

## ***Section 0: Introduction***

### **0.0 Get to it!**

The purpose of the 2010 MARS Summer Challenge, “*Cube Capture*,” is to prepare MARS and its students for the 2011 FIRST Robotics Season. It is designed to teach students new skills with special emphasis on knowledge being passed from graduating and current field “experts” to other team members. The Challenge “*Cube Capture*” is engineered in such a way as to promote the development of techniques and skills in areas the MARS is currently weakest in, while still reinforcing the team’s current strengths.

## ***Section 1: Communication***

### **1.0 Resources**

[www.marsfirst.org](http://www.marsfirst.org)

[WVU-FRC-ROBOTICS@listserv.wvu.edu](mailto:WVU-FRC-ROBOTICS@listserv.wvu.edu)

[www.usfirst.org](http://www.usfirst.org)

[www.chiefdelphi.com](http://www.chiefdelphi.com)

## ***Section 2: Organization***

### **2.0 Picking the Competition Teams**

The MARS team will be divided up into 2 approximately equal size and equal capability teams. Each team will compete to win the 2010 MARS Summer Challenge. The method for selecting which students will be on which team will be prescribed by the MARS mentors. Under NO circumstances will all of currently technically savvy MARS students be allowed to be on the same competition team. This means that the skills of the current “experts” (i.e. wiring and programming etc.) will have to be shared among the two competition teams (with an emphasis on the training of new “experts”) as an example of Gracious Professionalism<sup>TM</sup>.

### **2.1 Competition Team Captains**

Each competition team will need one very dedicated MARS student to be a leader in the role of team captain. This student will be responsible for keeping his or her team on track and meeting its goals. Nominations for student team captains are currently be accepted by the MARS mentors. The MARS mentors will prescribe the method by which the team captains will be selected.

### **2.2 The Role of the MARS Mentors**

The MARS mentors will of course be available and ready to offer assistance, however, the MARS 2010 Summer Challenge will primarily be a student-led process.

## ***Section 3: At the Events***

### **3.0 Location**

The *Cube Capture* Competition will take place on the 1<sup>st</sup> floor of Hodges Hall; with possible demonstrations at the Church on North High Street and at other locations.

### **3.1 Date**

The MARS mentors will determine the date of the *Cube Capture* Competition. It will most likely occur in late October, 2010.

### **3.2 Robot Inspection**

All robots must undergo inspection by the MARS mentors before they are allowed to compete in *Cube Capture*.

### **3.3 Team Pit Areas**

Team pit areas will be located in Phil's room. Teams may return to their pit areas in between matches in order to repair their robots.

### **3.4 Safety**

ANSI-certified safety glasses must be worn at all times during the competition (and for that matter during robot construction). Remember, there are **TWO** robots out there, please be aware of your surroundings and pay attention at all times!

### **3.5 Judging**

Judging will be conducted by MARS mentors and possibly volunteers who know little or nothing about MARS or FIRST. It will occur in the team pits, in between and possibly during robot matches. The teams will be judged such areas as CAD quality, wiring/pneumatic cleanliness, safety, and innovation in construction/design and programming techniques.

### **3.6 Gracious Professionalism™**

Gracious Professionalism™ will of course be practiced at all times during the completion and robot build season.

## ***Section 4: Robot Transportation***

### **4.0 Moving your Robots**

Please remember to wear gloves as you safely carry your robot from Phil's room all the way to the Hodges Hall 1<sup>st</sup> floor hallway.

## *Section 5: The Awards*

### 5.0 MARS 2010 Summer Challenge Scoring Rubric

Category:	Point Value:	Points Earned :
<b><i>Cube Capture (Highest-Scoring Match)</i></b>		
Retrieving Cubes	10 x #_____	
Pushing the Box	20	
Penalties	-5 x #_____	
<b>Judging Concentrations</b>		
Machine Appearance (Wiring/Pneumatic Cleanliness, etc.)	1-10	
Quality of CAD	1-10	
Innovative Programming/Control Techniques *	1-10	
Innovative Design Elements *	1-10	
<b>Bonuses</b>		
Lightest Robot	20	
Greatest Attention to Safety	5	
<b>Total</b>		

## Section 6: The Arena

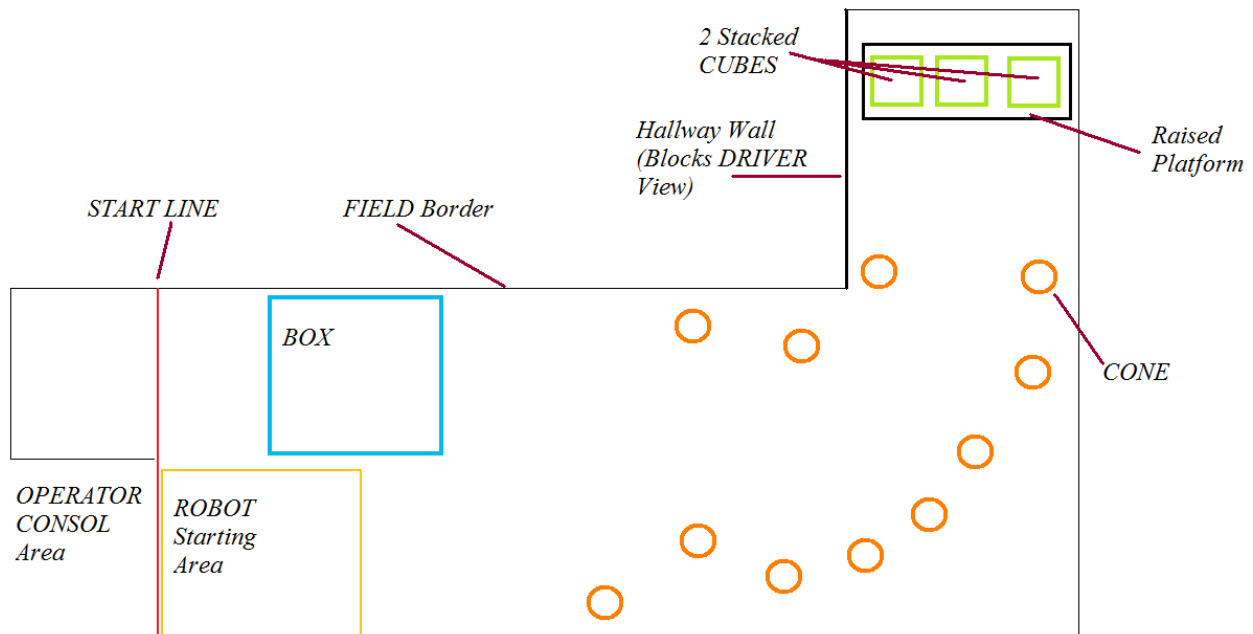
Note: this section is not even remotely finalized, that includes dimensions!

### 6.0 Description of Game Elements

CUBES: Are made out of 1 inch diameter PVC pipe.

BOX: Weighs 50 pounds when empty.

### 6.1 The Field and the Arena



## ***Section 7: The Game***

### **7.0 Overview**

*Cube Capture* is a game played on an L-Shaped, carpeted field. Points are scored by retrieving CUBES and dropping them into a BOX. Additional points are earned if the BOX is moved by the robot across the start line. Robots must avoid CONES or risk losing points.

### **7.1 Match Format**

Each MATCH consists a 2 minute TELEOPERATED PERIOD.

### **7.2 Definitions**

BOX: A heavy container into which CUBES are dropped to score points. It can be pushed across the START LINE for additional points

CONE: An obstacle that if contacted by a ROBOT during a MATCH will cause the TEAM to incur a PENALTY.

CUBE: The primary scoring object which must be returned to the BOX.

FIELD: The L-Shaped course (as defined in *Section 6*) in which the ROBOTS operate during a MATCH.

MATCH: A single iteration of play in which a TEAM attempts to complete the objectives of the *Cube Capture* game during a competition.

PENALTY: A 5-point decrement in the TEAM score assigned when a deserving violation of the game rules has been identified by a Referee.

RED CARD: An indication of disqualification of a TEAM.

REFEREE: A MARS mentor charged with ensuring that all of *Cube Capture's* game rules (*Section 7*) are followed by the TEAMS. Their decisions are Final.

SCORED: Each CUBE in a BOX at the end of a MATCH will contribute points to the TEAM's score. A BOX across the START LINE will also score points for a TEAM.

START LINE: See *Section 6*.

TEAM: The competition teams formed to participate in the 2010 MARS Summer Challenge



(DRIVE) TEAM: Three representatives from a registered competition team that interact with their ROBOT to play *Cube Capture*. Positions on the TEAM include:

COACH: A student designated as the team coach and advisor during the MATCH and Identified as the person wearing the designated "COACH" pin or button. There is one COACH per DRIVE TEAM. Their primary responsibility is to coordinate the actions of the DRIVERS.

DRIVER: A pre-college student team member responsible for operating and controlling the ROBOT. There are two DRIVERS per DRIVE TEAM.

TELEOPERATED PERIOD: The period during a MATCH where the DRIVE TEAM may remotely control their ROBOT.

## 7.3 Rules

### 7.3.0 Safety

<S01> Safe Operation and Design - If at any time a ROBOT'S operation or design is deemed unsafe, the ROBOT will be disabled for the remainder of the MATCH. If the safety violation is due to the ROBOT design, the Head Referee has the option to not allow the ROBOT back onto the FIELD until the design has been corrected. An example of unsafe operation would be uncontrolled motion that cannot be stopped by the DRIVERS. *Violation: PENALTY and Disablement.*

<S02> TEAM Member Safety – For reasons of personal safety, contact with ROBOTS and/or entering the FIELD are prohibited during a MATCH.

a. TEAM members may not directly contact any ROBOT at any time during the MATCH. *Violation: PENALTY and Disablement.*

b. TEAM members may not extend any part of their body into the FIELD during the MATCH. *Violation: PENALTY.*

<S03> E-Stop - An Emergency Stop (E-Stop) button is located on each TEAM'S OPERATOR CONSOL. Pressing an E-Stop button will cause the TEAM'S ROBOT to be disabled for the remainder of the MATCH. The E-Stop buttons are intended for remote shut down during a MATCH in the event of safety hazards and will not otherwise affect MATCH score or duration. Any TEAM member or referee may press the E-Stop button. *Violation: Inappropriate use of the E-Stop button (i.e. not for safety reasons) will result in a RED CARD.*

<S04> Permitted ROBOTS - Any ROBOT used during a MATCH must be in compliance with all Robot Rules (as defined in Section 8). *Violation: RED CARD.*

### 7.3.1 Game Play

<G01> ROBOTS must start the MATCH against the vertical projection of the START LINE and in their STARTING CONFIGURATION.

<G02> Each MATCH begins with the BOX 5 feet from the START LINE.

<G03> Each MATCH begins with 6 CUBES stacked in 3 columns, each 2 CUBES tall. All 3 columns elevated 1 foot off of the FIELD.

<G04> Each CUBE supported by (touching only) the BOX at the end of the MATCH will score the TEAM 10 points.

<G05> If the BOX is completely across the START LINE at the end of the MATCH the TEAM will receive an additional 20 points.

<G06> The BOX must be supporting at least 1 CUBE at the end of the MATCH in order for points to be received for moving it across the START LINE.

<G07> In order for the ROBOT to reach the columns of CUBES it must travel through an obstacle course defined by traffic CONES (as described in **Section 6**). Every time that a ROBOT contacts a CONE during a MATCH, the TEAM will be assigned a PENALTY.

<G08> If a ROBOT contacts any area outside the vertical projection of the FIELD as defined by **Section 6**, a PENALTY will be assigned.

<G09> The minimum final score for a match is zero.

<G10> Points for a MATCH will be assessed 10 seconds after the end of the TELEOPERATED PERIOD or until all objects in motion have come to rest, whichever comes first.

<G11> Issuance of a RED CARD will result in zero points for the violating TEAM for that MATCH.

<G12> DRIVE TEAM Starting Positions – Prior to the MATCH, all members of the DRIVE TEAM must be standing behind the STARTING LINE and facing their Players Station.

<G13> ROBOT Alignment Devices - Alignment devices (templates, tape measures, laser pointers, etc.) that are not part of the ROBOT may not be used to assist with positioning the ROBOT. *Violation: TEAMS that use external alignment devices to position their ROBOT will have their ROBOT arbitrarily repositioned by a referee before the start of the MATCH.*

<G12> FIELD Equipment - Other than the CUBES, BOX and competing ROBOT, no other items shall be placed on the FIELD prior to or during the MATCH. *Violation: RED CARD.*

<G13> ARENA Interaction – With the exception of the CUBES and the BOX, ROBOTS may NOT grab, grasp, grapple, attach to, push or react against any elements of the ARENA . *Violation: A warning will be issued when a ROBOT violates this rule. If the referee determines that the TEAM is disregarding the warning, their ROBOT will be disabled for the remainder of the MATCH.*

<G14> ROBOT ARENA Entanglement - ROBOTS that become entangled in the ARENA elements will not be freed until after the MATCH has finished. *No PENALTY will be assigned.*

<G15> ARENA Damage - ROBOTS may not damage any part of the ARENA, CUBES or the BOX. For ROBOTS that violate this rule, the competition team may be required to take corrective action (such as eliminating sharp edges, removing the damaging MECHANISM, and/or re-inspection) before the ROBOT will be allowed to compete in subsequent MATCHES. *Violation: Potential Disablement if the Head Referee determines that further damage is likely to occur.*

<G16> Detaching MECHANISMS - ROBOTS may not intentionally detach parts or leave MECHANISMS on the FIELD. *Violation: PENALTY for each incident and potential RED CARD if the competition team has been previously warned by the Head Referee.*

### **7.3.2 Drive Team Member Actions**

<G17> TEAM Members in ARENA – Each DRIVE TEAM shall have no more than the three designated members during a MATCH. *Violation: Any TEAM with additional personnel in the ARENA must have the additional personnel to leave the area before the MATCH may proceed.*

<G18> DRIVERS Operating ROBOTS - During a MATCH, the OPERATOR CONSOLE shall be operated solely by the DRIVERS. *Violation: Disablement and RED CARD.*

<G19> Respect and Professional Demeanor - MARS competitions promote respect and professional demeanor. While in the ARENA, including before and after a MATCH, DRIVE TEAM members must be civil towards competition personnel, other competition teams, and event attendees. *Violation: Potential RED CARD. TEAMS will not receive MATCH PENALTIES for off-field actions; however designated event personnel will hold them accountable for their off-field actions.*

### **7.3.3 Referee Interactions**

**<G20>** REFEREE Discussions - Any discussions regarding calls, rules, scores, or penalties must be between a pre-college student member of the Drive TEAM and the Head Referee.

## Section 8: The Robot

### 8.0 Conventions

Specific methods are used throughout this section to highlight warnings, cautions, key words or phrases. The intent is to alert the reader to important information designed to help teams in constructing a robot that complies with the rules in a safe and workmanlike manner.

Key words that have a particular meaning within the context of the 2010 FRC are defined and indicated by ALL CAPITAL letters throughout this text. References to other sections of the manual appear in ***bold italics***. References to specific rules within the manual are indicated with a bracketed reference to the rule (e.g. “Rule <S01>”). Operating keys, controls, buttons appear in bold capital letters (e.g. **OFF/ON** switch).

Warnings, cautions, and notes appear in blue boxes. These notes are intended to provide insight into the reasoning behind a rule, helpful information on understanding and interpreting a rule, and/or possible “best practices” for use when implementing systems affected by the rule. These notes are not part of the formal rules, and do not carry the weight of a rule (if there is an inadvertent conflict between a rule and a note, the rule applies). However, it is strongly recommended that you pay close attention to their contents.

### 8.1 Definitions

**COMPONENT** – A ROBOT part in its most basic configuration, which cannot be disassembled without damaging or destroying the part, or altering its fundamental function.

- Example 1: raw aluminum stock, pieces of steel, wood, etc., cut to the final dimensions in which they will be used on the ROBOT, would all be considered components. Bolting pieces of extruded aluminum together as a ROBOT frame would constitute a MECHANISM, and the collection of pieces would not be considered a COMPONENT.
- Example 2: a COTS (see immediately below) circuit board is used to interface to a sensor on the ROBOT, and it includes the circuit board and several electrical elements soldered to the board. The board is considered a COMPONENT, as this is the basic form in which it was purchased from the vendor, and removing any of the electrical elements would destroy the functionality of the board.

**COTS** – A “Commercial, Off-The-Shelf” COMPONENT or MECHANISM, in its unaltered, unmodified state. A COTS item must be a standard (i.e. not custom order) part commonly available from the VENDOR, available from a non-team source, and available to all teams for purchase.

- Example 1: a team orders two robot grippers from RoboHands Corp. and receives both items. They put one in their storeroom and plan to use it later. Into the other, they drill “lightening holes” to reduce weight. The first gripper is still classified as a COTS item, but the second gripper is now a “custom part” as it has been modified.
- Example 2: a team obtains openly available blueprints of a drive component commonly available from Wheels-R-Us Inc. and has local machine shop “We-Make-It, Inc.” manufacture a copy of the part for them. The produced part is NOT a COTS item, because it is not commonly carried as part of the standard stock of We-Make-It, Inc.
- Example 3: a team obtains openly available design drawings from a professional publication during the pre-season, and uses them to fabricate a gearbox for their ROBOT during the build period

following kick-off. The design drawings would be considered a COTS item, and may be used as “raw material” to fabricate the gearbox. The finished gearbox itself would be a **FABRICATED ITEM**, and not a COTS item.

**DRIVER STATION** - The collection of the Classmate PC, FirstTouch I/O Module and breadboard provided in the KOP, E-Stop Button, and a USB hub (either the one provided in the KOP, or a team-supplied USB hub device).

**FABRICATED ITEM** – Any **COMPONENT** or **MECHANISM** that has been altered, built, cast, constructed, concocted, created, cut, heat treated, machined, manufactured, modified, painted, produced, surface coated, or conjured partially or completely into the final form in which it will be used on the **ROBOT**.

- Example 1: A piece of extruded aluminum has been ordered by the team, and arrives in a 20-foot length. To make it fit in their storage room, the team cuts it into two ten-foot lengths. These would not be considered **FABRICATED ITEMS**, as they have not been cut to the final length in which they will be used on the **ROBOT**.
- Example 2: A team designs an arm mechanism that uses gears with a half-inch face width. They order a 12-inch length of gear stock and cut it into precise half-inch slices. They do not bore out the mounting bores in the center of the gears. The slices are now considered **FABRICATED ITEMS**, as the final fabrication process has started, even though all the machining operations (the center bore) may not yet be completed.

**KIT OF PARTS (KOP)** – The collection of items listed in the **2010 Kit Of Parts Checklist** (provided on line at <http://www.usfirst.org/community/frc/content.aspx?id=452>). For rookie teams, all of these items will be provided to them by *FIRST* at the FRC Kick-off. For veteran teams, some of these items will be provided by *FIRST* and some must be either retrieved from previous **ROBOTS** or purchased separately. For the purposes of these rules, the 2010 versions of all of the items listed in the **2010 Kit Of Parts Checklist** will be considered “in the 2010 Kit” regardless of the method of acquisition.

**MECHANISM** – A COTS or custom assembly of **COMPONENTS** that provide specific functionality on the **ROBOT**. A **MECHANISM** can be disassembled (and then reassembled) into individual **COMPONENTS** without damage to the parts.

**OPERATOR CONSOLE** – the **DRIVER STATION** devices, and any associated equipment, control interfaces, display systems, structure, decorations, etc. used by the **DRIVERS** to operate the **ROBOT**.

**PLAYING CONFIGURATION**- The physical configuration and orientation of the **ROBOT** during a **MATCH**.

**REPLACEMENT PARTS** – A **COMPONENT** or **MECHANISM** constructed as a functional duplicate of an existing part of the **ROBOT**, for the purpose of replacing a broken or defective part. **REPLACEMENT PARTS** may be either COTS items or **FABRICATED ITEMS**. They must be functionally identical to the original part but can be modified to provide more robust performance of the function.

- Example 1: A lever arm made of polycarbonate on your **ROBOT** breaks. You manufacture a **REPLACEMENT PART** made of aluminum plate, using the design drawings of the original. As the new part provides the same function as the broken part, the new part is a valid **REPLACEMENT PART**.

- Example 2: A sensor on the ROBOT is connected to the control system with 24 AWG single-strand wire, and runs across a hinged joint. The flexing of the wire causes it to break, and you want to replace it with 18 AWG multi-strand wire. If the new wire follows the same path as the original and connects only the same devices, then it is a valid REPLACEMENT PART (i.e. it has added robustness without changing function). But if the wire is then used to connect an additional sensor to the same circuit, it is providing a functionally different capability, and is no longer a “replacement.”

ROBOT - A FRC ROBOT is a remotely operated vehicle designed and built by a FRC team to perform specific tasks when competing in the 2010 MARS Summer Challenge “*Cube Capture*.” The ROBOT must include all the basic systems required to be an active participant in the game – power, communications, control, mobility, and actuation. The ROBOT implementation must obviously follow a design approach intended to play the 2010 MARS Summer Challenge (e.g. a box of unassembled parts placed on the FIELD, or a ROBOT designed to play a different game, would not satisfy this definition).

PARE PARTS – A COMPONENT or MECHANISM constructed as an identical duplicate of an existing part of the ROBOT, for the purpose of replacing a broken or defective part. SPARE PARTS may be either COTS items or FABRICATED ITEMS, but they must be physically and functionally identical to the original part.

UPGRADE PARTS - A COMPONENT or MECHANISM intended to provide additional functionality not currently available on the ROBOT. UPGRADE PARTS may be COTS items or custom FABRICATED ITEMS, and may either add to or replace existing functionality.

- Example 1: A ROBOT is designed with a four-wheel drive system. The system works well on flat floors, but high-centers when trying to drive up the BUMPS. The team adds two more wheels on the centerline of the ROBOT to prevent this problem, and the wheels are identical to those already on the ROBOT. The new wheels would be considered UPGRADE PARTS even though they are the same as the ones already in place, as they alter the functionality of the ROBOT and provide new capability.

STARTING CONFIGURATION – The physical configuration and orientation of the ROBOT when the MATCH is started. This is the state of the ROBOT immediately before being enabled by the Field Management System, before the ROBOT takes any actions, deploys any mechanisms, or moves away from the starting location.

VENDOR – A legitimate business source for COTS items that satisfies all of the following criteria:

- A. The VENDOR must have a Federal Tax Identification number. The Federal Tax Identification number establishes the VENDOR as a legal business entity with the IRS, and validates their status as a legitimate business. In cases where the VENDOR is outside of the United States, they must possess an equivalent form of registration or license with the government of their home nation that establishes and validates their status as a legitimate business licensed to operate within that country.
- B. The VENDOR shall not be a “wholly owned subsidiary” of a team or collection of teams. While there may be some individuals affiliated with both a team and the VENDOR, the business and activities of the team and VENDOR must be completely separable.
- C. The VENDOR must be normally able to ship any general (i.e., non-*FIRST* unique) product within five business days of receiving a valid purchase request. It is recognized that certain unusual circumstances (such as 1,000 *FIRST* teams all ordering the same part at once from the same

VENDOR) may cause atypical delays in shipping due to backorders for even the largest VENDORS. Such delays due to higher-than-normal order rates are excused.

- D. The business should maintain sufficient stock or production capability to fill teams orders within a reasonable period during the build season (less than 1 week). Note that this criterion may not apply to custom-built items from a source that is both a VENDOR and a fabricator. For example, a VENDOR may sell flexible belting that the team wishes to procure to use as treads on their drive system. The VENDOR cuts the belting to a custom length from standard shelf stock that is typically available, welds it into a loop to make a tread, and ships it to a team. The fabrication of the tread takes the VENDOR two weeks. This would be considered a FABRICATED ITEM, and the two weeks ship time is acceptable. Alternately, the team may decide to fabricate the treads themselves. To satisfy this criterion, the VENDOR would just have to ship a length of belting from shelf stock (i.e. a COTS item) to the team within five business days and leave the welding of the cuts to the team.
- E. The VENDOR makes their products available to all FRC teams. VENDORS must not limit supply or make a product available to just a limited number of FRC teams.

## 8.2 ROBOT RULES

These rules establish the global ROBOT construction and performance constraints dictated by the characteristics of the provided KOP, along with the size and weight design limits. **Compliance with the rules is mandatory, and is the responsibility of every team! Any ROBOT construction not in compliance with the rules (as determined at inspection) must be rectified before a ROBOT will be allowed to compete.**

When constructing the ROBOT, the team is allowed to use the items in the *2010 KOP Checklist* and additional materials. Many of the rules listed below explicitly address what and how parts and materials may be used. There are many reasons for the structure of the rules, including safety, reliability, parity, creation of a reasonable design challenge, adherence to professional standards, impact on the competition, compatibility with the KOP, etc. When reading these rules, please use technical common sense (engineering thinking) rather than “lawyering” the interpretation and splitting hairs over the precise wording in an attempt to find loopholes. Try to understand the reasoning behind a rule.

However, COTS items that have been specifically designed as a solution to part of the FRC challenge may or may not fit within the FRC intent, and must be carefully considered. If the item provides general functionality that can be utilized in any of several possible configurations or applications, then it is acceptable (as the teams will still have to design their particular application of the item). However, COTS items that provide a complete solution for a major ROBOT function (e.g. a complete manipulator assembly, pre-built pneumatics circuit, or full mobility system) that require no effort other than just bolting it on to the ROBOT are against the intent of the competition, and will not be permitted.

In addition, another intent of these rules is to have all energy sources and active actuation systems on the ROBOT (e.g. batteries, compressors, motors, servos, cylinders, and their controllers) drawn from a well-defined set of options. This is to ensure that all teams have access to the same actuation resources, and to ensure that the inspectors are able to accurately assess the legality of a given part.

### 8.2.1 Safety & Damage Prevention

<R01> Energy used by FRC ROBOTS, (i.e., stored at the start of a MATCH), shall come only from the following sources:

- A. Electrical energy derived from the onboard 12V battery (see Rule <R40> for specifications and further details).



- B. Compressed air stored in the pneumatic system, stored at a maximum pressure of 120 PSI in no more than four Clippard Instruments tanks. Extraneous lengths of pneumatic tubing shall not be used to increase the storage capacity of the air storage system.
- C. A change in the altitude of the ROBOT center of gravity.
- D. Storage achieved by deformation of ROBOT parts.

Teams must be very careful when incorporating springs or other items to store energy on their ROBOT by means of part or material deformation. A ROBOT may be rejected at inspection if, in the judgment of the inspector, such items are unsafe

**<R02>** ROBOT parts shall not be made from hazardous materials, be unsafe, or cause an unsafe condition. Items specifically PROHIBITED from use on the ROBOT include (but are not limited to):

- A. Shields, curtains, or any other devices or materials designed or used to obstruct or limit the vision of any DRIVERS and/or COACHES and/or interfere with their ability to safely control their ROBOT
- B. Speakers, sirens, air horns, or other audio devices that generate sound at a level sufficient to be a distraction or hindrance affecting the outcome of a MATCH
- C. Any devices or decorations specifically intended to jam or interfere with the remote sensing capabilities of another robot, including vision systems, acoustic range finders, sonars, infrared proximity detectors, etc.(e.g. including imagery on your robot that, to a reasonably astute observer, mimics the VISION TARGET)
- D. Exposed lasers of any type (COTS devices with completely enclosed integral lasers, such as a laser ring gyro, are permitted)
- E. Flammable gasses
- F. Any devices intended to produce flames or pyrotechnics
- G. Materials that out-gas noxious or toxic gasses
- H. Materials that produce hazardous inhalable particles
- I. Caustic chemicals
- J. Hydraulic fluids or hydraulic components

Teams should provide MSD Sheets for any materials they use that might be considered questionable during ROBOT inspection.

**<R03>** Custom circuits and COTS electronics are expressly PROHIBITED if they:

- A. Interfere with the operation of other ROBOTS.
- B. Directly affect any output devices on the ROBOT, such as by directly powering a motor, supplying a PWM signal directly to a speed controller or supplying a control signal directly to a relay module (see Rules <R63> and <R64> for the specific exception regarding CAN-bus devices).

**<R04>** Protrusions from the ROBOT shall not pose hazards to GAME PIECES or people. If the ROBOT includes protrusions that form the “leading edge” of the ROBOT as it drives, and are less than one square inch in surface area, it will invite detailed inspection. For example, forklifts, lifting arms, grapples, etc. may be carefully inspected for these hazards.

Note: inspectors will be looking for sharp corners and edges that could cause injury, pinch points, entanglement hazards, and impaling projections. Please mitigate all such hazards. This is for the protection of team members and field personnel as well as game equipment.

<R05> Exterior or exposed surfaces on the ROBOT shall not present undue hazards to the team members, event staff or GAME PIECES. Reasonable efforts must be taken to remove, mitigate, or shield any sharp edges, pinch points, entanglement hazards, projectiles, extreme visual/audio emitters, etc. from the exterior of the ROBOT. All points and corners that would be commonly expected to contact a Game Piece should have a minimum radius of 0.125 inches to avoid becoming a snag/puncture hazard. All edges that would be commonly expected to contact a Game Piece should have a minimum radius of 0.030 inches. All of these potential hazards will be carefully inspected.

<R06> MECHANISMS or COMPONENTS on the ROBOT shall not pose obvious risk of entanglement. If the structure of a COMPONENT permits easy penetration by an object less than four square inches in cross section, it will invite detailed inspection. Willful entanglement actions are addressed *in Section 7*.

Note: Nets, loose rope or wire, voluminous sheets of fabric, etc. may be carefully inspected for these hazards. A  $\frac{1}{8}$ " x  $\frac{1}{8}$ " tight-mesh net (or very loose mesh fabric, depending on your point of view) may be a reasonable material that would not automatically pose an entanglement hazard. However, any flexible material has the potential to become an entanglement hazard if it is not firmly attached to an appropriate structure or left in a loose, voluminous configuration. Therefore, you must use your best judgment to determine if your particular use of the material will pose an entanglement hazard. However, actual performance on the playing field will determine if the potential for entanglement is significant or not.

<R07> ROBOT wheels, tracks, and other parts intended to provide traction on the carpet may be purchased or fabricated ("traction devices" include all parts of the ROBOT that are designed to transmit any propulsive and/or braking forces between the ROBOT and the FIELD). In no case will traction devices that damage the carpet or other playing surfaces be permitted. Traction devices shall not have surface features such as metal, sandpaper, hard plastic studs, cleats, or other attachments. Anchors (i.e. devices that are deployed/used to keep one's ROBOT in one place and prevent it from being moved by another ROBOT) shall not use metal in contact with the carpet to "stay put." Gaining traction by using adhesives or Velcro-like fastener material is not allowed.

### 8.2.2 General Robot Design

<R08> Each registered FRC team can enter ONE (1) ROBOT into the 2010 MARS Summer Challenge.

<R09> During the MATCH, the ROBOT will assume one of two operating configurations. When in each configuration, the ROBOT shall fit within the limits shown below (note: these limits are defined in reference to the ROBOT, not the FIELD).

	Maximum Horizontal Dimensions	Maximum Height	Maximum Weight
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STARTING CONFIGURATION	Rectangular space no more than 28 inches (71.12cm) by 38 inches (96.52cm)	60 inches (152.40cm)	120 pounds (54.43Kg)
NORMAL CONFIGURATION	84 inch (213.4cm) diameter vertical right cylindrical volume	90 inches (243.8cm)	120 pounds (54.43Kg)

A. Exception: solely for the purposes of determining compliance with the weight and volume limitations, these items are NOT considered part of the ROBOT and are NOT included in the weight and volume assessment:

- The 12V battery and its associated half of the Anderson cable quick connect/disconnect pair (including no more than 12 inches of cable per leg, the associated cable lugs, connecting bolts, and insulating electrical tape),

<R10> When determining weight, the basic ROBOT structure and all elements of all additional mechanisms that might be used in different configurations of the ROBOT shall be weighed together. Included in the weight limit are the robot control system, decorations, and all other attached parts.

- Example: A team has decided to design their ROBOT such that, before any given MATCH, they may change the configuration of the ROBOT based on perceived strengths or weaknesses of an opponent. The team accomplished this by constructing a basic drive train platform plus two versions of a GAME PIECE manipulator, each manipulator being a quick attach / detach device such that either one or the other (but not both) may be part of the ROBOT at the beginning of a MATCH. Their ROBOT platform weighs 107 lb, version A of the manipulator weighs 6 lb, and version B weighs 8 lb. Although only one version will be on the ROBOT during a MATCH, both manipulators (and all components of the manipulators that would be used during the MATCH) must be on the scale along with the ROBOT platform during weigh in. This would result in a **rejection** of the ROBOT because its total weight comes to 121 lb.

<R11> When positioned on the ROBOT, the primary battery must be secured so that it will not dislodge should the ROBOT be turned over or placed in any arbitrary orientation.

## 8.2.3 Material Utilization

<R12> Lubricants may be used only to reduce friction within the ROBOT. Lubricants shall not be allowed to contaminate the FIELD or other ROBOTS.

## 8.2.4 Power Distribution

<R13> The only legal primary source of electrical energy on the ROBOT during the competition is one MK ES17-12 12VDC non-spillable lead acid battery, OR one EnerSys NP 18-12 battery, as provided in the 2010 KOP. Teams may use other equivalent 12V batteries during development, testing and practice MATCHES. However, during competition MATCHES only one MK ES17-12 battery OR one EnerSys NP 18-12 battery can be used on the ROBOT.

<R14> An automatic battery charger rated for a maximum of 6 amperes must be used to charge the supplied batteries. When recharging the KOP batteries, either the charger provided by *FIRST* or an automatic charger with an equivalent charging current rating may be used.

<R15> Items specifically PROHIBITED from use on the ROBOT include:

- A. Any battery other than, or in addition to, the one primary battery permitted by Rule <R40>.
- B. Circuit breakers used on the Power Distribution Board that are different from the Snap Action breakers provided in the KOP,
- C. Power distribution panels and/or fuse panels different other than the single Power Distribution Board provided in the 2010 KOP,
- D. Motor speed controllers other than Innovation First, Inc. “Victor 884” speed controllers or Luminary Micro/Texas Instruments “Jaguar” (MDL-BDC or MDL-BDC24) speed controllers,
- E. Relay modules other than Innovation First, Inc. Spike relays,
- F. Aluminum or other non-copper wiring.

<R16> All wiring and electrical devices, including all control system components, shall be electrically isolated from the ROBOT frame. The ROBOT frame must not be used to carry electrical current (e.g. this is necessary due to polarity reversals that occur under certain operating conditions such as during motor direction reversals).

The chassis for the cRIO-FRC and the supplied KOP camera have grounded enclosures. Under this rule (and for their protection), it is REQUIRED that they be electrically isolated from the ROBOT frame when installed on the ROBOT.

<R17> The 12V battery, the main 120-amp circuit breaker, and the Power Distribution Board shall be connected as follows:

- A. The battery must be connected to the ROBOT power system through the use of the Anderson Power Products (APP) connector.
- B. The APP connector must be attached to the battery with either the copper lugs provided in the BURNDY Bag or appropriately-rated and -sized lug connectors.
- C. The battery terminals and the connecting lugs must be insulated with shrink tubing and/or electrical tape.
- D. The main 120-amp circuit breaker must be directly connected to the hot (+) leg of the ROBOT-side APP connector. Only one 120 amp main circuit breaker is allowed. This breaker must not be bypassed.
- E. The Power Distribution Board must be directly connected to the APP connector and main 120-amp circuit breaker. No other loads may be connected to the main 120-amp circuit breaker.
- F. Each primary power connection between the battery and Power Distribution Board must be made with 6 AWG red and black wire or larger
- G. The 120-amp circuit breaker must be quickly accessible from the exterior of the ROBOT. It is recommended that the 120-amp circuit breaker location be clearly and obviously labeled to permit it to be easily found by field personnel during a MATCH.
- H. The Power Distribution Board and all circuit breakers must be easily visible for inspection at each FRC event.

**<R18>** All electric power utilized by the ROBOT shall be distributed from the load terminals of the Power Distribution Board. Circuits may not bypass the Power Distribution Board to connect directly to the 120-amp loop.

- A. The cRIO-FRC power input must be connected to the 24 Vdc supply terminals on the Power Distribution Board. With the exception of one Solenoid Breakout Board, no other electrical load can be connected to these terminals.
- B. The Linksys Wireless Bridge power feed must be connected to the marked 12 Vdc supply terminals located at the end of the Power Distribution Board (i.e. the terminals located between the indicator LEDs, and not the main WAGO connectors along the sides of the Power Distribution Board). No other electrical load can be connected to these terminals.
- C. If a 5V camera is used (such as the KOP camera), the camera power feed must be connected to the 5 Vdc supply terminals on the Power Distribution Board.
- D. All other branch circuits must connect to, and have power sourced solely by, a protected 12 Vdc WAGO connector pair on the Power Distribution Board.
- E. Only one wire shall be connected to each WAGO connector on the Power Distribution Board. If multi-point distribution of circuit power is required (e.g. to provide power to the three KOP breakout boards via one 20-amp circuit), then all incoming wires must be appropriately spliced into the main lead, and only one lead inserted into the WAGO connector to connect the circuit.
- F. Sensors and custom circuits may be connected to the 5 Vdc sources on the Analog Breakout boards or the Digital Sidecars. By being logically downstream from the Power Distribution Board, they are protected by the 20-amp breaker at the circuit root.
- G. Servos may be connected to the 6 Vdc sources on the Digital Sidecars (via the designated PWM connections, and with a “6Vdc enable” jumper in place for the corresponding port). By being logically downstream from the Power Distribution Board, they are protected by the 20-amp breaker at the circuit root. No other electrical load can be connected to these sources.

**<R19>** All active Power Distribution Board branch circuits shall be protected from overload with an appropriate value auto resetting Snap Action circuit breaker (from the KOP or identical equivalent).

- A. Each speed controller branch circuit must be protected by one and only one 20-amp, 30-amp, or 40-amp circuit breaker on the Power Distribution Board. No other electrical load can be connected to the breaker supplying this circuit.
- B. Each Spike relay module branch circuit must be protected with one and only one 20-amp circuit breaker on the Power Distribution Board. No other electrical load can be connected to the breaker supplying this circuit.
- C. Each Digital Sidecar branch circuit must be protected with one and only one 20-amp circuit breaker on the Power Distribution Board. No other electrical load can be connected to the breaker supplying this circuit.
- D. If the compressor is used, the Spike relay module branch circuit supplying the compressor must be protected with a 20-amp circuit breaker. No other electrical load can be connected to the breaker supplying this circuit.
- E. A single branch supply circuit may be spliced to supply power to one, two or three of the Analog/Solenoid Breakout Boards. This circuit must be protected with one and only one 20-amp circuit breaker on the Power Distribution Board. No other electrical load can be connected to the breaker supplying this circuit.

- F. Custom circuits and sensors powered via the cRIO-FRC or the Digital Sidecar are protected by the breaker on the circuit(s) supplying those devices. Power feeds to all other custom circuits must be protected with a dedicated 20-amp circuit breaker on the Power Distribution Board.
- G. In addition to the required branch power circuit breakers, smaller value fuses or breakers may be incorporated into custom circuits for additional protection.

<R20> All active Power Distribution Board branch circuits shall be wired with appropriately sized wire:

- A. **12 AWG (2.052mm) or larger** diameter wire must be used for all circuits protected by a 40A circuit breaker.
- B. **14 AWG (1.628mm) or larger** diameter wire must be used for all circuits protected by a 30A circuit breaker.
- C. **18 AWG (1.024mm) or larger** diameter wire must be used for all circuits protected by a 20A circuit breaker.
- D. **20 AWG (0.8128mm) or larger** diameter wire must be used for the power connection between the Power Distribution Board and the cRIO-FRC .
- E. **20 AWG (0.8128mm) or larger** diameter wire must be used for the power connection between the Power Distribution Board and the Linksys Wireless Bridge
- F. **20 AWG (0.8128mm) or larger** diameter wire must be used for the power connections between the Power Distribution Board and the Analog Breakouts and/or Solenoid Breakout if individual power feeds are used. **18 AWG or larger** diameter wire must be used if a common power feed is used for multiple breakouts.
- G. **24 AWG (0.5106mm) or larger** diameter wire must be used for providing power to pneumatic valves.

<R21> All active Power Distribution Board branch circuit wiring with a constant polarity (i.e., except for relay module, speed controller, or sensor outputs) shall be color-coded as follows:

- A. Use red, white, brown, or black with stripe wire for +24 Vdc, +12 Vdc and +5 Vdc connections.
- B. Use black or blue wire for common (-) connections.

<R22> Each power-regulating device (speed controller or relay module) shall control one and only one electrical load (motor, actuator or compressor).

- A. Exception: Multiple low-load, pneumatic solenoid valves may be connected to a single relay module. This would allow one relay module to drive multiple pneumatic actions. No other electrical load can be connected to a relay module used in this manner.

<R23> Custom circuits shall NOT directly alter the power pathways between the battery, Power Distribution Board, speed controllers, relays, motors, or other elements of the robot control system (including the power pathways to other sensors or circuits). Custom high impedance voltage monitoring or low impedance current monitoring circuitry connected to the ROBOT'S electrical system is acceptable, because the effect on the ROBOT outputs should be inconsequential.

<R24> Decorations may draw power from the 12 VDC electrical system as long as they are powered via a dedicated 20 amp circuit breaker on the Power Distribution Board, and do not affect the operation of other control system components.

## 8.2.5 Motors & Actuators

<R25> Motors specifically permitted on 2010 FRC ROBOTS include:

- A. All motors, actuators, and servos listed in the 2010 KOP.
- B. Anything that MARS has lying around.

<R26> Items specifically PROHIBITED from use on the ROBOT include:

- A. Electric motors and/or servos different from, or in addition to, those in the KOP, with the exception of those specifically permitted by Rule <R52>.
- B. Electric solenoid actuators (note: electric solenoid actuators are NOT the same as pneumatic solenoid valves – the latter are permitted, the former are not).

<R27> So that the maximum power level of every ROBOT is the same, motors and servos used on the ROBOT **shall not be modified in any way**, except as follows:

- A. The mounting brackets and/or output shaft/interface of the motors may be modified to facilitate the physical connection of the motor to the ROBOT and actuated part.
- B. The gearboxes for the Fisher-Price motors are not considered “integral” and may be separated from the motors.
- C. The electrical input leads on the motors may be trimmed to length as necessary.

The intent is to allow teams to modify mounting tabs and the like, not to gain a weight reduction by potentially compromising the structural integrity of any motor. The integral mechanical and electrical system of the motor is not to be modified.

<R28> All electrical loads (motors, actuators, compressors) must be supplied by an approved power regulating device (speed controller, relay module, or Digital Sidecar PWM port) that is controlled by the cRIO-FRC on the ROBOT.

- A. Each CIM motor and Fisher-Price motor must be connected to one and only one approved speed controller. These motors must not be connected to relay modules.
- B. Servos must be directly connected to the PWM ports on the Digital Sidecar. They must not be connected to speed controllers or relay modules.
- C. If used, the compressor must be connected to one and only one Spike relay module.
- D. Each other electrical load (motor or actuator) must be supplied by one and only one approved speed controller, or one and only one relay module.

## 8.2.6 Control, Command & Signals System

<R29> ROBOTS must be controlled via the programmable National Instruments cRIO-FRC (National Instruments part number 780406-01). Other controllers shall not be used.

<R30> The cRIO-FRC, Classmate PC, wireless bridge, and wireless router must be configured to correspond to the correct IP Address (either 2615 or 2616). The procedures for configuring these devices are contained in the FRC control system documentation.

<R31> One KOP wireless bridge (either model WGA600N or WET610N) is the only permitted mechanism for communicating to and from the ROBOT during the MATCH. The signal output from the wireless bridge must be directly connected to Port 1 of the cRIO-FRC with an Ethernet cable. All signals must originate from the OPERATOR CONSOL and be transmitted to the ROBOT via a wireless router. No other form of wireless communications shall be used to communicate to, from or within the ROBOT (e.g. radio modems from previous *FIRST* competitions and Bluetooth devices are not permitted on the ROBOT during competition).

<R32> ROBOTS shall use the diagnostic Robot Signal Light provided in the KOP. It must be mounted on the ROBOT such that it is easily visible while standing three feet in front of the ROBOT in the STARTING CONFIGURATION. The team has no direct control over the light and no programming is required.

A. The Robot Signal Light must be connected to the “RSL” supply terminals on a Digital Sidecar (see the ***FRC Control System Manual, Section 3.5*** and the item bulletin online at <http://literature.rockwellautomation.com/idc/groups/literature/documents/in/41063-177-01.pdf> for connection details). These terminals provide power and control for the light.

B. The Digital Sidecar must be connected to a NI 9403 module in Slot 4 of the cRIO-FRC. If it is connected through any other slot, the light will not function properly.

C. The light must be wired for “solid light” operation, by placing a jumper between the La and Lb terminals on the light.

<R33> The control system is designed to allow wireless control of the ROBOTS. The Classmate PC, FirstTouch I/O module, cRIO-FRC, speed controllers, relay modules, wireless bridge, batteries, and battery charger shall not be tampered with, modified, or adjusted in any way(tampering includes drilling, cutting, machining, gluing, rewiring, disassembling, etc.), with the following exceptions:

A. User programmable “dashboard” code in the Classmate PC may be customized.

B. User programmable code in the cRIO-FRC may be customized.

C. Dip switches on the cRIO-FRC may be set.

D. Speed controllers may be calibrated as described in owner's manuals.

E. The supplied fans attached to the Victor speed controllers may be powered from the Victor power input terminals.

F. The fuse on the Spike relays may be replaced with a 20 Amp Snap-Action circuit breaker.

G. The alligator clips on the battery charger leads may be replaced with Anderson Power Pole connectors (note: this is a recommended modification).

H. Wires, cables, and signal lines may be connected via the standard connection points provided on the devices.

I. Fasteners may be used to attach the device to the OPERATOR CONSOLE or ROBOT.

J. Labeling may be applied to indicate device purpose, connectivity, functional performance, etc.

K. Brake/Coast jumpers on speed controllers may be changed from their default location.

L. If CAN-bus functionality is used, limit switch jumpers may be removed from a Jaguar speed controller and a custom limit switch circuit may be substituted (so that the cRIO-FRC may read the status of the limit switches).



- M. If CAN-bus functionality is used, the Jaguar firmware must be updated as required by *FIRST* (see Rule <R63-D>).
- N. If the FirstTouch I/O module is not used as part of the OPERATOR CONSOLE, the embedded software may be modified. If the First Touch I/O module is used as part of the OPERATOR CONSOLE, the default software image must be used.

<R34> Relay module outputs, speed controller outputs, or PWM outputs must not be connected to the analog/solenoid breakout boards or the Digital Sidecar. 12Vdc power must not be connected to any terminal on the analog/solenoid breakout boards or the Digital Sidecar except the designated 12Vdc input terminals. Doing so may damage or destroy components of the control system.

<R35> Every relay module, servo, and Victor speed controller shall be connected via PWM cable to the Digital Sidecar and be controlled by signals provided from the cRIO-FRC via the Digital Sidecar. They shall not be controlled by signals from any other source.

<R36> Each Jaguar speed controller must be controlled with signal inputs sourced from the cRIO-FRC and passed via either a connected PWM cable or a CAN-bus connection.

- A. The Jaguar must receive signals via either a PWM cable -OR- a CAN-bus connection. Both cannot be used simultaneously.
- B. PWM configuration: If the Jaguar speed controller is controlled via PWM communications, the PWM port on the Jaguar speed controller must be connected directly to a PWM port on the Digital Sidecar with a PWM cable. No other devices may be connected to these PWM ports. No other devices may be connected to any other ports on the Jaguar speed controller with the exception of connection to the coast/brake port.
- C. CAN-bus configuration: If the Jaguar speed controller is controlled via CAN-bus communications, then each Jaguar speed controller must be connected to either the cRIO-FRC or another CAN-bus device with a CAN-bus cable.
- D. If the CAN-bus configuration is used, the firmware on all Jaguar speed controllers must be updated to at least Version 86 of the official FIRST firmware.

<R37> If CAN-bus communications are used, the CAN-bus must be connected to the cRIO-FRC through either Ethernet Port 2 or the RS-232 DB-9 serial port connection. No other connections to the cRIO-FRC may be used by the CAN-bus.

- A. Ethernet-to-CAN convertors, serial-to-CAN convertors, serial-to-CAN cables, “black” Jaguars, or other network bridging devices may be used to connect the CAN-bus to the selected cRIO-FRC port.
- B. If a “black” Jaguar (TI Model MDL-BDC24) is used as the serial-to-CAN bridge, the first Jaguar on the CAN-bus must be a “black” Jaguar. Any “grey” Jaguars (TI Model MDL-BDC) on the bus must be located downstream from the first “black” Jaguar.
- C. Additional switches, sensor modules, custom circuits, third-party modules, etc. may also be placed on the CAN-bus.
- D. No device that interferes with, alters, or blocks communications between the cRIO-FRC and the Jaguars will be permitted (tunneling packets for the purposes of passing them through an Ethernet-to-CAN convertor is acceptable as the commands are not altered).

<R38> Solenoid Breakout outputs shall be connected to pneumatic valve solenoids only. No other devices shall be connected to these outputs.

<R39> A National Instruments 9201 module must be installed in slot 1 of the cRIO-FRC . An analog breakout must be connected to this module. A jumper must be installed in the “Power” position (two outer pins) on the analog breakout. The analog breakout must be powered from the Power Distribution Panel. Please refer to Section 3.4 of the “FRC Control System Component Data Sheets” for information on these connections. These connections enable monitoring of the battery charge by the team and the Field Management System. This is a required element of the ROBOT configuration.

<R40> For the purposes of the FRC, generally available software modules obtained from open sources (e.g. professional publications, commonly used FRC community-accessible web resources, industry source code repositories, etc.) that are not specifically affiliated with individual FRC teams shall be considered COTS items, and may be used.

<R41> All outputs from sensors, custom circuits and additional electronics shall connect to only the following:

- A. other custom circuits, or
- B. additional COTS electronics, or
- C. input ports on the Digital Sidecar, or
- D. input ports on the Analog Breakout, or
- E. the RS-232 DB-9 serial port on the cRIO-FRC, or
- F. the Ethernet bus connected to Port 2 of the cRIO-FRC, or
- G. the CAN-bus if and only if all Jaguar speed controllers on the CAN-bus are wired in full compliance with Rule <R63> and Rule <R64>, or
- H. the sensor inputs on the Jaguar speed controller.

<R42> A signal filter may be wired across motor leads or PWM leads. For the purposes of inspection and rules compliance, such filters will not be considered custom circuits, and will not be considered a violation of Rule <R54> or Rule <R68>. Acceptable signal filters are:

- A one microfarad (1  $\mu$ F) or less non-polarized capacitor may be applied across the power leads of any motor on your ROBOT (as close to the actual motor leads as reasonably possible)
- A resistor may be used as a shunt resistor for the PWM control signal feeding a servo

<R43> Any decorations that involve broadcasting a signal to/from the ROBOT, such as remote cameras, must be cleared with *FIRST* Engineering (via e-mail to [frcteams@usfirst.org](mailto:frcteams@usfirst.org)) prior to the event and tested for communications interference at the venue. Such devices, if reviewed and approved, are excluded from Rule <R58>.

## 8.2.7 Pneumatic System

<R44> To satisfy multiple constraints associated with safety, consistency, robot inspection, and constructive innovation, no pneumatic parts other than those explicitly permitted by the Pneumatic System Rules may be used on the ROBOT.

<R45> In addition to the items included in the KOP, pneumatic system items specifically permitted on 2010 FRC ROBOTS include the following items. All included items must be “off the shelf” pneumatic

devices rated by their manufacturers for pressure of at least 125psi, and used in their original, unaltered condition (except as required for assembly with other components).

- A. One or two additional Clippard air storage tanks (Clippard Part Number AVT-32-16), equivalent to those provided in the kit. This means that up to four, and no more, Clippard air storage tanks can be used on the ROBOT.
- B. Pneumatic pressure vent plug valves functionally equivalent to those provided in the KOP (Parker Part Number PV609-2).
- C. Solenoid valves. All such valves must have a maximum  $\frac{1}{8}$ " NPT port diameter, and a maximum Cv of 0.32 (if non-KOP valves are used, the team will be required to provide part documentation validating that the valves meet these constraints). Solenoid valves that are rated for a maximum pressure that is less than 125psi rating mandated above are permitted, however if employed, an additional pressure relief valve must be added to the low pressure side of the main regulator. The additional relief valve must be set to a lower pressure than the maximum pressure rating for the solenoid valve.
- D. In addition to the pneumatic cylinders provided in the KOP and the "free" pneumatic cylinders available for order through the Free Pneumatic Components Order Form, additional air cylinders or rotary actuators may be used. Cylinders may be of any configuration, and may be of any size up to a maximum of 24-inch stroke and 2-inch diameter.
- E. Additional 0.160" inch inside diameter pneumatic tubing functionally equivalent to that provided in the KOP, with the pressure rating clearly factory-printed on the exterior of the tubing (note: alternate tubing colors are acceptable).
- F. Pressure transducers, pressure gauges, and connecting fittings.
- G. Pressure regulators with a maximum bypass pressure of no more than 60psi.
- H. For the purposes of the *FIRST* competition, a device that creates a vacuum is not considered to be a pneumatic device and are not subject to the pneumatic rules (although they must still satisfy all other appropriate rules). These include, but are not limited to, venturi-type vacuum generators and off-the-shelf vacuum devices (as long as they are powered by provided or permitted motors).
- I. For the purposes of the *MARS Summer Competition*, closed-loop COTS pneumatic (gas) shocks are not considered pneumatic devices, and are not subject to the pneumatic rules (although they must still satisfy all other appropriate rules).
- J. For the purposes of the *MARS Summer Competition*, air-filled (pneumatic) wheels are not considered pneumatic devices, and are not subject to the pneumatic rules (although they must still satisfy all other appropriate rules).

**<R46>** Items specifically PROHIBITED from use on the ROBOT include:

- A. Any pneumatic part or component rated for less than 125psi.
- B. Any pneumatic part or component that has been altered, modified, machined, coated, or changed from its original "out of the box" condition, except as required for normal assembly with other components. The only acceptable modifications are:
  - Tubing may be cut.
  - Wiring for pneumatic devices may be modified to interface with the control system.
  - Assembling and connecting pneumatic components using the pre-existing threads, mounting brackets, quick-connect fittings, etc.
  - Removing the mounting pin from a pneumatic cylinder, provided the cylinder itself is not modified.

- Labeling applied to indicate device purpose, connectivity, functional performance, etc.

Do not, for example, file, machine, or abrasively remove any part of a pneumatic cylinder – this would cause the part to become a prohibited item. Consider pneumatic components sacred.

<R47> If pneumatic components are used on the ROBOT, the pneumatic system on the ROBOT must contain as a minimum the following components, connected in accordance with this section.

- Pressure gauges to display the “stored” and “working” air pressure
- A pressure relief valve, calibrated and set to release at 125psi
- A pressure switch, calibrated and connected to the ROBOT control system
- An easily visible and accessible pressure vent plug valve to manually relieve the stored pressure (see Rule <R79>).

<R48> Compressed air for the pneumatic system on the ROBOT must be provided by one and only one compressor. This compressor may be either the Thomas Industries compressor from the KOP, or an equivalent compressor that does not exceed any of the KOP compressor performance specifications (specifically: 12v, 0.8cfm flow rate, 120psi continuous pressure, 120psi maximum pressure compressor). Note: if an alternative compressor is used, during inspection the team may be required to provide documentation to show compliance with the performance specifications. Compressed air shall not come from any other source. The compressor may be mounted on the ROBOT, or it may be left off the ROBOT and used to pre-charge compressed air in the storage tanks prior to bringing the ROBOT onto the FIELD. Off-board compressors must be controlled and powered by the ROBOT.

The only difference between an on- and off-board compressor is that the off-board compressor is physically removed from the ROBOT. The intent of this rule is to permit teams to take advantage of the weight savings associated with keeping the compressor off-board. However, using the compressor off-board of the ROBOT does NOT permit non-compliance with any other applicable rules.

<R49> “Working” air pressure on the ROBOT must be no greater than 60psi. All working air must be provided through one primary Norgren adjustable pressure regulator.

- All “working” pneumatic components (e.g. valves, cylinders, rotary actuators, etc.) must be downstream from this regulator.
- Only the compressor, relief valve, pressure switch, pressure vent plug valve, pressure gauge, storage tanks, tubing, and connecting fittings may be in the high-pressure pneumatic circuit upstream from the regulator.
- Pressure gauges must be placed in easily visible locations upstream and downstream of the regulator to display the “stored” and “working” pressures.
- If the compressor is not included on the ROBOT the regulator may be located on-board or off-board, provided all other pneumatic rules are satisfied. Note that if the regulator is kept off-board the ROBOT with the compressor, then only low-pressure (60psi or less) “working” air can be stored on the ROBOT.

<R50> The relief valve must be attached directly to the compressor. **If the relief valve is already set to 125psi, teams are not allowed to adjust it. If the relief valve is not set to 125psi, teams are**

**required to adjust to release air at 125psi.** The valve may or may not have been calibrated prior to being supplied to teams.

<R51> The Nason pressure switch must be connected to the high-pressure side of the pneumatic circuit (i.e. prior to the pressure regulator) to sense the “stored” pressure of the circuit. The two wires from the pressure switch must be connected directly to a digital input and ground port on the Digital Sidecar, and the cRIO-FRC must be programmed to sense the state of the switch and operate the relay module that powers the compressor to prevent over-pressuring the system.

<R52> The Parker pressure vent plug valve must be connected to the pneumatic circuit such that, when manually operated, it will vent to the atmosphere to relieve all stored pressure. The valve must be placed on the ROBOT so that it is visible and easily accessible. If the compressor is not used on the ROBOT, then an additional vent valve must be obtained and connected to the high-pressure portion of the pneumatic circuit off board the ROBOT with the compressor.

### 8.2.8 Operator Console

<R53> The DRIVER STATION provided in the KOP is the only system permitted to collate driver/operator inputs and communicate them to the ROBOT. Operator Interfaces and devices from previous *FIRST* competitions shall not be used.

<R54> Teams are permitted to connect a portable computing device (Laptop computer, PDAs, etc.) to the DRIVER STATION for the purpose of displaying feedback from the ROBOT while participating in competition MATCHES. Portable computing devices may only connect to the DRIVER STATION – they must not directly connect to any ARENA ports or equipment. Please note that ***AC power will not be available at the PLAYERS STATIONS so these devices will have to run on internal batteries or be self-powered.***

<R55> The Classmate PC must be positioned within the OPERATOR CONSOLE so that the screen display can be clearly seen during inspection and during operation in a MATCH. The Ethernet port on the OPERATOR CONSOLE must be easily and quickly accessible. This will greatly facilitate installation and removal of the OPERATOR CONSOLE from the ARENA, and analysis by field personnel in case of problems during the competition.

<R56> Other than the system provided by the ARENA, no other form of wireless communications shall be used to communicate to, from or within the OPERATOR CONSOLE (e.g. active wireless network cards and Bluetooth devices are not permitted in the OPERATOR CONSOLE).

### 8.2.9 Robot Inspection

<R57> At the time of inspection, the ROBOT must be presented with ***all*** MECHANISMS (including ***all*** COMPONENTS of each MECHANISM) ***and configurations*** that will be used on the ROBOT during the entire competition event. It is acceptable, however, for a ROBOT to play MATCHES with a ***subset*** of the MECHANISMS that were present during inspection. Only MECHANISMS that were present during the inspection may be added, removed or reconfigured between MATCHES. If subsets of MECHANISMS are changed between MATCHES, the reconfigured ROBOT must still meet all inspection criteria.

<R58> The ROBOT will be inspected for compliance with the dimension constraints specified in Rule <R09> while in its STARTING CONFIGURATION, by being placed within a *FIRST* Sizing Device that has inside surface dimensions consistent with the rule. Other than resting on the floor of the Sizing Device, no part of the ROBOT can break the plane of the sides or top of the Sizing Device during size inspection. The ROBOT must be self-supporting while in the Sizing Device.

<R59> All decorations must be on the ROBOT at the time of final inspection.

<R60> Any ROBOT construction technique or element that is not in compliance with the Robot Rules (*Section 8*) must be rectified before a ROBOT will be allowed to compete or continue competing.

<R61> If a ROBOT is rejected by inspectors due to a safety issue or concern related to the team's method of storing energy (see Rule <R01>), the concerned items must be disabled or removed from the ROBOT before it can compete in a MATCH. The team bears the burden of proof that such a rejection is not valid. Teams should be prepared to provide justifiable test data or calculations during inspection to support their design.

<R62> If a ROBOT is modified after it has passed inspection, that ROBOT must be re-inspected.

<R63> *MARS* Officials may randomly re-inspect ROBOTS participating in competition MATCHES to assure compliance with the rules.

<R64> For the safety of all those involved, inspections must take place with the ROBOT powered off, pneumatics unpressurized, and springs or other stored energy devices in their lowest potential energy states (i.e. battery removed). Power should only be enabled on the ROBOT during those portions of the inspection process where it is absolutely required to validate certain system functionality and compliance with specific rules (firmware check, etc). Inspectors may allow the ROBOT to be powered up beyond the parameters above if both criteria below are met.

- The ROBOT design requires power or a charged stored energy device in order to confirm that the ROBOT meets volume requirements **AND**
- The team has included safety interlocks that prevent unexpected release of such stored energy.

## ***Section 9: The Tournament***

### **9.0 Matches**

Each team will have one PRACTICE match and three SCORED matches. The PRACTICE match is to give teams the opportunity to test the robot's systems, especially how they act on official competition FIELD, the PRACTICE match will have no effect on a team's score. The top *Cube Capture* score earned out of the three SCORED matches will be factored into the team's overall 2010 MARS Summer Challenge score, as described in **Section 5**. Please remember the decisions of the referees are Final.

### **9.1 Match Schedule**

Teams can expect to have approximately 30 minutes between matches.

## ***Section 10: The Kit of Parts***

### **10.0 2010 MARS KoP**

The 2010 KoP consists of everything you can find, whether it be in Phil's shop, the loading dock, or one of the closets or lockers. Remember, MARS is like a grad student, it's poor, so try to make optimal use the parts already in its possession.

IMPORTANT: This product is composed of 100% matter: It is the responsibility of the User to make sure that it does not come in contact with antimatter. Under no circumstances will the Manufacturer be liable for User mishandling in this regard.