Section

4

FIRST®Robotics Competition

THE ROBOT

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4 OVERVIEW

This section of the 2011 *FIRST* Robotics Competition (FRC) manual provides rules applicable to the design and construction of the 2011 ROBOT. ROBOTS will be inspected at each FRC event to verify rules compliance before being allowed to compete.

4.1 RELATED DOCUMENTS & RESOURCES

In addition to this chapter, other sections in this manual and other documents should be reviewed before proceeding with the robot design process. Note that all referenced documents are available on the *FIRST* website at www.usfirst.org/frc/competitionmanual.

A. ***2011 FRC Game Manual***

B. Kit of Parts item information and related documents posted on the *FIRST* website at: www.usfirst.org/frc/kitofparts.

C. Crate constraints and deadlines as listed in ***2011 FRC Manual, Section 5: Robot Transportation***

4.2 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 2011 FRC are defined in the Glossary (1.6) of ***Section 1: Introduction*** of the ***2011 FRC Game Manual*** and indicated in 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.

4.3 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 ***2011 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.

One of the purposes of the *FIRST* Robotics Competition is to provide team members with the experience of conceiving, designing, and constructing their solution to the annual competition challenge. We want each student to have the experience of creating a new system each year. As the team considers the creation of their machine, this aspect of the program should be kept in mind. Solutions that merely bolt together a minimum number of externally-designed COTS subsystems may not offer the students the opportunity to understand the “why” or “how” of an item’s design. Likewise, solutions that are merely minor modifications of a design utilized for a previous competition does not offer the current students complete insight into the full design process. Purchasing optimization and design re-use are both important concepts, however teams must be cautious not to over-utilize them to the point that the student’s experience is compromised.

This intent is clearly met when a team obtains a MECHANISM or COTS items that was designed for non-*FIRST* purposes, and then modifies or alters it to provide functionality for the ROBOT. For example, if a team obtains a gearbox from a power drill and modifies it to use on the ROBOT, they gain insight into the design of the original gearbox purpose, learn to characterize the performance of the original design, and implement the engineering design process to create their customized application for the gearbox.

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.

4.3.1 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 <R34> for specifications and further details).

B. Compressed air stored in the pneumatic system, stored at a maximum pressure of 120 PSI.

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, infra-red 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 off-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.

Examples of items that are considered directly affecting the output devices on the ROBOT include those that directly power a motor, supply a PWM signal directly to a speed controller or supply a control signal directly to a relay module (see Rules <R58> and <R59> for the specific exception regarding CAN-bus devices).

<R04> Protrusions from the ROBOT and exposed surfaces on the ROBOT shall not pose hazards to the ARENA, GAME PIECES or people.

If the ROBOT includes protrusions that form the “leading edge” of the ROBOT as it drives and are less than 1”^{2} in surface area, it will invite detailed inspection. For example, forklifts, lifting arms, grapplers. etc. may be carefully inspected for these hazards.

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” 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”.

<R05> 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 4”^{2} in cross section, it will invite detailed inspection.

Nets, loose rope or wire, voluminous sheets of fabric, etc. may be carefully inspected for these hazards. A ⅛” x ⅛” 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.

Actual performance on the playing field will determine if the potential for entanglement is significant or not. Willful entanglement *actions* are addressed in Rule <G48>.

<R06> 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.

4.3.2 Bumper Rules

<R07> Teams are required to use BUMPERS on their ROBOTS while on the competition field.

BUMPERS have several advantages, such as reducing damage to ROBOTS when they contact other ROBOTS or ARENA elements, and being excluded from the calculation of ROBOT weight and volume constraints specified in Rule <R11>. The BUMPER location and design have been specified so that ROBOTS will make BUMPER-to-BUMPER contact during most collisions. If implemented as intended, a ROBOT that is pushed against a vertical wall in any STARTING CONFIGURATION will always have the BUMPER be the first thing to contact the wall. To achieve this, BUMPERS must be constructed as described below and illustrated in Figure 3-1.

General recommendations for BUMPER construction include:

- Using 1000 dernier Cordura Plus® for the BUMPER cover
- Using lengths of aluminum angle to clamp the cover in place on the plywood.
- Considering methods for carrying the ROBOT while designing BUMPER mounts as BUMPERS typically do not make good handles.
- Noting that the use of BUMPERS may preclude the use of other technologies in their out-of-the-box configurations. Teams will need to carefully consider the interactions between BUMPER design options and other elements of their ROBOT design.

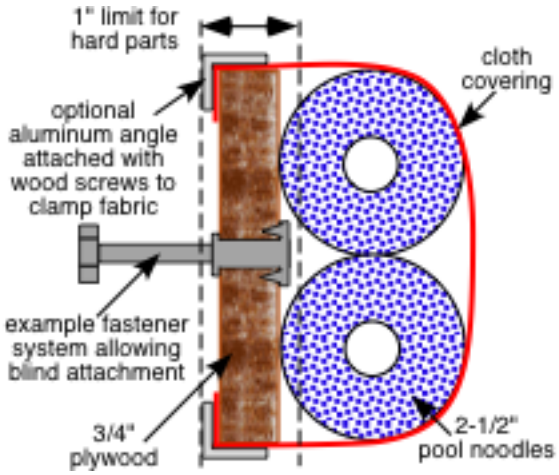


Figure 4-1

A. BUMPERS must provide complete protection of the entire FRAME PERIMETER of the ROBOT (i.e. BUMPERS must wrap entirely around the ROBOT). As part of the 100% coverage, BUMPERS must protect all exterior corners of the FRAME PERIMETER. For adequate protection, a full segment of BUMPER must be placed on each side of the corner (see Figure 3-2).

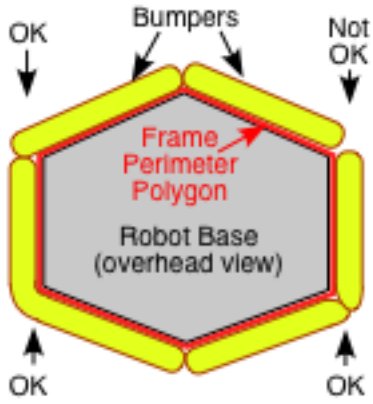


Figure 4-2

B. The BUMPERS must be located entirely within the BUMPER ZONE when the ROBOT is standing normally on a flat floor, and must remain there (i.e. the BUMPERS must not be articulated or designed to move outside of the BUMPER ZONE).

C. Joints between BUMPER segments and the radial projections of corners must be filled with "soft" BUMPER materials. This may be done with short pieces of vertically oriented pool noodle, by wrapping the pool noodles around the corners, or by beveling the ends between adjacent segments so they form a tight and complete protective surface (see Figure 3-2).

D. BUMPERS segments must have a minimum length of six inches (as defined by the BUMPER backing), and a maximum length that does not exceed the maximum horizontal dimension of the ROBOT (except for the soft cushion in the corner, as permitted by Rule <R07-C>).

E. BUMPERS must use a stacked pair of 2½ inch "pool noodles" as the bumper cushion material.

F. Each BUMPER segment must be backed by a piece of ¾" thick by 5" tall piece of plywood. Small clearance pockets and/or access holes in the plywood backing are permitted, as long as they do not significantly affect the structural integrity of the BUMPER.

G. The exterior of the BUMPERS must be covered with a rugged, smooth cloth. The cloth must completely enclose all exposed surfaces of the plywood and pool noodle material.

H. The fabric covering the BUMPERS must be a solid red or blue in color. Visually, the red or blue must be as close to the corresponding color in the *FIRST* logo as reasonable (i.e. to a reasonably astute observer, they appear similar). The only markings permitted on the BUMPER fabric cover are the team number (see Rule <R09>).

I. Each set of BUMPERS (including any fasteners and/or structures that attach them to the ROBOT) must weigh no more than 20 pounds.

J. BUMPERS must be designed for quick and easy installation and removal, to aid in weighing and inspection.

As a guideline, BUMPERS should be removable by one person in less than ten minutes.

K. BUMPERS must attach to the FRAME PERIMETER of the ROBOT with a rigid fastening system to form a tight, robust connection to the main structure/frame (e.g. not attached with Velcro). The attachment system must be designed to withstand vigorous game play. All removable fasteners (e.g. bolts, locking pins, pip-pins, etc.) will be considered part of the BUMPERS.

If a multi-part attachment system is utilized (e.g. interlocking brackets on the ROBOT and the BUMPER), then the elements permanently attached to the ROBOT will be considered part of the ROBOT, and the elements attached to the BUMPERS will be considered part of the BUMPER. Each element must satisfy all applicable rules for the relevant system.

The BUMPER backing must be supported by the structure/frame of the ROBOT (i.e. the gap between the backing material and the frame must not be greater than 1/4" and no section of BUMPER greater than 8" may be unsupported). See Figure 3-3.

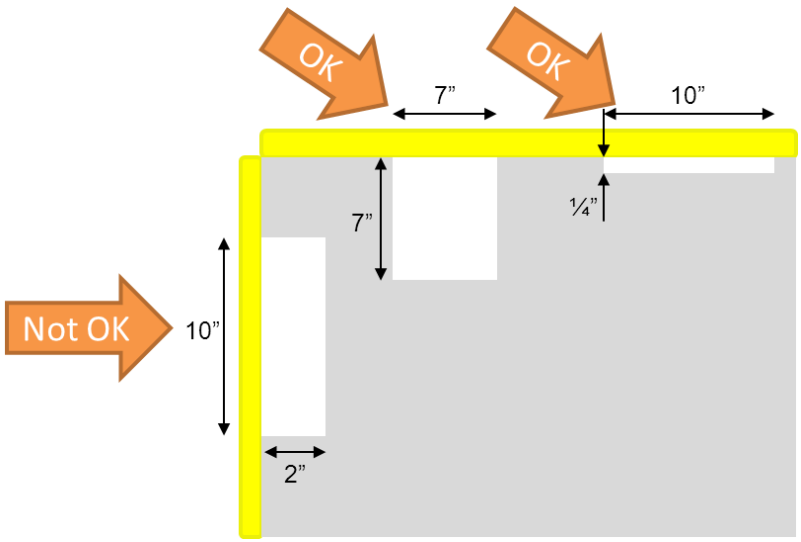


Figure 4-3

L. "Hard" parts of the BUMPER (i.e. plywood backing, fastening system, and clamping angles) may extend up to a maximum of 1" beyond the FRAME PERIMETER. "Soft" parts of the BUMPERS (i.e. pool noodles and cloth covering) may extend up to 3½" beyond the FRAME PERIMETER.

<R08> The color of the BUMPERS will be used to identify the ALLIANCE to which the ROBOT has been assigned, red or blue. Therefore, each ROBOT must be able to display red BUMPERS and blue BUMPERS. This may be done via either of two acceptable methods:

A. Each ROBOT may be built with two complete sets of interchangeable BUMPERS, one red and one blue. If this method is chosen, the BUMPERS must be identical except for the color of the covering fabric (see Rule <R07-H>).

B. Alternately, the ROBOT may use changeable BUMPER covers. The BUMPER covers

- may be removable, reversible, or fixed
- must completely enclose the BUMPERS
- must show only show red or blue such that when the BUMPER covers are in use, only fabric of the assigned ALLIANCE color may be visible.
- must be constructed solely of fabric and a fastening/restraining system to hold the cover in place. The fastening/restraining system must extend no further than 1" beyond the FRAME PERIMETER (i.e. no further than any other hard parts of the BUMPER, see Rule <R07-L>).

Please note that the fastening/restraining system *must* be designed with robust performance in mind. The restraints must hold the cover in place during vigorous interactions with other ROBOTS and FIELD elements during the MATCH without allowing the cover to come off.

<R09> Teams shall display their team number on the BUMPERS in four locations at approximately 90° intervals around the perimeter of the ROBOT. The numerals must be at least 4" high, at least in ¾" stroke width and in a contrasting color from its background. Team Numbers must be clearly visible from a distance of not less than 100 feet, so that judges, referees, and announcers can easily identify competing ROBOTS.

4.3.3 General Robot Design

<R10> Each registered FRC team can enter ONE (1) ROBOT into the 2011 FRC. That ROBOT shall fully comply with all rules specified in the ***2011 FRC Game Manual***.

<R11> During the MATCH, the ROBOT may not exceed the volume constraints of either STARTING or PLAYING CONFIGURATIONS (note: these limits are defined in reference to the ROBOT, not the FIELD).

	Maximum Horizontal Dimensions	**Maximum Height**	**Maximum Weight**
STARTING CONFIGURATION	28" x 38" (71.12cm x 96.52cm) rectangular space	60" (152.40cm)	120 pounds (54.43Kg)
PLAYING CONFIGURATION	84" (213.4cm) diameter vertical right cylindrical volume	N/A	

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.

For the purposes of determining compliance with the weight and volume limitations, the items listed below are NOT considered part of the ROBOT and are NOT included in the weight and volume assessment:

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

B. BUMPER assemblies (including BUMPER covers, if appropriate) that are in compliance with Rules <R07> and <R08>,

C. the OPERATOR CONSOLE, and

D. the MINIBOT.

Note that the total weight of the ROBOT, MINIBOT, BUMPERS, and battery may approach 165 pounds. Please think carefully about lifting the weight safely. Teams are encouraged to use their forth TEAM member (typically in charge of the ROBOT cart) to carry the MINIBOT on to the FIELD separately. Teams are also encouraged to think about handles or lifting bars to aid in lifting and carrying the ROBOT.

<R12> The FRAME PERIMETER must be comprised of fixed, non-articulated structural elements of the ROBOT.

<R13> ROBOTS shall display their school name (or the name of the supporting youth organization, if appropriate), and primary sponsor name and/or logo whenever the ROBOT is competing.

The support provided by the corporate sponsors and mentors on your team is important, and is to be acknowledged with the appropriate display of their names/logos on the exterior of the ROBOT.

<R14> When a ROBOT is in its STARTING CONFIGURATION, no part of the ROBOT shall extend outside the vertical projection of the FRAME PERIMETER.

This means no "mushroom-bots." If a ROBOT is designed as intended and in its STARTING CONFIGURATION, you should be able to push the ROBOT (with BUMPERS removed) up against a vertical wall, and the FRAME PERIMETER will be the only point of contact with the wall.

<R15> Any non-functional decorations included on the ROBOT must not affect the outcome of the MATCH, and must be in the spirit of Gracious Professionalism.

<R16> 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.

LOGO MOTION™ is a very vigorous game, with potential for changes in ROBOT orientation and significant interaction among ROBOTS. There is a high probability that your ROBOT will be overturned at some point. Should that happen, your design must prevent the battery from falling out and damaging itself, your ROBOT, or other ROBOTS.

<R17> Field power to the ROBOTS will **not** be re-enabled after a MATCH. ROBOTS must be designed to permit removal of GAME PIECES from the ROBOT, and removal of the ROBOT from other FIELD elements and/or other ROBOTS without requiring activation of the ROBOT power system.

4.3.4 Budget Constraints

<R18> All items and materials used in the construction of a ROBOT and their associated costs, shall be recorded (in US dollars) in a consolidated Bill Of Materials (BOM). The BOM must use the *FIRST*-approved template available for download at www.usfirst.org/frc/competitionmanual. Please refer to Rule <R82> in ***Section 3.4.13 - Robot Inspection*** for information regarding submission of the BOM.

All KOP items used on the ROBOT must be included in the BOM. The source for each of the KOP items should be listed as "KOP" and the indicated cost should be listed as "$0.00."

<R19> The total cost of all non-KOP items shall not exceed $3,500.00 USD.

A. All costs are to be determined as explained in ***Section 3.4.5, Cost Determination of Additional Parts.***

B. No individual item shall have a value of over $400.00. The total cost of COMPONENTS purchased in bulk may exceed $400.00 USD as long as the cost of an individual COMPONENT does not exceed $400.00.

<R20> The following items are *excluded* from the total cost calculation:

A. all items provided in the 2011 KOP,

B. the cost of any non-functional decorations,

C. the cost of individual fasteners, adhesives, or lubricants, unless any one component exceeds $1.00,

D. the costs of SPARE PARTS. A SPARE PART used as a direct replacement for a failed or defective ROBOT part (either KOP item or non-KOP item) that has already been included in the cost accounting is covered by the accounting for the original part, and

E. all costs for the construction of the OPERATOR CONSOLE.

<R21> Individual COMPONENTS or MECHANISMS retrieved from previous ROBOTS and used on 2011 ROBOTS must have their undepreciated cost included in the 2011 ROBOT cost accounting and applied to the overall cost limits.

4.3.5 Cost Determination of Additional Parts

The "cost" of each non-KOP item is calculated based on the following criteria, as applicable:

A. The purchase price of a COTS item offered for sale by a VENDOR to any customer.

B. The total cost (materials + labor) of an item you pay someone else to make.

> Example: A team orders a custom bracket fabricated by a VENDOR to the team's specification. The VENDOR'S material cost and normally charged labor rate apply.

C. The fair market value of an item obtained at a discount or as a donation. Fair market value is that price at which the supplier would normally offer the item to other customers. Also considered to be "fair market value" are the discounted prices offered to all teams by suppliers with established relations with *FIRST*.

> Example: Special price discounts from National Instruments and Texas Instruments are being offered to all *FIRST* teams. The discounted purchase price of items from these sources would be used in the additional parts accounting calculations.

D. The cost of raw material obtained by a team + the cost of non-team labor expended to have the material processed further. Labor provided by team members and/or by a recognized team sponsor whose employees are members of the team does not have to be included.

> Example: A team purchases steel bar stock for $10.00 and has it machined by a local machine shop. The machine shop is not considered a team sponsor, but donates two hours of expended labor anyway. The team must include the estimated normal cost of the labor as if it were paid to the machine shop, and add it to the $10.00.
>
> Example: A team purchases steel bar stock for $10.00 and has it machined by a local machine shop that is a recognized sponsor of the team. If the machinists are considered members of the team, their labor costs do not apply. The total applicable cost for the part would be $10.00.
>
> It is in the best interests of the teams and *FIRST* to form relationships with as many organizations as possible. Teams are encouraged to be expansive in recruiting and including organizations in their team, as that exposes more people and organizations to *FIRST*. Recognizing supporting companies as sponsors of, and members in, the team is encouraged - even if the involvement of the sponsor is solely through the donation of fabrication labor.

E. The cost of items purchased in bulk or large quantities may be prorated on the basis of the smallest commonly available unit that satisfies the need for the item.

> Example: A team purchases a 4' x 4' sheet of aluminum, but only uses a piece 10" x 10" on their ROBOT. The team identifies a source that sells aluminum sheet in 1' x1' pieces. The team may cost their part on the basis of a 1' x 1' piece, even though they cut the piece from a larger bulk purchase. They do not have to account for the entire 4' x 4' bulk purchase item.

F. Shipping costs are not counted.

G. If the item is part of a modular system that can be assembled in several possible configurations or applications, then each individual module must fit within the price constraints defined in Rule <R19>. If the modules are designed to assemble into a single configuration, and the assembly is functional in only that configuration, then the total cost of the complete assembly including all modules must fit within the price constraints defined in Rule <R19>.

4.3.6 Fabrication Schedule

FIRST recognizes that it is the responsibility of each team to design and construct their ROBOT within the schedule constraints defined below. As compliance with these rules takes place outside of the competition venues, *FIRST* is not able to directly monitor compliance. One of the fundamental values of *FIRST* is the concept of "gracious professionalism." We are relying upon the honor, integrity, and professional behavior of each team to recognize and abide by the fabrication schedule rules.

Note that schedule rules apply to both hardware and software development. Hardware and software design processes are thought-intensive activities, and team members are likely to continue to consider and analyze their designs long after the ROBOT is "completed." Teams cannot be prevented from thinking about their hardware and software designs, and it is not our intention to do so. However, the timeline permitted for the development of the actual competition version of the ROBOT is intentionally restricted. Pondering software issues to be resolved, researching general case solutions, discussing solutions with teammates, collecting raw materials, sketching mechanisms, preparing tools, and outlining high-level descriptions of software algorithms are all reasonable activities before the scheduled build period. However, completing detailed dimensioned drawings of specific parts, and any actual fabrication of any hardware items intended to go on the actual competition ROBOT is prohibited outside of the approved fabrication periods. On the software side, writing actual lines of code, verification of syntax, final debugging, etc would all be considered development of the final software implementation, and must be completed during the approved fabrication periods.

<R22> No final design, fabrication, or assembly of any elements intended for the final ROBOT is permitted prior to the Kick-off presentation.

Please note that this means that FABRICATED ITEMS from ROBOTS entered in previous *FIRST* competitions may not be used on ROBOTS in the 2011 FRC.

Before the formal start of the Robot Build Season, teams are encouraged to think as much as they please about their ROBOTS. They may develop prototypes, create proof-of-concept models, and conduct design exercises. Teams may gather all the raw stock materials and COTS COMPONENTS they want.

Example: A TEAM designs and builds a two-speed shifting transmission during the fall as a training exercise. When designing their competition ROBOT, they utilize all the design principles they learned. To optimize the transmission design for their ROBOT, they improve the transmission gear ratios and reduce the size, and build two new transmissions, and place them on the ROBOT. All parts of this process are permitted activities.

Example: The same TEAM realizes that the transmission designed and built in the fall perfectly fits their need for a transmission to drive the ROBOT arm. They build an exact copy of the transmission from the original design plans, and bolt it to the ROBOT. This would be prohibited, as the transmission – although fabricated during the competition season – was built from detailed designs developed prior to kick-off.

Example: A TEAM developed an omni-directional drive system for the 2010 competition. Over the summer of 2010 they refined and improved the control software (written in C) to add more precision and capabilities. They decided to use a similar system for the 2011 competition. They copied large sections of unmodified code over into the control software of the new ROBOT (also written in C). This would be a violation of the schedule constraint, and would not be allowed.

Example: The same TEAM decides to use the LabView as their software environment for 2011. Following kickoff, they use the previously-developed C code as a reference for the algorithms and calculations required to implement their omni-directional control solution. Because they developed new LabView code as they ported over their algorithms, this would be permitted.

Example: A different team develops a similar solution during the fall, and plans to use the developed software on their competition ROBOT. After completing the software,

<R23> During the BUILD SEASON, teams are to design and fabricate all the COMPONENTS and MECHANISMS required to complete their ROBOT. When the ROBOT shipment deadline arrives, all work on the ROBOT must cease and the ROBOT must be placed in a “hands-off” condition. The entire ROBOT (including all FABRICATED ITEMS intended for use during the competition in alternative configurations of the ROBOT) must be crated or bagged (as appropriate for your event), and out of team hands by the shipment deadline specified in the ***FRC Administrative Manual, Section 5*** (with the exception of the items covered by the WITHHOLDING ALLOWANCE).

Teams are encouraged to use all the materials, sources and resources available to them that are in compliance with the rules of the 2011 FRC during the BUILD SEASON. There is no limit to the amount of time that may be put into this effort during the BUILD SEASON, other than via the realities of the calendar.

<R24> During the period between ship date and the competitions, all teams may manufacture SPARE, REPLACEMENT, and UPGRADE PARTS, and develop software for their ROBOT at their home facility.

Teams may continue development of any items retained under the WITHHOLDING ALLOWANCE during this period, and then bring them to the competition events.

The primary intent of this rule is to allow teams to withhold the ROBOT control system, the OPERATOR CONSOLE, and selected relevant subsystems and access them after the shipping deadline. This will allow teams to have the maximum time possible prior to each competition event to develop and complete the software for their ROBOT while maximizing the potential capabilities provided by the control system.

<R25> While at competitions, teams may repair, modify or upgrade their competition ROBOT. To support this, teams may bring SPARE, REPLACEMENT and UPGRADE PARTS and COTS items to the competitions (within the limits specified in Rule <R33>). Work can only be done on-site in the pits or at any facility made available to all teams at the event (e.g., in a team's repair trailer or a local team's shop offered to all teams to use). Fabrication may be done when the pit area is open for normal operations during the period starting with the opening of the pit area on the first day of the competition event and ending at 4:00PM on last day of the event. All work must be stopped when the pit area closes each evening. Parts shall not be removed from the competition site and retained overnight after the pit area closes. At the conclusion of a regional competition event, the entire ROBOT (including all FABRICATED ITEMS intended for use during the competition in alternative configurations of the ROBOT) must be bagged or crated and out of team hands for shipping to the next event or back to the team.

Exception: A limited amount of FABRICATED ITEMS (not to exceed the limits specified in Rule <R33>) may be retained as part of the WITHHOLDING ALLOWANCE and brought back to the team's home facility for continued development.

<R26> During the periods between events, all teams (not just those teams attending a Regional Competition) may utilize the same opportunities, and must operate under the same restrictions as specified in Rule <R24>.

4.3.7 Material Utilization

<R27> Robots entered into the 2011 FRC shall be fabricated and/or assembled from COMPONENTS, MECHANISMS and COTS items that are constructed from:

A. Items provided in the KOP (or their exact REPLACEMENT PART)

B. Additional parts and materials as permitted in these Rules, in quantities consistent with the Budget Constraint rules (found in ***Section 3.4.4***). The use of non-KOP items or materials shall not violate any other robot design or fabrication rule.

<R28> COTS items that are generally available may be used on the ROBOT. The parts shall be generally available from suppliers such that any other *FIRST* team, if it so desires, may also obtain them at the same price. A specific device fabricated by a team from non-KOP materials for use by that team does not have to be available to others; however, the materials from which it is made must be available to other teams.

<R29> COTS items from ROBOTS entered in previous *FIRST* competitions or COTS items that are no longer commercially available may be used under the following conditions:

A. The item must be functionally equivalent to the original condition as delivered from the VENDOR (e.g. a part that has non-functional label markings added would be permitted, but a part that has device-specific mounting holes added would be prohibited), and

B. The item must satisfy ALL applicable 2011 FRC materials/parts use rules.

<R30> Parts custom-made for *FIRST* and provided to FRC teams in the KOP for previous FRC competitions (e.g. 2006 FRC transmissions, custom-made motor couplers, custom sensor strips, FRC CMUcam II modules, etc.) may be used if the part is still functionally equivalent to the original condition.

<R31> Lubricants may be used only to reduce friction within the ROBOT. Lubricants shall not be allowed to contaminate the FIELD or other ROBOTS.

<R32> Teams may acquire and bring an unlimited amount of COTS items to the competitions to be used to repair and/or upgrade their ROBOT at the competition site.

<R33> Teams may bring a maximum of 30 pounds of custom FABRICATED ITEMS (SPARE PARTS, REPLACEMENT PARTS, and UPGRADE PARTS, plus all WITHHOLDING ALLOWANCE items) to each competition event to be used to repair and/or upgrade their ROBOT at the competition site. All other FABRICATED ITEMS to be used on the ROBOT during the competition shall arrive at the competition venue packed in the shipping crate or lockout bag with the ROBOT.

There are two exceptions to this rule:

A. the OPERATOR CONSOLE is not included in the incoming parts weight restriction,

B. the MINIBOT is not included in the incoming parts weights restriction, and

C. any competition legal12V batteries and their associated half of the Anderson cable quick connect/disconnect pair (including no more than 12” of cable per leg, the associated cable lugs, connecting bolts, and insulating electrical tape) are not included in the incoming parts weight restriction.

4.3.8 Power Distribution

<R34> The only legal source of electrical energy for the ROBOT/HOSTBOT 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 2011 KOP. Batteries integral to and part of a COTS computing device are also permitted (i.e. laptop batteries), provided they’re only used to power the COTS computing device.

Teams may use other equivalent 12V batteries during development, testing and practice MATCHES.

<R35> 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 <R34> the MINIBOT battery, or a battery contained in a COTS computing device,

B. circuit breakers used on the PD (PD) Board that are different from the Snap Action breakers provided in the KOP,

C. PD panels and/or fuse panels different other than the single PD Board provided in the 2009, 2010, or 2011 KOP, and

D. non-copper wiring.

<R36> 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.

<R37> The 12V battery, the main 120-amp circuit breaker, and the PD Board shall be connected as shown in Figure 3-4. In particular:

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 KOP 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 PD 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 PD Board must be made with #6 AWG (4.11mm) 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 PD Board and all circuit breakers must be easily visible for inspection.

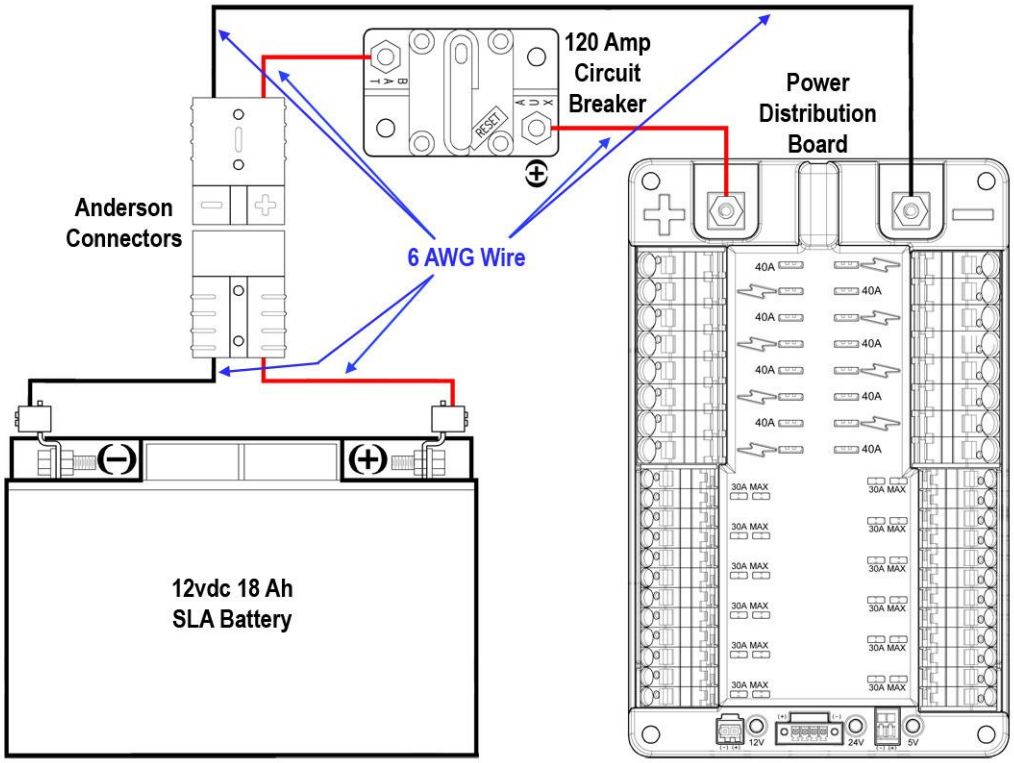


Figure 4-4

<R38> All electric power utilized by the ROBOT shall be distributed from the load terminals of the PD Board. Circuits may not bypass the PD 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 PD Board. With the exception of one Solenoid Breakout Board, no other electrical load can be connected to these terminals.

B. The radio power feed must be connected via the 5V converter (model # TBJ12DK025Z) to the marked 12 Vdc supply terminals located at the end of the PD Board (i.e. the terminals located between the indicator LEDs, and not the main WAGO connectors along the sides of the PD Board). No other electrical load can be connected to these terminals (please see the *2011 Robot Power Distribution Diagram* posted online at www.usfirst.org/frc/kitofparts for wiring information).

C. All other branch circuits must connect to, and have power sourced solely by, a protected 12 Vdc WAGO connector pair on the PD Board.

D. Only one wire shall be connected to each WAGO connector on the PD 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.

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 PD Board, they are protected by the 20-amp breaker at the circuit root.

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 PD Board, they are protected by the 20-amp breaker at the circuit root. No other electrical load can be connected to these sources.

<R39> All active PD 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 PD Board. No other electrical load can be connected to the breaker supplying this circuit.

B. Each relay module branch circuit must be protected with one and only one 20-amp circuit breaker on the PD 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 PD Board. No other electrical load can be connected to the breaker supplying this circuit.

D. If the compressor is used, the 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 PD 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 PD Board.

In addition to the required branch power circuit breakers, smaller value fuses or breakers may be incorporated into custom circuits for additional protection.

<R40> All active PD Board branch circuits shall be wired with appropriately sized wire:

Application	Minimum wire size
40A circuit	12 AWG (2.052mm)
30A circuit	14 AWG (1.628mm)
20A circuit	18 AWG (1.024mm)
between the PD Board and the Analog and/or Solenoid Breakouts if a common power feed is used	18 AWG (1.024mm)
between the PD Board and the Analog and/or Solenoid Breakouts if individual power feeds are used	20 AWG (0.8128mm)
between the PD Board and the cRIO-FRC	20 AWG (0.8128mm)
between the PD Board and the radio	20 AWG (0.8128mm)
pneumatic valves	24 AWG (0.5106mm)

<R41> All active PD 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.

<R42> Each power-regulating device (speed controller or relay module) shall control one and only one electrical load (motor, actuator or compressor).

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.

<R43> Custom circuits shall NOT directly alter the power pathways between the battery, PD 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.

<R44> 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 PD Board, and do not affect the operation of other control system components.

4.3.9 Motors & Actuators

<R45> Motors specifically permitted on 2011 FRC ROBOTS include:

A. all motors, actuators, and servos listed in the ***2011 KOP Checklist***,

B. an unlimited number of COTS servos with a maximum power rating of 4W ,

> The burden of proof that the servo meets the criteria is on the team. The team must show the appropriate data sheet to the inspector.

C. one or two additional 2½" CIM motors (part #FR801-001, M4-R0062-12, AM802-001A, or PMR25R-45F-1003) in addition to those provided in the KOP. This means that up to four, and no more, 2½" CIM motors can be used on the ROBOT,

D. up to four, in any combination, of the BaneBots motors provided in the KOP (RS-775, RS-550, RS-540, RS-395),

Example combinations include, but are not limited to,
- four RS-775s,
- one of each motor
- two RS-775s and two RS-550s,
- three RS-540s and one RS-395.

E. identical one-to-one SPARE PARTS for motors, actuators, and servos provided in the 2011 KOP that may have failed or become damaged,

F. drive motors or fans that are part of a speed controller or COTS computing device.

<R46> 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 <R45>.

Electric solenoid actuators (note: electric solenoid actuators are NOT the same as pneumatic solenoid valves – the latter are permitted, the former are not).

<R47> 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 electrical input leads on the motors may be trimmed to length as necessary.

C. The locking pins on the window motors may be removed.

The intent of this rule is to maintain the maximum power level for each ROBOT, yet still 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.

<R48> 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 approved 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.

4.3.10 Control, Command & Signals System

The FRC robot control system has been designed to provide advanced capabilities for the ROBOTS. The system has been designed around an open architecture that will allow teams to easily develop custom software to control the ROBOT and add electronics and custom circuits to expand the functionality of the ROBOT. Custom circuits may be used to indirectly affect the robot outputs by providing enhanced sensor feedback to the cRIO-FRC to allow it to more effectively control the ROBOT.

Note that with increased capability comes increased responsibility. Teams are ultimately responsible for any software bugs introduced into the standard robot control software, or undesirable effects from added custom circuits. So, teams will have to exercise care to prevent these conditions. To assist with this, teams are encouraged to investigate, learn and practice industry-standard software Validation and Verification (V&V) techniques and develop thorough hardware testing plans.

The control system hardware is provided to rookie teams in the 2011 KOP. Veteran teams are required to reuse control system hardware provided in earlier KOP, or purchase exact SPARE PART equivalents for use on their 2011 FRC ROBOTS.

<R49> ROBOTS must be controlled via the programmable National Instruments cRIO-FRC (National Instruments part number 780406-01). Other controllers shall not be used.

<R50> Connections to the cRIO-FRC Ethernet ports must be compliant with the following parameters:

A. The DAP-1522 radio is connected to the cRIO-FRC Ethernet port 1 (either directly or via a CAT5 Ethernet pigtail).

B. Ethernet-connected COTS devices or custom circuits may connect to either cRIO-FRC Ethernet port; however, these devices may not transmit or receive UDP packets using ports 1100-1200 except for ports 1130 and 1140.

<R51> The cRIO-FRC , Driver Station software, and radio must be configured to correspond to the correct team number (assigned to the team by *FIRST*). The procedures for configuring these devices are contained in the FRC control system documentation.

<R52> One D-Link DAP-1522 is the only permitted mechanism for communicating to and from the ROBOT during the MATCH. All signals must originate from the OPERATOR CONSOLE and/or the Field Management System, and be transmitted to the ROBOT via the official ARENA hardware. 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).

<R53> The DAP-1522 radio must be mounted on the ROBOT such that the diagnostic lights are visible to FIELD personnel.

> Teams are encouraged to mount the radio away from noise generating components such as the CIM motors. By making the diagnostic lights visible, FIELD personnel are in a better position to assist teams.

<R54> ROBOTS shall use the diagnostic Robot Signal Light (RSL) 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 NORMAL CONFIGURATION. The team has no direct control over the RSL and no programming is required.

A. The RSL must be connected to the “RSL” supply terminals on a Digital Sidecar

> See the ***2011 Robot Data Diagram*** on the KOP website (www.usfirst.org/frc/kitofparts) and the item bulletin online at http://literature.rockwellautomation.com/idc/groups/literature/documents/in/41063-177-01.pdf for connection details.

B. The Digitial Sidecar must be connected to a NI 9403 module in Slot 4 of the cRIO-FRC.

C. The RSL must be wired for “solid light” operation, by placing a jumper between the La and Lb terminals on the light per Figure 3-5.

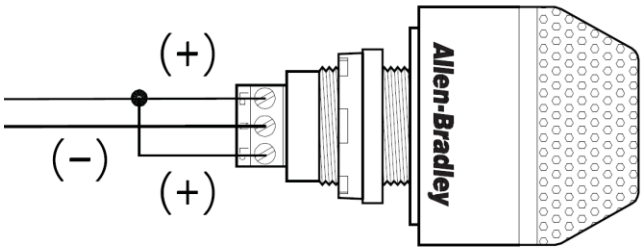


Figure 4-5

<R55> The control system is designed to allow wireless control of the ROBOTS. The Driver Station software, FirstTouch I/O module, cRIO-FRC, speed controllers, relay modules, radio, and batteries 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 code in the cRIO-FRC may be customized.

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

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

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

E. A fuse on a relay feeding the compressor may be replaced with a 20 Amp Snap-Action circuit breaker.

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

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

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

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

J. 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).

K. If CAN-bus functionality is used, the Jaguar firmware may (must) be updated as required by *FIRST* (see Rule <R58-D>).

L. The First Touch I/O module's firmware may be modified.

Please note that the Driver Station application is a separate application from the Dashboard. The Driver Stations software may not be modified, while teams are expected to customize their Dashboard code.

Note that if you are using the FirstTouch I/O module as part of the OPERATOR CONSOLE, you should not update the firmware if the manufacturer releases a new version. The new version will wipe out the *FIRST* custom firmware and your FirstTouch I/O module will no longer function with the Driver Station software.

<R56> 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.)

<R57> Every relay module, servo, and PWM 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.

<R58> Each Jaguar 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 may not 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.

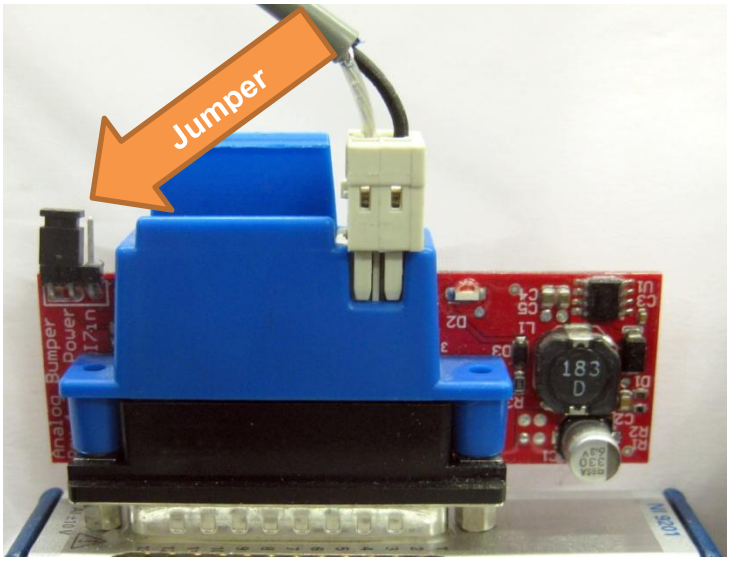
D. If the CAN-bus configuration is used, the firmware on all Jaguar speed controllers must be updated to at least Version 92 of the official *FIRST* firmware.

<R59> If CAN-bus communications are used, the CAN-bus must be connected to the cRIO-FRC through either the Ethernet network connected to Port 1, Port 2, or the DB-9 RS-232 port connection.

A. Ethernet-to-CAN bridges or RS-232-to-CAN bridges (including the “black” Jaguars, MDL-BDC24) may be used to connect the CAN-bus to the cRIO-FRC.
B. Additional switches, sensor modules, custom circuits, third-party modules, etc. may also be placed on the CAN-bus.
C. 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 bridge is acceptable as the commands are not altered).

<R60> Solenoid Breakout outputs shall be connected to pneumatic valve solenoids only. No other devices shall be connected to these outputs.

<R61> 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 PD Panel. (Please refer to the 2011 FRC Control System Manual for details 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.

<R62> 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 RS-232 port on the cRIO-FRC, or

F. the Ethernet network connected to either Port 1 or 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 <R58> and Rule <R59>, or

H. the sensor inputs on the Jaguar speed controller.

Custom circuits and additional electronics are allowed to utilize the Port 2 Ethernet bus and/or the CAN-bus to communicate between devices. Note however, that the ROBOT must be controlled by the cRIO-FRC (see Rule <R49>). Thus, any additional devices on the Ethernet or CAN-bus must not provide command signals that do not originate from the cRIO-FRC It is our intent to incrementally open access to the full control system technologies in a controlled manner that reduces the risk of "unanticipated surprises" as we gain experience with the system.

<R63> 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 <R47> or Rule <R62>. Acceptable signal filters are:

- A one microfarad (1 µF) 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

<R64> 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) prior to the event and tested for communications interference at the venue. Such devices, if reviewed and approved, are excluded from Rule <R52>.

4.3.11 Pneumatic System

<R65> 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.

<R66> In addition to the items included in the KOP, pneumatic system items specifically permitted on 2011 FRC ROBOTS include the following items. All included items must be "off the shelf" COTS pneumatic devices rated by their manufacturers for working pressure of at least 125psi and burst pressure of 250psi, and used in their original, unaltered condition (except as required for assembly with other components).

A. Pneumatic pressure vent plug valves functionally equivalent to those provided in the KOP,

> Parker valves PV609-2 or MV709-2 are recommended.

B. Solenoid valves with a maximum ⅛" 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).

C. Solenoid valves that are rated for a maximum working 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. Additional 0.160" 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,

E. Pressure transducers, pressure gauges, and connecting fittings,

F. Pressure regulators with a maximum bypass pressure of no more than 60psi,

G. For the purposes of the FRC, 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).

H. For the purposes of the FRC, 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).

I. For the purposes of the FRC, 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).

J. Pneumatic cylinders.

K. Pneumatic storage tanks.

<R67> Items specifically PROHIBITED from use on the ROBOT include:

A. Any pneumatic part or component rated for less than 125psi (with the exception of those expressly permitted in Rule <R66>.

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.

<R68> 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.

A. Pressure gauges to display the "stored" and "working" air pressure (see Rule <R70>),

B. A pressure relief valve, calibrated and set to release at 125psi (see Rule <R71>),

C. A pressure switch, calibrated and connected to the ROBOT control system (see Rule <R72>),

D. An easily visible and accessible pressure vent plug valve to manually relieve the stored pressure (see Rule <R73>).

<R69> Compressed air for the pneumatic system on the ROBOT must be provided by one and only one compressor. This compressor may be either the compressor from the KOP, or an equivalent compressor that does not exceed any of the KOP compressor performance specifications (specifically: nominal 12v, 1.03 cfm flow rate, 120psi maximum working pressure). Compressed air shall not come from any other source. Off-board compressors must be controlled and powered by the ROBOT.

If an alternative compressor is used, the team may be required to provide documentation to show compliance with the performance specifications.
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.
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.

<R70> "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.

A. All “working” pneumatic components (e.g. valves, cylinders, rotary actuators, etc.) must be downstream from this regulator.

B. 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.

C. Pressure gauges must be placed in easily visible locations upstream and downstream of the regulator to display the “stored” and “working” pressures.

D. If the compressor is not included on the ROBOT (under the provisions of Rule <R69>), the regulator and high-pressure gauge 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.

<R71> The relief valve must be attached directly to the compressor.

If necessary, teams are required to adjust the relief valve to release air at 125psi. The valve may or may not have been calibrated prior to being supplied to teams.

<R72> The 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.

<R73> The 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 (see Rule <R69>).

<R74> Each commanded motion of a pneumatic cylinder or rotary actuator must be accomplished via the flow of compressed air through only one approved pneumatic valve. Plumbing the outputs from multiple valves together into the same input on a pneumatic cylinder is prohibited.

4.3.12 Operator Console

<R75> The Driver Station software provided on the FRC website (www.usfirst.org/frc/kitofparts) is the only tool permitted to collate driver/operator inputs and communicate them to the ROBOT. The Driver Station software must be revision 01.05.11.00 or newer.

Teams are permitted to use a portable computing device of their choice (laptop computer, PDAs, etc.) to host the Driver Station software while participating in competition MATCHES.

Please note that 19V DC, 2A power will be provided at the PLAYER STATION for Classmates provided in the 2010 and 2011 KOPs via Classmate power adapters. The manufacturer has confimed that the power supply provided at the PLAYER STATION is compatible with both 2010 and 2011 Classmate versions. No 120VAC port will be available.

The FMS will verify that the Driver Station software is correct before it will permit a ROBOT to operate on the FIELD.

<R76> Devices hosting the Driver Station software may only interface with the Field Management System (FMS) via the Ethernet cable provided at the PLAYER STATION. 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

Teams are strongly encouraged to use pigtails on the Ethernet port used to connect to the FMS. Such pigtails will reduce wear and tear on the port and, with proper strain relief employed, will protect the port from accidental jerks.

<R77> The OPERATOR CONSOLE designed by the team must fit on the 60” wide by 12” deep shelf in the ALLIANCE STATION (excluding any items that are held or worn by the DRIVERS during the MATCH).

<R78> The OPERATOR CONSOLE must include a graphic display to present the Driver Station disgnostic information. It must be positioned within the OPERATOR CONSOLE so that the screen display can be clearly seen during inspection and during operation in a MATCH.

<R79> 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.

Examples of prohibited wireless systems include, but are not limited to, active wireless network cards and Bluetooth devices.

<R80> The E-Stop button provided in the KOP shall not be included as part of the OPERATOR CONSOLE during competition MATCHES.

Competition versions of this device is included in the ARENA, and the KOP version is duplicative.

4.3.13 ROBOT Inspection

<R81> 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.

<R82> At the time of inspection, teams must submit an electronic copy of their Bill Of Materials (BOM) of all items used in the construction of their ROBOT, and their associated costs, to the inspector (see Rule <R18>). BOMs must be transferred to inspectors at the event via USB drive (inspector or team provided).

<R83> The ROBOT will be inspected for compliance with the dimension constraints specified in Rule <R11> while in its STARTING CONFIGURATION, by being placed within a 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.

<R84> All decorations must be on the ROBOT at the time of final inspection.

<R85> Any ROBOT construction technique or element that is not in compliance with the Robot Rules must be rectified before a ROBOT will be allowed to compete or continue competing. ROBOTs must fully pass inspection before they will be allowed to compete in Qualification Rounds.

<R86> ROBOTS will normally be allowed to participate in scheduled practice MATCHES prior to passing inspection. However, the lead inspector and/or head referee may determine at any time that the ROBOT is unsafe, and may prohibit further participation in practice MATCHES until the condition is corrected and the ROBOT passes inspection.

<R87> 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.

<R88> If a ROBOT is modified after it has passed inspection, that ROBOT must be re-inspected.

If an observation is made that another team's ROBOT may be in violation of the robot rules, please approach *FIRST* officials to review the matter in question. This is an area where Gracious Professionalism is very important

<R89> *FIRST* Officials may randomly re-inspect ROBOTS participating in competition MATCHES to assure compliance with the rules.

<R90> 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 and air pressure 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.

A. The ROBOT design requires power or a charged stored energy device in order to confirm that the ROBOT meets volume requirements *AND*

B. the team has included safety interlocks that prevent unexpected release of such stored energy.

4.3.14 MINIBOT

<R91> The MINIBOT may not exceed a 12” x 12” x 12” volume and weigh no more than 15 lbs.

MINIBOTS will be inspected for the volume constraint by being placed in a five-sided box with internal dimensions of 12" x 12" x 12". If the lid (the sixth side of the cube) does not seat properly, the MINIBOT does not pass this part of the MINIBOT inspection.

<R92> The following items are the only permitted materials for use on the MINIBOTS:

A. TETRIX components that are not in violation of any other rules,
B. no more than two motors (PN W739083),
C. exactly one 12V rechargeable NiMH battery pack identical to those supplied in the FTC kit of parts (PN W739057)
D. No more than one HiTechnic DC motor controllers,
E. No more than one NXT controller with the Bluetooth functionality disabled,
F. Polycarbonate,
G. Polycarbonate glue,
H. Aluminum sheet, 90° angle, u-channel, tube, bar,
I. rivets,
J. non-metallic rope or cord,
K. wire nuts,
L. cable ties,
M. limit switches,
N. no more than two common household light switches,
O. electrical hookup wire,
P. non-slip pad,
Q. PVC or CPVC pipe,
R. PVC cement or cleaner,
S. Mechanical hardware (i.e. screws, bolts, etc) ,
T. Loctite or similar thread-locking product,
U. Rubber bands,
V. Surgical tubing,
W. Electrical tape and shrink tubing,
X. PWM extension cables,
Y. Universal security clips to hold the PWM connectors together,
Z. Hook and loop fastener (may not be used as tape),
AA. Magnets, and
BB. NXT compatible sensors and related connectors/cables.

Use of glues/cements may not be allowed in the pits at tournaments based on site-specific rules.

Please note that the FTC Samantha module is not considered a TETRIX component and is not permitted on the MINIBOT.

<R93> Motors may not be modified with exceptions of those in Rule <R47>.

<R94> The MINIBOT must be designed such that it can easily be removed from the TOWER at the end of the MATCH.

4.3.15 MINIBOT Inspection

MINIBOT use is independent of the ROBOT inspection. For example, any FTC team can bring a MINIBOT to an event, get it inspected, and if legal, that MINIBOT can compete with any FRC ROBOT (that has passed ROBOT inspection). There are legal HOSTBOTS and legal MINIBOTS; they are independent of each other regarding inspection.

<R95> At the time of inspection, the MINIBOT must be presented with all MECHANISMS (including all COMPONENTS of each MECHANISM), decorations, and configurations that will be used on the MINIBOT during the entire competition event. It is acceptable, however, for a MINIBOT 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 MINIBOT must still meet all inspection criteria.

<R96> At the time of inspection, teams must submit an electronic copy of their Bill Of Materials (BOM) of all items used in the construction of their MINIBOT to the inspector. BOMs must be transferred to inspectors at the event via USB drive (inspector or team provided).

<R97> The MINIBOT will be inspected for compliance with the dimension constraints specified in Rule <R91> by being placed within a 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 MINIBOT can break the plane of the sides or top of the Sizing Device during size inspection.

<R98> Any MINIBOT construction technique or element that is not in compliance with the MINIBOT Rules must be rectified before a MINIBOT will be allowed to compete or continue competing.

<R99> MINIBOTS must fully pass inspection before being allowed to compete in any Qualification Matches.

<R100> MINIBOTS will normally be allowed to participate in scheduled practice MATCHES prior to passing inspection. However, the lead inspector and/or head referee may determine at any time that the MINIBOT is unsafe, and may prohibit further participation in practice MATCHES until the condition is corrected and the MINIBOT passes inspection.

<R101> If a MINIBOT is rejected by inspectors due to a safety issue or concern related to the team's method of storing energy, the concerned items must be disabled or removed from the MINIBOT 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.

<R102> If a MINIBOT is modified after it has passed inspection, that MINIBOT must be re-inspected.

<R103> *FIRST* Officials may randomly re-inspect MINIBOTS participating in competition MATCHES to assure compliance with the rules.

4.1 REVISION HISTORY

Revision	Release Date	Changes
-	1/5/11	Original release

A	1/11/11	Section 4.2: Revised text to describe the correct location of the definitions.
		Revised <R03> so that rule references were not highlighted
		Revised <R11> to change the maximum horizontal dimension for the ROBOT PLAYING CONFIGURATION from 60” to 84”
		Revised <R16>, Text box: replaced “LogoMotion” with “LOGO MOTION™”
		Revised <R45> to include alternate CIM motor part numbers AM802-001A and PMR25R-45F-1003.
		Revised <R75> to fix a typo (inserted “to”)
		Revised <R92> to clarify that Tetrix parts must be legal per other rules and allow NXT sensors and related cables and connectors
		Added a Blue Box to the beginning of Section 4.3.15 to clarify the distinction between MINIBOT and HOSTBOT inspection
		Added ***Section 4.1, Revision History***
B	1/14/11	Revised <R66> to include pneumatic cylinders and storage tanks.
		Revised <R91> to include information about how MINIBOT size will be inspected
		Revised <R92-O> to relieve constraint on wire guage on the MINIBOT