



Request for Proposal – FRC Wireless Solution

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2. FIRST® Robotics Competition Overview

The FIRST Robotics Competition, FRC®, is a unique varsity Sport for the Mind™ designed to help high-school-aged young people discover how interesting and rewarding the lives of engineers and scientists can be. FRC stages short games played by robots. The robots are designed and built in a limited time frame (from a common set of parts) by a team of high-school-aged young people and their mentors. FRC teams program and remotely control the robots in competition rounds on a competition field comparable in size to a volleyball court.

Teams typically organize in the fall. The annual FRC Kickoff in early January starts the short “build” season. Competitions take place in March and April in arenas worldwide. They involve 40 to 70 teams cheered by thousands of fans over three days. Championship-level events cap the season. Referees oversee the competition. Judges evaluate teams and present awards for design, technology, sportsmanship, and commitment to FIRST. The Chairman’s Award is the highest honor at FIRST and recognizes a team that exemplifies the values of FIRST.

3. Project Overview

The current FRC Robot Control System is a custom configuration of devices from various suppliers used by teams to program and wirelessly control actuators and sensors on their robots. Details about the existing FRC control system are hosted on the FIRST website [here](#).

The wireless solution used by FRC has evolved over the last decade. The history is described below.

	When	What (Robot side)	What (Client side)
Innovation First, Inc.	2001-2008	900MHz Serial Radio	900MHz Serial Radio
Linksys/Cisco Solution	2009 - 2010	Linksys Dual Band Gaming Adapter (WGA600N)	Home - Linksys Wireless N Broadband Router (WRT160N) Field - Cisco 1250 series 5GHz AP
DLink/Cisco Solution	2011-2015	D-Link Combo Bridge/AP (DAP-1522)	Home - Laptop client (DAP as AP) Field - Cisco 1250 Series 5GHz (DAP as bridge)
OpenMesh/Cisco Solution	2016	OpenMesh OM5P-AN Dual Band AP running OpenWRT	Home - Laptop client (OM5P as AP) Field - Cisco 1250 Series 5GHz (OM5P as bridge)
OpenMesh/Linksys Solution	2017-*	OpenMesh OM5P-AN or OM5P-AC Dual Band AP running OpenWRT	Home - Laptop client (OM5P as AP) Field - Linksys AP (WRT1900 ACS running OpenWRT, OM5P as bridge)

FIRST is seeking a Wireless Solution to facilitate the communication between the “Driver Station” laptop computer (DS) and the mobile robot controller (MRC) used in the current system. Ideally, proposed solutions would be adaptable to a next-generation Robot Control System as well. The proposed wireless system must accommodate



operation at home (individual team) and at events (6 teams on a field with up to 6 fields co-located). If appropriate, the proposed solution may include continuing with the existing hardware for field use (Linksys WRT1900 ACS running OpenWRT).

4. Schedule

The immediate proposal-specific timeline for the FRC Wireless Solution project is outlined below. A detailed proposed schedule for efforts leading up to the 2020 season is included in *Appendix A - Detailed Schedule*. Proposals will also be accepted for the 2019 season; any proposal for the 2019 season should include a detailed proposed schedule to meet the final delivery deadline of September 30, 2018. Respondents are encouraged to include added detail or proposed adjustments as required by their business models (including any FCC testing impact on schedule), as well as a general schedule to support the complete duration of the proposal.

RFP published/distributed:	February 6, 2018
Letters of Intent due to <i>FIRST</i> :	February 23, 2018
Proposals due to <i>FIRST</i> :	March 9, 2018
Final Selection (no later than):	March 31, 2018

5. Project Requirements

FIRST needs a partner that will develop and support a system per the team populations expected below.

2019: 3,900

2020: 4,200

2021: 4,500

2022: 4,800

2023: 5,200

5.1 Manufacturing

Any and all manufacturing efforts must include NRE efforts, material sourcing, production, testing, and quality assurance.

This effort also requires the back-end support for RMAs and warranty support.

5.2 Software/Firmware support

FIRST needs a partner that can recommend, execute, test, and support any firmware or software changes needed to support the next-generation control system.

5.3 Sales

To comprehensively support team competition needs, all components must be available to teams for purchase, in the event that a team needs replacements for damaged units or spare inventory. *FIRST* does not host a store front



to accommodate this and needs a partner that can own inventory, house inventory, host a store front, and process orders in a timely manner (shipping within, at most, two days of a placed order).

Sales may or may not require a passive royalty paid to *FIRST* to be mutually agreed upon by all parties affected.

5.4 Technical Support/Documentation

FIRST is seeking a partner that can provide Wireless Solution technical support for both FRC and FRC teams. A preferred support structure includes the following components:

- a) development support for *FIRST* for any changes required for hardware, firmware, or software
- b) support for incorporating any changes into the FRC software libraries
- c) support for manufacturing efforts (approval of alternate components, updates to relevant files, etc.)
- d) support for FRC teams
 - i. updates to documentation that provide clean, concise instruction and information
 - ii. accessibility for teams that needed additional help via phone, forum, email (preferably all)
- e) Presence at FRC events for triage and technical support during competitions

A product warranty with rapid replacement for critical components during the build season is required.

6. General Requirements

There are a number of considerations for the next generation Wireless Solution that must be addressed in any proposal. The overall objective is to provide a challenging and satisfying experience to for FRC teams. Generally, the FRC desires to *minimize* the following parameters:

- a) complexity (wiring, etc.)
- b) user set up time (20-30 minutes maximum)
- c) cost
- d) size
- e) fragility
- f) boot up time (target is fewer than 20 seconds)

With every system, there are tradeoffs which must be made; to that end, the following criteria are detailed in this document to elaborate on FRC's priorities and expectations for a comprehensive proposal.

The wireless solution shall function in accordance with the top-level block diagram illustrated below in Figure 1.

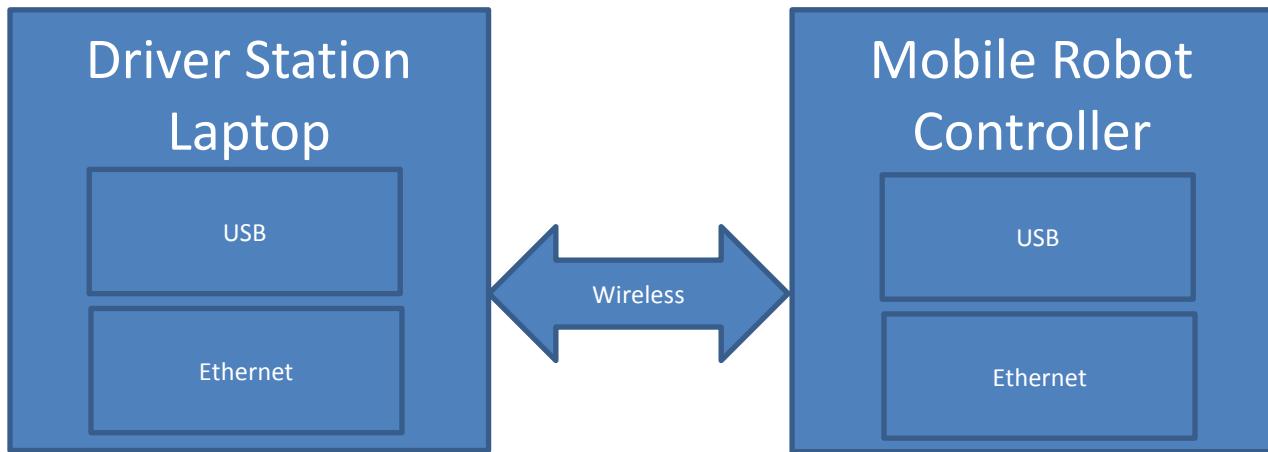


Figure 1: General block diagram for Wireless functionality.

6.1 Safety

Safety must be foremost in the design and operation of all aspects of the FRC Control System.

Safety features must prevent all run-away conditions. The most basic level of safety for every system level is to prevent robot operation in the event of loss of communications. The existing control system has built-in functionality to accomplish this goal; any wireless solution must not compromise this existing functionality (e.g. by delivering excessively stale data).

6.2 Wireless Robot Control Feature Set

This feature set is derived based on experience during the 2009 - 2017 FRC competition seasons.

Required:

- WRC1. Capable of controlling 8 co-located active fields simultaneously with up to 6 robots on each field.
- WRC2. <15ms max latency (5ms average)
- WRC3. Secured communication with no known breaks.
- WRC4. Automated setup for home use and competitions.
- WRC5. Boot and acquisition within 1 minute
- WRC6. Reliable, robust functionality in hostile wireless environments (> 150 other access points, cell phones, AV equipment, etc.)
- WRC7. Powered by either 5V or 12V DC < 2A or unfiltered 5-14V DC (battery voltage).
- WRC8. Factory/initial default setup recovery (may be via external but protected button or software such as a bootloader)
- WRC9. If shared medium, throughput limit per device (1 device sending excess data can't take down the whole network)
- WRC10. Per robot throughput of 4 Megabits/second (Mbps) for 6 robots per field
- WRC11. Must support international use (including but not limited to US, Canada, Mexico, Israel, Turkey, and China)
- WRC12. Must either not require licenses to be obtained and held by FIRST, or must provide a comprehensive plan of license management compatible with FIRST's event model and individual team usage



WRC13. Must meet specifications of WRC2 and WRC10 at a distance of up to 75 ft. between robot and base station.

Desired:

- WRC14. Locking / secured power connection
- WRC15. Mechanical mounting features for teams
- WRC16. Boot and acquisition within 20 seconds
- WRC17. Per robot throughput 10 Mbps
- WRC18. A dedicated power supply for the radio (to protect diagnostic information/tools in the event of a robot power outage/event)
- WRC19. Communication QoS reported and recorded from each member in the network.
- WRC20. On-board data logging

6.3 User Experience

FRC teams present a wide range of technical capacity with diverse backgrounds. It is important for the wireless solution to provide intuitive interfaces and streamlined setup for users. Features promoting system convenience are encouraged.

6.3.1 Simplicity of setup

A user should be able to configure the wireless components for use in 20 minutes or less. This setup time includes:

1. Firmware/software upgrade on the wireless solution.
2. Configuration of any team-specific settings on the wireless solution.
3. Wiring the Wireless Solution into the existing robot control system.

The Wireless Solution must provide for programming and firmware updates (if appropriate) that are non-bricking and can be recovered via a factory settings reset.

6.3.2 Documentation and User Resources

The submission must include a proposed portfolio for comprehensive, yet concise information dissemination to teams. Content shall include, but not necessarily be limited to device specifications, a quick-start guide, a detailed user guide, etc.

A strong bias toward graphical information representation is encouraged. Information distribution that accommodates teams with all levels of resources is crucial, but assumption that each team has access to a computer and the internet is appropriate. Information distributed by additional methods (smart phone app, etc.) are encouraged.

6.3.3 Technical System Diagnostics

The Wireless Solution must have diagnostics to aid in both system setup and troubleshooting. The module level diagnostics should include the ability to verify basic operation and configuration of the various modules including software and hardware revisions. The diagnostics should point the users towards connection level issues as an aid for debugging.



6.4 Robustness

The robot environments (at a home shop, in a team pit, and on the competition field) are a particularly harsh environment with mechanical, electrical and environmental conditions that stress the wireless solution significantly. The wireless solution must be designed to withstand these conditions, assuming at least 4-5 events per season and ideally provide multi-year reliable service. The events are played out in 2 minute 30 second matches with between 9 and 18 matches (including playoffs) spanning 2-3 days. A failure of a module causing a lost match is a negative user experience, the need to maintain the operation of the core components of the system and logging of status is critical.

6.5 Environmental

The robots must operate under standard commercial operating conditions. Industrial operating conditions capacity is desired as robots are operated throughout the summer and in non-air-conditioned venues. Operation in these conditions is expected and must not reduce the lifetime of the devices.

6.6 Mechanical

The mechanical conditions include shock, vibration, and stress due to repeated insertion/removal of module connections. It would not be unusual for the Wireless Solution components installed on a competition robot to experience up to 50Gs during operation and significant vibration (including inverted falls of the robot). The modular nature of the system facilitates swap out of components with the expectation that the connectors will not fail nor become loose or disconnected during operation and be able to sustain hundreds of insertion/removals over the expected lifetime of the modules. Wireless Solution modules must be protected from metal debris induced failures and come with a rugged case.

6.7 Electrical

The electrical environment is harsh both during robot operation and assembly. Reverse battery protection is desired to prevent damage to components due to an oversight or miss wiring of power connections. The robots will encounter significant ESD events both from interaction with the field and humans. ESD protection must be designed in and tested for all devices. Short circuit and overcurrent protection is preferred to ensure that mis-wired, cut, or shorted lines will not damage the module.

6.8 Electro-Magnetic Interference

The wireless solution must be able to withstand the EMI generated by the on-board DC motors. Due to the limited space on the robot, Wireless Solution components will be in close proximity to the DC motors.

6.9 Field Management System (FMS) Interface

The DS must be capable of interfacing with the FMS via an Ethernet interface. The user experience between use on and off the competition field shall be as identical as practically possible.

For background information, the communication between the DS and MRC is currently routed through a central wireless access point on the field. The new wireless solution may continue to use this format or use a new format such as point-to-point wireless communication between each DS/MRC pair. Figure 2 and Figure 3 illustrate the existing architecture.

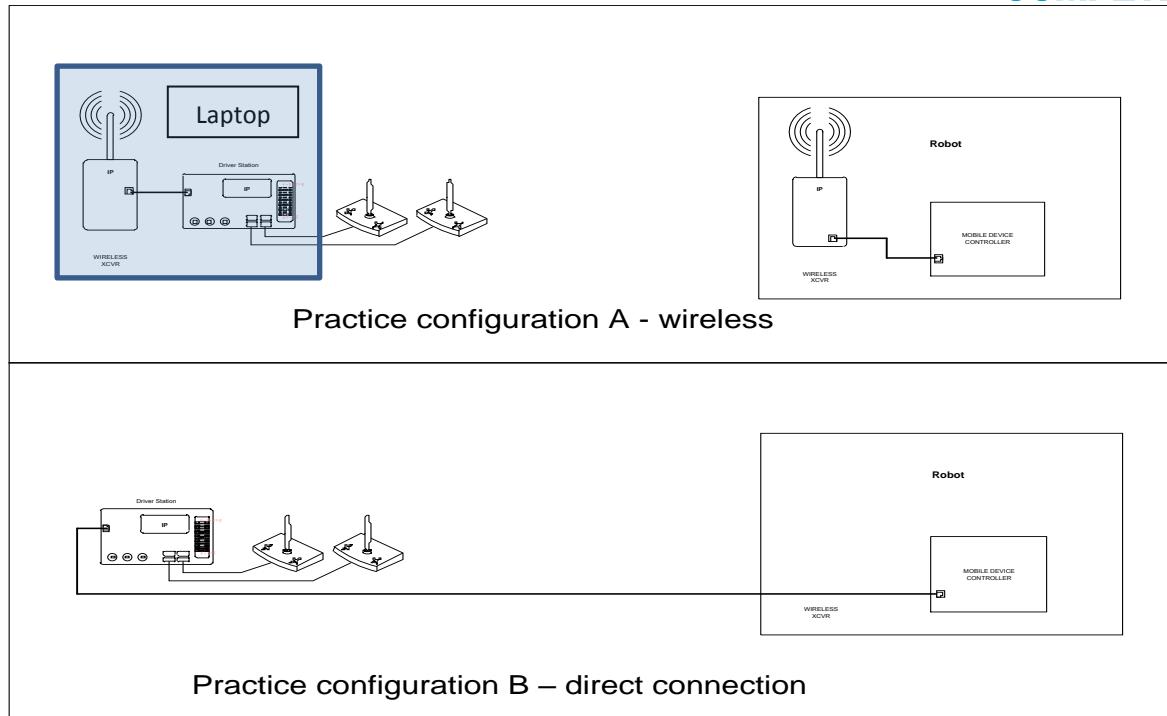
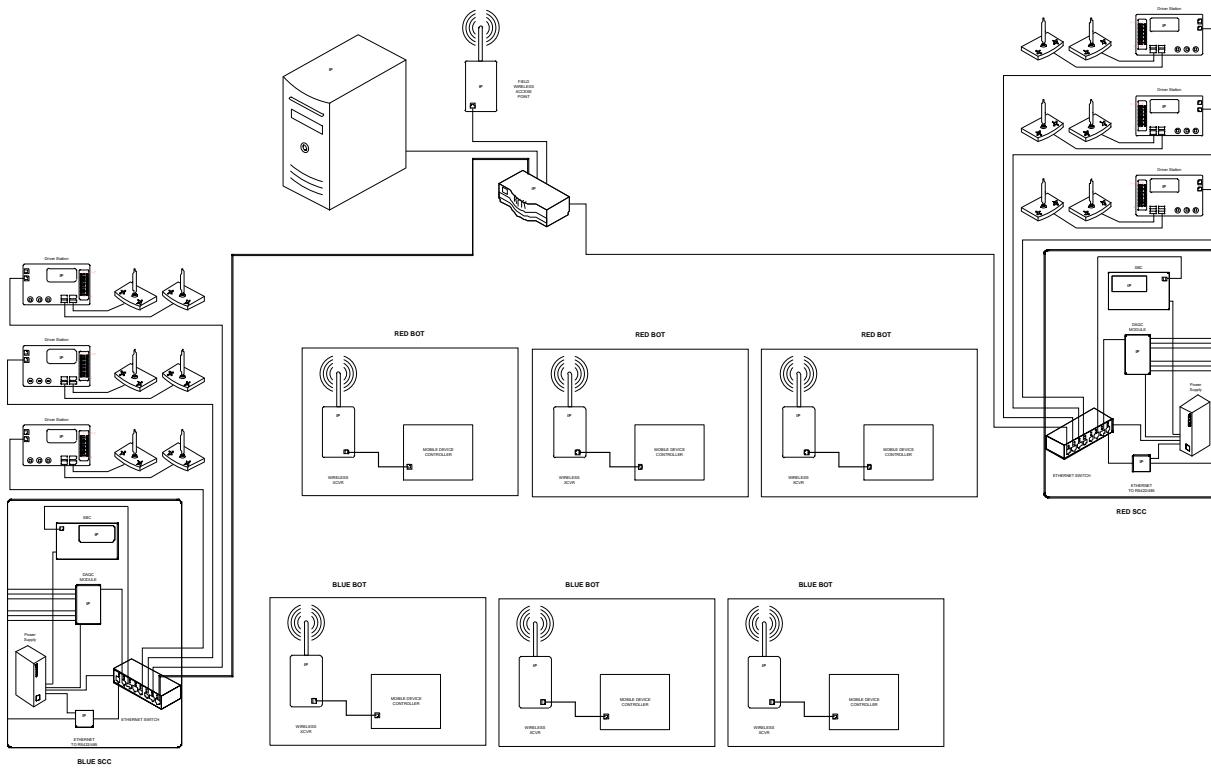


Figure 2: Illustration of current setup for wired and wireless “home” use.



Current Field Setup

Figure 3: Illustration of current field setup.



6.10 Volume Requirements

The size and weight of the wireless solution must be kept to a minimum to ease integration onto robot platforms and enable teams to meet the strict robot weight requirements. The target size for the robot side of a wireless solution should be less than 5"x6"x2". The weight should be less than 1 lb.

6.11 Costing

The Wireless Solution is meant to be easy to implement on robots and affordable for teams. Teams will need at least one full wireless setup while many will likely demand more than one complete setup. The cost of the full solution and sub-components will be a major factor taken into account when evaluating proposals.

- Target cost per system to *FIRST*: \$0
- Target cost per system to sold directly to FRC teams: <\$100

There is a likely chance that *FIRST*, working with the Electronics Component Industry Association, ECIA, and other Suppliers, may minimize material costs. In submitting proposals, please itemize material costs as a separate line item. Also, the manufacturing partner will likely need to incorporate/accommodate donated material (but is invited to include the material commitment and due dates needed to accommodate the manufacturing timeline). *FIRST* assumes that any donated components/materials will be removed from any/all invoiced costs to *FIRST*.

7. Ownership of Materials

All materials submitted in response to this RFP shall become the property of *FIRST*. Proposals and supporting materials will not be returned to suppliers.

8. Proposal Elements

Respondents to this Request for Proposals, RFP, have the option of bidding on all requirements outlined in this document alone, with a suite of partners, or propose a robot-side-only solution compatible with the existing field hardware, as they feel appropriate per their business model.

Supplier Letters of Intent to Bid shall be sent to Erin Weinelt, eweinelt@firstinspires.org, no later than February 23, 2018.

Proposals are due by March 9, 2018 and must accommodate the following layout and content:

8.1 Cover Page

8.2 Transmittal Letter

The supplier shall prepare a brief transmittal letter on their business stationery with a company logo. The transmittal letter should provide all of the following:

- a) The supplier's legal company name and addresses for the office submitting the proposal as well as the address of the company's legal headquarters.
- b) A statement that the person signing this proposal is authorized to make decisions towards the proposal and the prices quoted.



- c) The name, title and telephone numbers of the persons authorized to negotiate the contract on behalf of the organization.
- d) The names, title and telephone numbers of persons to be contacted for clarification of the proposal if needed.

8.3 Section I – Executive Summary

The executive summary shall serve to familiarize *FIRST* executives and evaluators with the key elements and unique features of your proposal by briefly describing what you are proposing to do and how you intend to accomplish the work.

The executive summary shall contain the following:

- a) A summary of your approach to the project, including the main points of all sections. Material should include the business features that make your proposal attractive and different.
- b) A master milestone schedule of all major efforts to be undertaken in the project. Dates shall begin as listed in Section 0 of this RFP.
- c) A list of exceptions taken against this RFP and the reason these exceptions were taken. If an alternative solution or product is being proposed, it should be briefly described.

8.4 Section II – General Company Information

- a) Full legal company name.
- b) Year business started.
- c) State of incorporation or headquarters.
- d) Are you a United States corporation?
- e) Tax identification number.
- f) Brief company history.
- g) Current number of employees.
- h) Are you a public or private corporation?
- i) Is your company currently involved in any litigation in which an adverse decision might result in a material change in the company's financial position or future viability?
- j) Most recent annual audited company financial report or public annual report.

8.5 Section III – Technical Commitments

The technical component of the proposal shall address the requirements listed in this document. Responses shall indicate the specifications they intend to preserve, as well as any they propose to modify. If modifications are proposed, this section must include detail regarding any proposed modifications.

8.6 Section IV – Management Section

In this section, the supplier shall provide information organized into the following sections.

- a) Project Management. Suppliers shall present their company's approach and ability to provide experienced project managers and resources to successfully execute this project.
- b) Maintenance. Supplier shall provide a detailed description of all maintenance activities, daily or monthly support activities and principal period of maintenance.
- c) Education and Training. Supplier shall provide a detailed description of all education and training required for this project.



8.7 Section V – Supplier References

Suppliers shall include a minimum of three references where related contracts have been awarded within the last three years.

8.8 Section VI – Additional Information

Suppliers may submit additional information that is relevant but was not requested in the RFP. This information should clarify or enhance the proposal or provide information about areas in the RFP that are deficient and need to be corrected.

8.9 Section VII - Pricing

Provided that the service or product is not a donation, suppliers are to provide firm, fixed pricing proposals for this project. The pricing section shall include detailed line items and to provide detailed explanations where required.

- a) Manufacturing
 - o Any NRE costs
 - o Unit material cost
 - o Unit production cost
- b) Sales
 - o Projected sales price
 - o Proposed passive royalty to *FIRST*
- c) Software/Firmware Support
 - o Cost of support
- d) Technical Support
 - o Cost to team support during the season
 - o Cost of team support per event

9. Proposal Costs

FIRST is not responsible for any costs incurred by the supplier in the preparation of the proposal, site visit or prototype production and/or demonstrations.

10. Available Project Resources

Upon granting of the bid, *FIRST* will be able to provide the following resources:

- a) Existing system architecture documentation
- b) Existing *FIRST*-owned source & object code for product operation & test/programming

11. Recognition Opportunities

Partner(s) selected to participate in the Control System effort will be eligible for recognition by *FIRST* within the *FIRST* Community. Opportunities for recognition are as follows:

- a) Recognition, based on in-kind contribution value (as stated by the supplier) per the [Supplier Opportunities document](#) (may be updated for following seasons, but the 2018 version provides the general content).



- b) Co-branding opportunity on the wireless solution components (per proof approval by *FIRST*)
- c) Opportunity to interface directly with end users/customers at FRC events to build brand recognition/appreciation.
- d) In-kind contributions to *FIRST* are tax deductible
- e) Networking access to other FRC Suppliers via FRC events

12. Proposal Evaluation Criteria

FIRST is interested a solution that addresses the requirements contained in this RFP. Proposals that meet the instructions and requirements will be given a thorough and objective review. Proposals that are late and do not comply with proposal instructions or take exception to mandatory requirements will be eliminated without further consideration.

FIRST will evaluate proposals based on criteria including, but not necessarily limited to the following (no one criterion will “make or break” a proposal):

- a) Minimized cost to *FIRST*
- b) Minimized cost to teams
- c) Quality of the user experience (Please note: *FIRST* has bias for neither a custom FRC solution nor a system which integrates various components. Both architectures have their own strengths and weaknesses and the solutions presented will be evaluated based on the criteria listed here.)
- d) Confidence in meeting quality standards, including but not limited to process for FOD prevention in components
- e) Confidence in meeting schedule
- f) Comprehensiveness of support proposed to *FIRST* and for end users
- g) Past experience/relationship with organization
- h) Breadth of *FIRST* support
- i) Company health and reputation
- j) Strength of product warranty
- k) Replacement part turn-around time during the build season

13. Non-Disclosure

FIRST requires all suppliers responding to this RFP sign and return a nondisclosure agreement (NDA), included as a separate document, to the address specified in Section 16, Contacts.

14. RFP Amendments

FIRST reserves the right to amend this RFP at any time prior to the submission date.

15. Offer Expiration Date

Proposals in response to this RFP shall be valid for 60 days from the proposal due date.



16. Contacts

FIRST contacts for questions about this proposal are listed below:

FRC Robotics Engineer

Kevin O'Connor

koc Connor@firstinspires.org

603-666-3906 x114

Strategic Sourcing Manager

Erin Weinelt

eweinelt@firstinspires.org

603-666-3906 x226

17. Signatures

 Date: 2/5/18

Erin Weinelt, Strategic Sourcing Manager, Strategic Sourcing

 Date: 2/5/18

Kate Pilotte, Kit of Parts Manager, FRC



18. Appendix A - Detailed Schedule

RFP Effort

- Letter of Intent Due: February 23, 2018
- Proposals Due: March 9, 2018
- Selection Decision (no later than): March 31, 2018

Implementation

- Alpha testing (FIRST HQ): August 1, 2018 – September 30, 2018
- Alpha testing (select teams): October 1, 2018 – November 30, 2018
- Beta testing (Teams/events): October 1, 2018 – November 30, 2018
- Final testing (Teams/events): June 1, 2019 – November 30, 2019
- Purchase Order: May 31, 2019
- Delivery for 2020 KOP: September 30, 2019



19. Appendix B – Acronym Listing

DS: Driver Station

EMI: Electro-Magnetic Interference

ESD: Electro-Static Discharge

FMS: Field Management System

FOD - Foreign Object Damage

FRC: *FIRST* Robotics Competition

MRC - Mobile Robot Controller

NRE – Non Recurring Engineering

QoS - Quality of Service

RMA - Return Material/Merchandise Authorization