 inches deep. There is a 4-1/2-foot long by two-inch wide strip of Velcro tape ("loop" side) along the center of the support shelf that may be used to secure the OPERATOR CONSOLES to controls the ROBOT. Each setup location includes a competition cable (to provide Ethernet connectivity) that attaches to the Ethernet Port of the OPERATOR CONSOLE. The cable provides communications with the ROBOT. Each setup location also includes a power adaptor cable that may be used to power the Classmate laptops that were provided to teams in 2010 and 2011. Emergency Stop (E-Stop) buttons for each TEAM are located on the left end of each PLAYER STATION shelf. ARENA components (including team number displays, competition arena hardware, alliance lights, control hardware cabinets and clock displays) are also located above the PLAYER STATIONS and below the shelf.

Req.	Priority (1-3)	Difficulty (1-3)	Board Control Requirement Descriptions
BC 01	Prio-1	Diff-1	**Switch**: Minibot / Endgame – There shall be a switch to deploy the Minibot. Switch shall be covered to avoid being accidentally activated **MR01**
BC 02	Prio-3	Diff-2	**Indicator**: (Minibot): When the Teleoperated Period starts, a timer value will be initialized to zero or 120 seconds (determine if you want the counter to count up or down). During the first period of time 1-90 seconds, the RED LED will illuminate (YELLOW and GREEN LED's will not illuminate). From 90-110 second – the YELLOW LED will illuminate and blink while the other two are dark. Lastly, from 110-120 seconds, the GREEN LED will illuminate and blink while the other two are dark.
BC 03	Prio-3	Diff-1	**Indicator**: (Line Sensors): Use of light sensors is predominately used during the Autonomous period. For the Teleoperated Period, it is

considered an additional aid to the driver for the purpose of aligning the robot for scoring when Driver vision of the robot may be impaired.

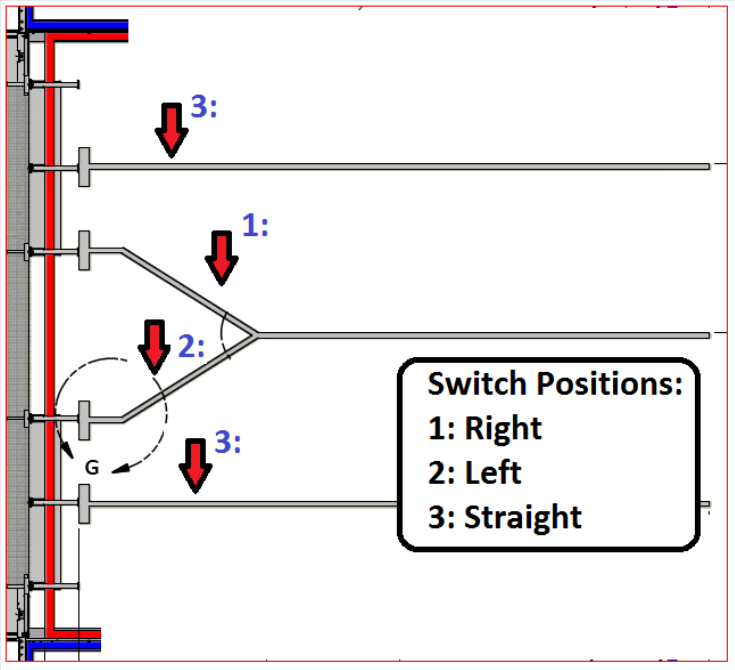
There will be three light sensors on the front of the robot. They are to be referred to as Left, Middle and Right light sensors. The value of each sensor will constantly be monitored. If a line on the floor is observed by any light sensor, the corresponding light sensor on the board will illuminate.

It's best to explicitly show a value at all times. RED LED's will indicate line is not observed. GREEN LED's will indicate that the line is observed by the specific light sensor.

NOTE: Another way to do this is to use a singular color LED and use values of the LED being On or Off. However, there is no difference between a light sensor incorrectly wired or signaling cable dislodged causing an LED to be dark as opposed to it working correctly and no line is observed.

Left	Middle	Right	Indication
Red	Red	Red	No line observed
Green	Red	Red	Robot RIGHT of line
Red	Green	Red	Robot centered on line
Red	Red	Green	Robot LEFT of line

AR04



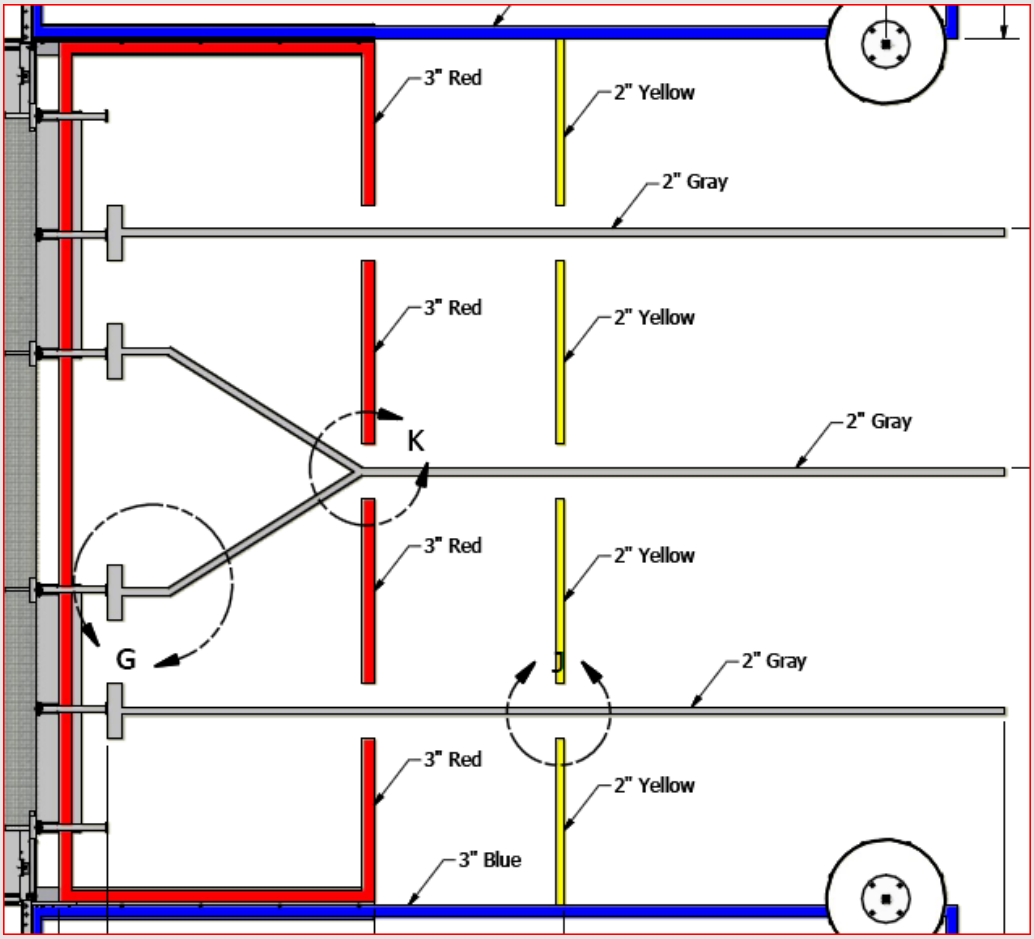
BC 04	Prio-1	Diff-1	**Switch**: Autonomous – Line Selector (3-position-switch) Position Choices: Right / Left / Straight Indicates which type of line to follow on the playing field. If the switch is on "Straight", then a straight line is expected. If the switch is on "Left" or "Right", then the line with the "Y" (divergent path) is expected. **AR04**
BC 05	Prio-1	Diff-1	**Switch**: Autonomous – Scoring Grid Height Selector (3-position-switch) Position Choices: High / Medium / Low Indicates to robot which angle the Arm should be to target for scoring as well as the height of the Elevator. The use of the other Autonomous switch above (BC 04) will cause one of the six pre-determined positions of the Elevator and Arm combinations to be used. **AR03**
BC 06	Prio-2	Diff-1	**Buttons**: Scoring Grid Presets Driver Station will have a diagram of a Scoring Grid (which is composed of three vertical columns, with three horizontal Scoring Pegs attached to each column). Each of the three columns in the diagram will have three buttons to indicate which Scoring Peg to target. The two outer columns will cause the same action for the robot. They are there to assist the Operator under stressful conditions. Two other modifications of this idea are (a) have only two columns on the Driver Station that has buttons on them, or (b) have the buttons on the outer columns be wired in such a way that either button pressed will cause the action to occur. Left Scoring Column: 3 push buttons Middle Scoring Column: 3 push buttons Right Scoring Column: 3 push buttons **MR10**
BC 07	Prio-2	Diff-1	**Button**: Ground Catch When pressed, the Elevator and Arm will move into a preset position that allows the Operator to catch a tube on the ground **MR10**

BC 08	Prio-2	Diff-1	**Button**: Feeder Slot When pressed, the Elevator and Arm will move into a preset position that allows the Operator to catch a tube from the Feeder Slot at the other end of the Playing Field **MR10**
BC 09	Prio-3	Diff-1	**NOTE: See note on next requirement.** **Button:** Feeder Slot Request Button Three buttons are to be setup to indicate which of the types of tubes the Driver/Operator is requesting of the Human player on the far side of the playing field. The three buttons are to represent the Red-triangle, White-circle and the Blue-square. When any of the three buttons are pressed, the corresponding LED on the Board Control will illuminate as well as the "beacon" on the Robot. If the same button is pressed, the LED turns off as well as the "beacon" on the robot. 
BC 10	Prio-3	Diff-1	**NOTE: Students are concerned that this type of requirement MAY be against the rules. This must be verified before work performed on this requirement.** **Indicator:** Feeder Slot Request Beacon LED's on the board will correspond to the color of the beacon on the robot. The three LED's are to represent the Red-triangle, White-circle and the Blue-square. When Teloperated Period starts, the three LED's are to be dark. 
BC 11	Prio-3	Diff-1	**Indicator: Claw Catch Indicator:** An LED will illuminate when the Claw has 'caught' a tube. A limit switch described on MR12 will produce the signal for this LED. **MR12**
BC 12	Prio-2	Diff-1	**Classmate: Camera Streaming Output:** Stream output from the Camera to the Driver Station's Classmate notebook. **KR01**

7 AR: AUTONOMOUS PERIOD REQUIREMENTS

Autonomous Period Requirements (denoted with prefix "**AR**") – The Autonomous Period Requirements section defines any requirements upon the Programming or Controls teams when the Robot is running in autonomous period.

Req.	Priority (1-3)	Difficulty (1-3)	Autonomous Period Requirement Descriptions
AR 01	Prio-1	Diff-2	Initialize Encoders (Drive, Elevator and Arm), and Gyro prior to use in the Autonomous Period.
AR 02	Prio-1	Diff-1	The Robot will operate for the full 15 seconds of the Autonomous Period or until an Ubertube is placed onto targeted Scoring Peg
AR 03	Prio-1	Diff-2	The robot shall determine Scoring Column and Scoring Peg to target based on the two switches on the Controls Board



			Items of interest in regards to tape on ground for tracking purposes: **1. All tape ends under a pole in a "T" fashion. Therefore, in Autonomous mode, it may be that in order to score an Ubertube, the robot may need to reverse a certain distance to place the tube on the rack. In addition, it may be necessary to leave the Arm/Elevator in the Pre-Autonomous position until line tracking finds the end of the tape below the scoring pegs.** **2. Straight lines on the outer tracks are 246.4 inches (~20.5 feet)** **3. The middle line has 159.4 inches (~13.3 feet) of single (straight) tape before it diverges in a "Y" fashion** **The "Y" angle needs to be calculated for proper taping in practice. This will assist with determining how well the line sensors work with various speeds.**
AR 04	Prio-1	Diff-2	Using Light Sensors (and Encoders if its warranted), move robot in a predetermined manner to a Scoring Column/Peg combination based on observing line and distances
AR 05	Prio-1	Diff-2	Based on accomplishing AR 04 above, determine when best to operate Elevator and Arm to position Ubertube onto Scoring Peg. Arm/Elevator may need to move into a scoring position prior to arrive at the "T" in the tape that's directly below the Scoring Peg. Once Ubertube is in a scoring position, release the tube and stop all other robot motion for the duration of the Autonomous period.
AR 06	Prio-1	Diff-2	Move Elevator and Arm into scoring position based on the Autonomous switches on the Driver Station.
AR 07	Prio-1	Diff-2	Robot will score during autonomous mode by placing Ubertube on Scoring Peg.
AR 08	Prio-3	Diff-3	If Camera can be used to target Scoring Column/Peg location via reflective tape, use it to move Robot into scoring position

8 TR: TELEOPERATED PERIOD REQUIREMENTS

Teleoperated Period Requirements (denoted with prefix "**TR**") – The Teleoperated Period Requirements section defines any requirements upon the Programming team when the Robot is running in the Teleoperated period.

Req.	Priority (1-3)	Difficulty (1-3)	Teleoperated Period Requirement Descriptions
TR 01	Prio-1	Diff-2	"Zero Out" Integral portion of the PID algorithm. This is to be performed for the requirements that utilize the PID algorithm. **NOTE: See Mr. Tucker for any questions.**

9 MH: MINIBOT – HANDOFF REQUIREMENTS

Minibot Handoff Requirements (denoted with prefix "**MH**") – Refers to our team's ability to create a Minibot that can be placed onto another team's Robot. Questions arise as to what our team would have to do to accomplish this task for another team to receive the Minibot. The requirements here highlight the assumption that another team doesn't have anything in place to launch a Minibot.

The main issue to overcome is – regardless of how the Minibot would physically be placed onto another team's robot, you must supply them with the ability to 'launch' it. The following requirements are seen as necessary to allow another team to utilize our Minibot.

Req.	Priority (1-3)	Difficulty (1-3)	Minibot-Handoff Requirement Descriptions
MH 01	Prio-3	Diff-3	Driver Station Requirements for OTHER team: 1. Supply them a 'red-mushroom-button', joystick or game controller to plug into their Driver Station setup to be used to deploy the Minibot 2. Must account for driver stations with one controller, as we place an additional controller on their system 3. Must account for driver stations with two controllers, as we place an additional controller on their system 4. Must account for driver stations with three controllers, as we place an additional controller on their system 5. Review the rules for Game-Setup as to what is legal for a driver station to have in regards to devices connected via USB. 6. Also may need to supply a 7-port USB to allow for them to add your device to their setup. The 7-port USB must NOT need (or have) a secondary battery source nor should it need to have a source off the classmate
MH 02	Prio-3	Diff-3	Robot Requirements of the OTHER team: 1. Physically, the Minibot needs to be released. 2. Whatever mechanism is used, it must tie into their cRIO/SideCar setup. 3. Mech team will need to figure this out and hand off to programming for how programming would setup code to be handed off to another team for incorporation.

MH 03	Prio-3	Diff-3	Programming Requirements of the OTHER team: 1. Create three 'sample' code snippets for other teams to incorporate the use of the Red-Button to deploy the Minibot 2. **LabVIEW Snippet**: Must do a sample in LabVIEW that can be on a flash drive to be presented to another team doing their robot code in LabVIEW 3. **C++ Snippet**: Must do a sample in C++ that can be on a flash drive to be presented to another team doing their robot code in C++ 4. **Java Snippet**: Must do a sample in Java that can be on a flash drive to be presented to another team doing their robot code in Java
MH 04	Prio-3	Diff-3	Mechanism Requirement: 1. To hand off a Minibot to another team, the mechanism that would deploy the Minibot would also need to be handed to another team. In that mindset, the deployment mechanism would need to account for robots that would have: a. Height issues in regards to be LOWER than the correct deployment height (between 18 and 30 inches off the ground) b. Height issues in regards to be HIGHER than the correct deployment height.