# Field Communications and Event Tips

Niv Aharonovich

# Niv Aharonovich

- I'm an FRC Alumni and former mentor
- I'm an FTA (FIRST Technical Advisor) in FRC
  - Formerly a CSA, FTAA and FTC FTA
  - Also formerly of MOST Group and Falafel
- I lived outside Israel most of my life
  - That's why this is in English – sorry

- What I'm not:
  - I'm not an employee of FIRST Israel
  - I'm not involved in designing FRC games, nor am I an authority on game rules.
    - I don't know the game for next year :(

# What are FTAs

- We are responsible for the technical systems during the event
  - Both communications systems and mechanical systems

- We are responsible for on field safety

- We are responsible for the management of the timetables and everything that happens on the field area during the event...
  - We're here to make sure the event runs smoothly, on-time and everything else.

- **We are all FRC Alumni and former Mentors** (all FTAs in Israel)
  - We understand what you're going through during the events
  - **We are here to help you**

- Our top role is to make sure you - the students - get the best, most consistent experience out of the event

We'll get back to what we do soon

# The FTAs



Leav, Shahar and Gal

Marc

Niv

# What will we talk about today

- Understanding the Field

- Connecting to the field

- How we monitor the matches

- Understanding Robot problems (at a basic level)
  - Drivers Station Log Viewer

- Robot Radios

- Coming onto the field

- Additional event and communications tips

# Before we begin

Everything I talk about is based previous years (2017) and our expectations for the future.

Some things may change between years. Don't make assumptions about the rules without checking the manual!
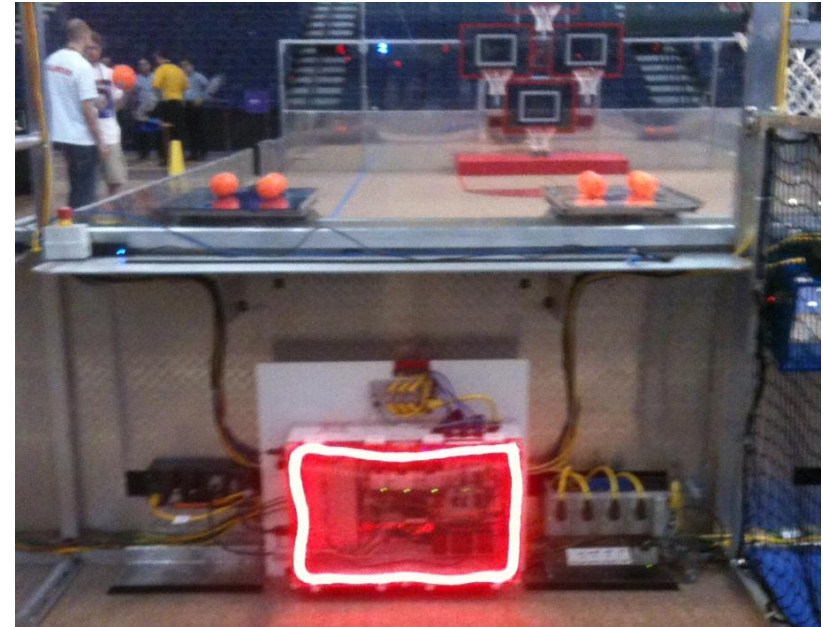
Specifically: firewall rules, robot side things (ie: radios), driver station stuff...

Read the manual, check the screensteps, listen to instructions at events.

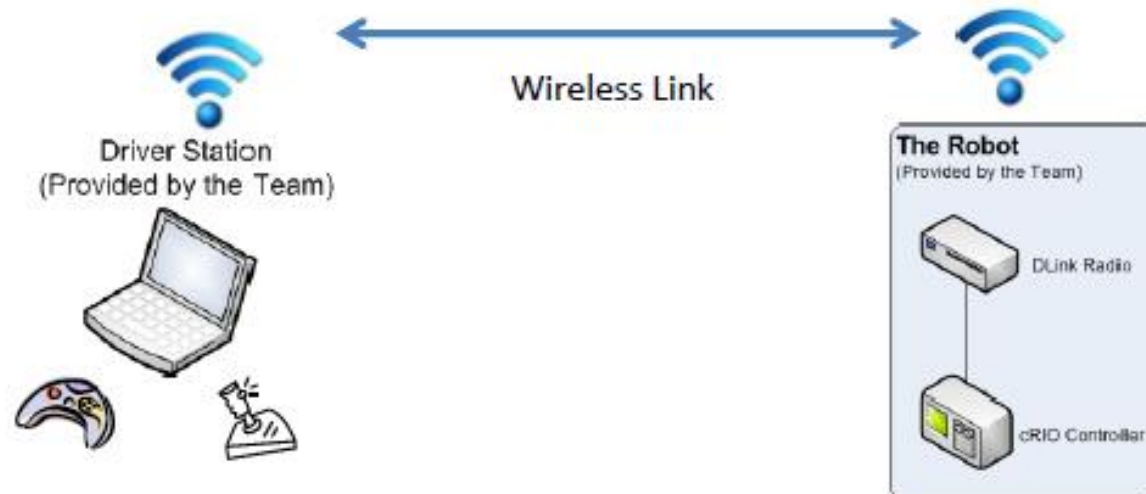# Understanding the Field

# What is the "Field"

- For our purposes – the electronics and software side of the FRC Field
  - The main server case, called "Scorpion"
    - With electronics and equipment inside
  - A "Station Control Cabinet" (SCC) for each side
  - The Field AP (Wireless Access Point)
  - The FMS (Field Management System)

Collectively I will refer to these as the "field systems"

# When you are at home

- Your drivers station connects to your robot's radio (OpenMesh)
  - Robot radio redefined by kiosk to be an Access Point

- Commands (UDP) from your Driver station get sent to your RoboRIO, transferring data (joysticks) and keeping the watchdog 'fed'

- Commands (UDP) from the RoboRio are sent to the Driver Station containing data about the robot's state and data (version numbers, battery voltage, dashboard data)



Driver Station
(Provided by the Team)

Wireless Link

The Robot
(Provided by the Team)

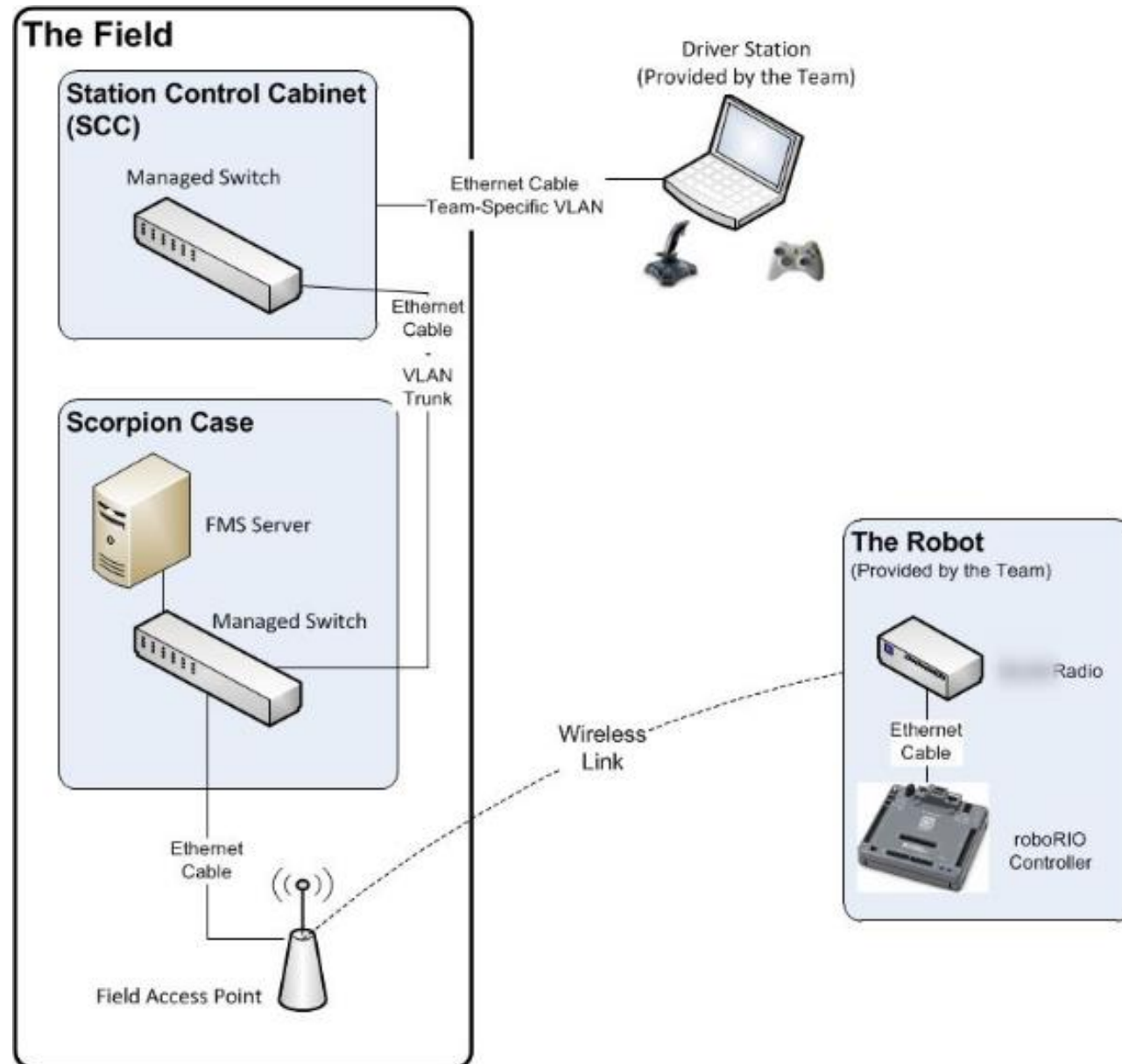DLink Radio

cRIO Controller

# What do the Field systems do?

- Event Management (Creates schedules, alliance selection…)
- Controls field and scoring systems (sensors, LEDs, motors, referee tablets)
- Flows communication between Driver Station and Robot
- Changes Game States
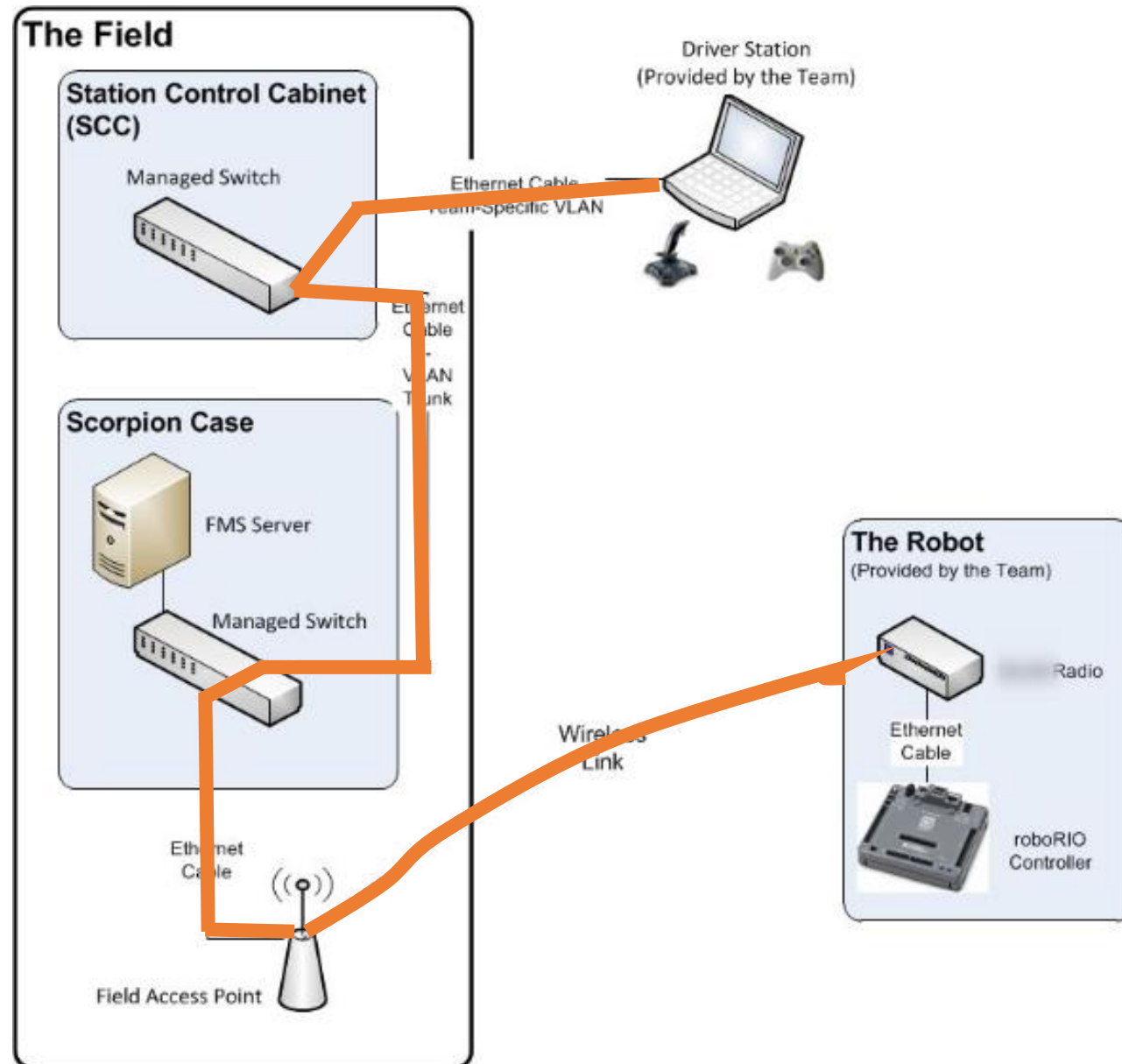- Defines networking structures (DHCP, Firewall…)

# What do the Field systems do?

- Event Management (Creates schedules, alliance selection…)
- Controls field and scoring systems (sensors, LEDs, motors, referee tablets)
- **Flows communication between Driver Station and Robot**
- **Changes Game States**
- **Defines networking structures (DHCP, Firewall…)**

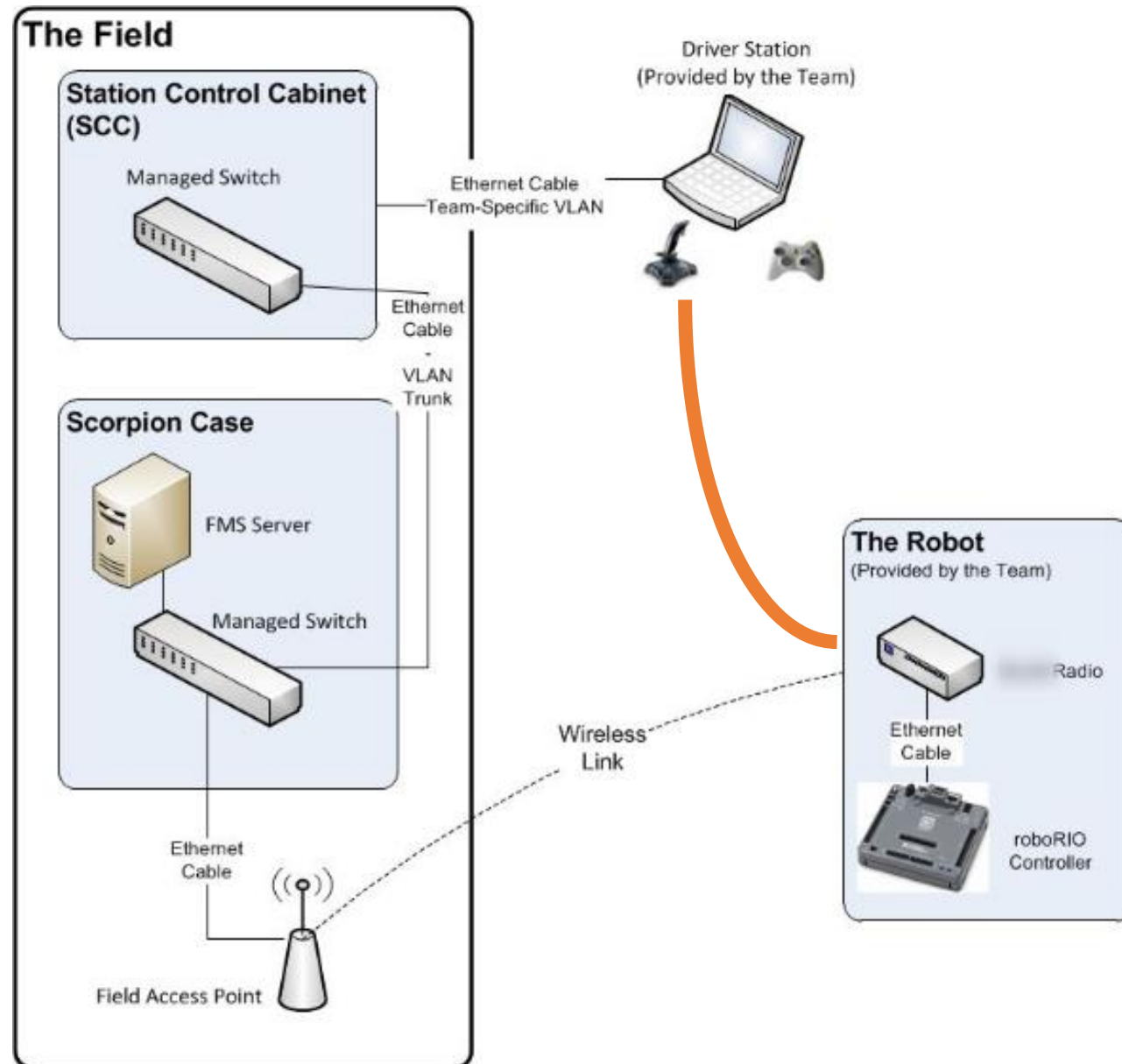**We will be focusing on these three in this presentation.**

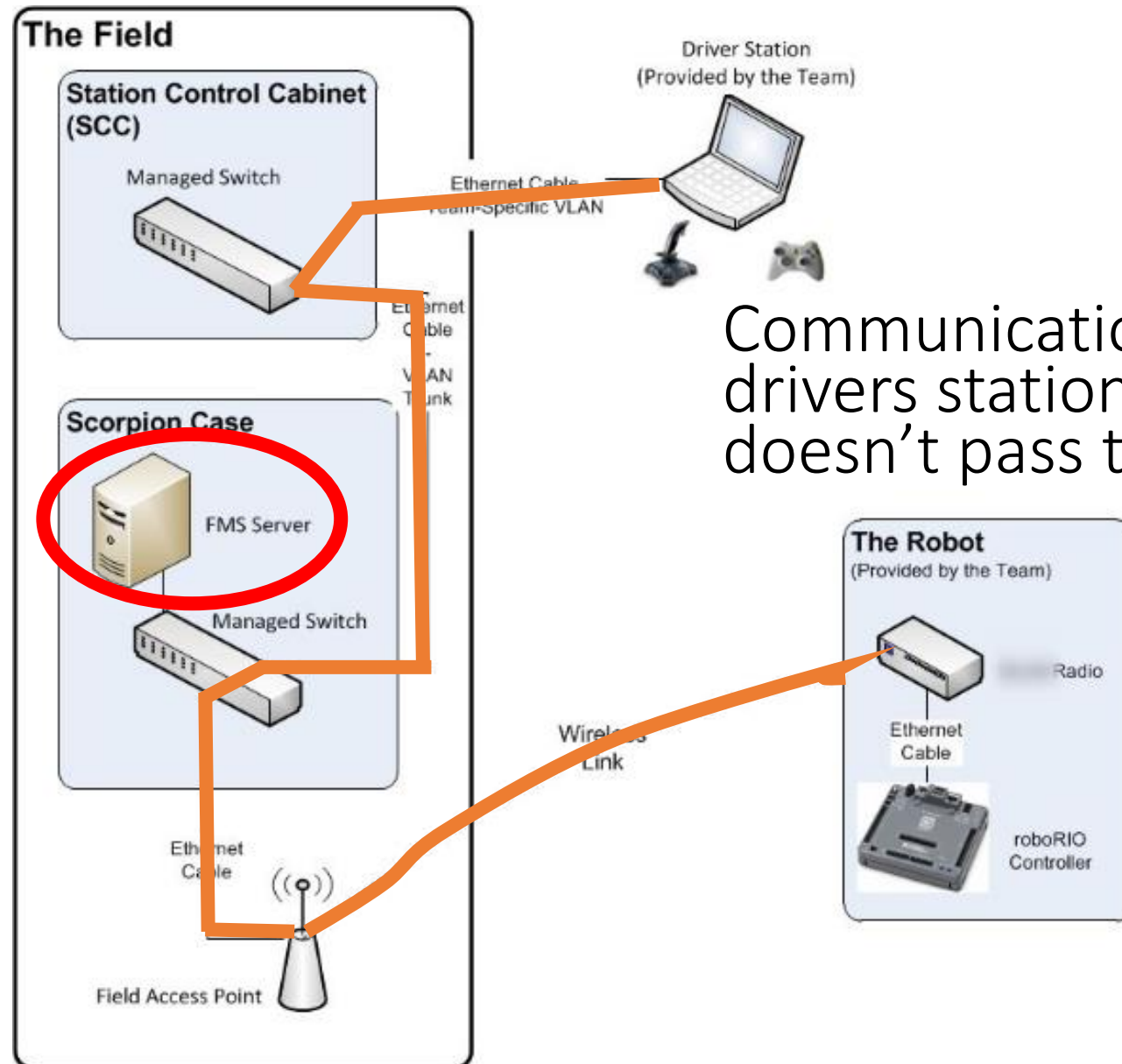# Driver Station to Robot Communication on Field

# Driver Station to Robot Communication on Field

# Communication tunneling Driver Station to Robot
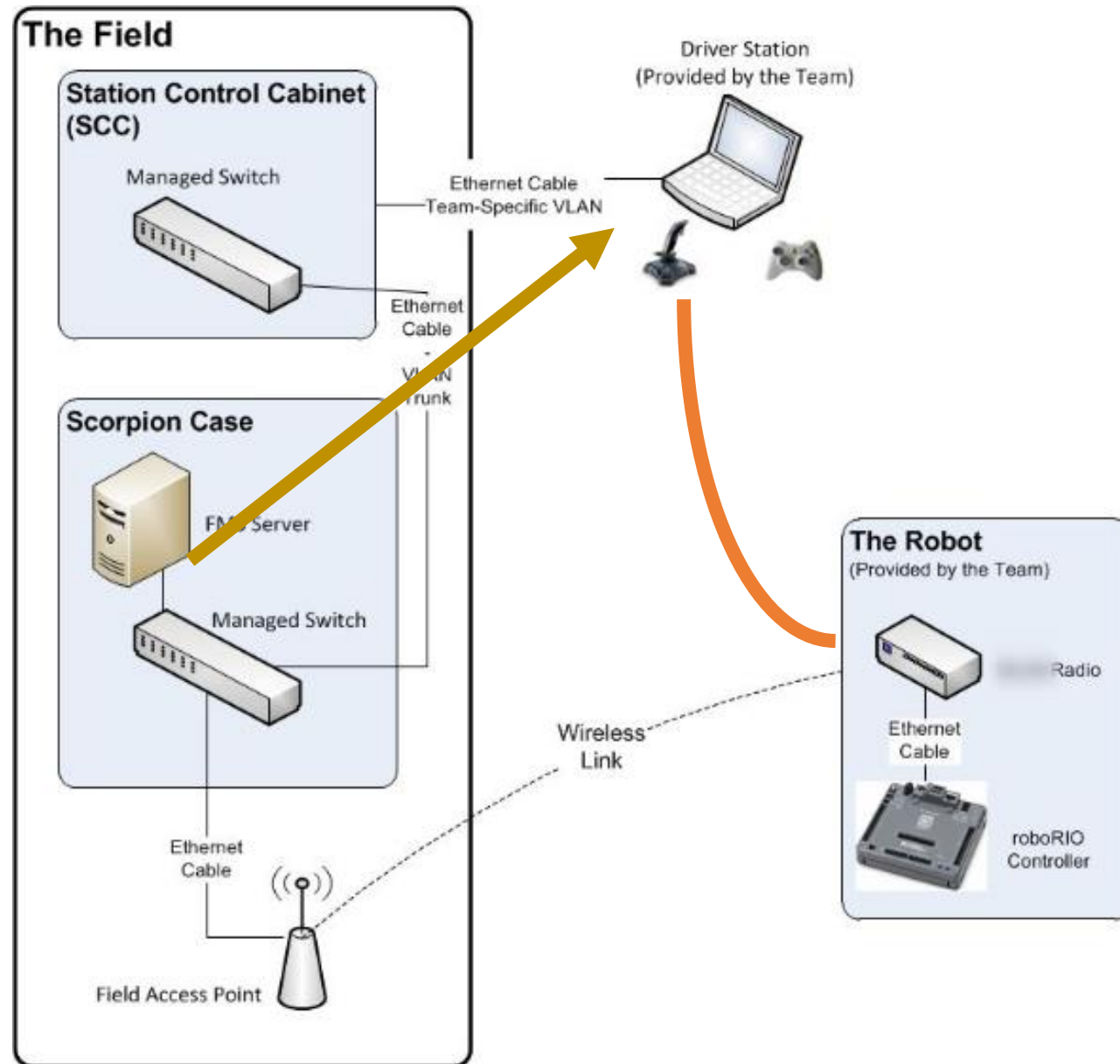
# Driver Station to Robot Communication on Field



Communication between your drivers station and the robot doesn't pass through the FMS

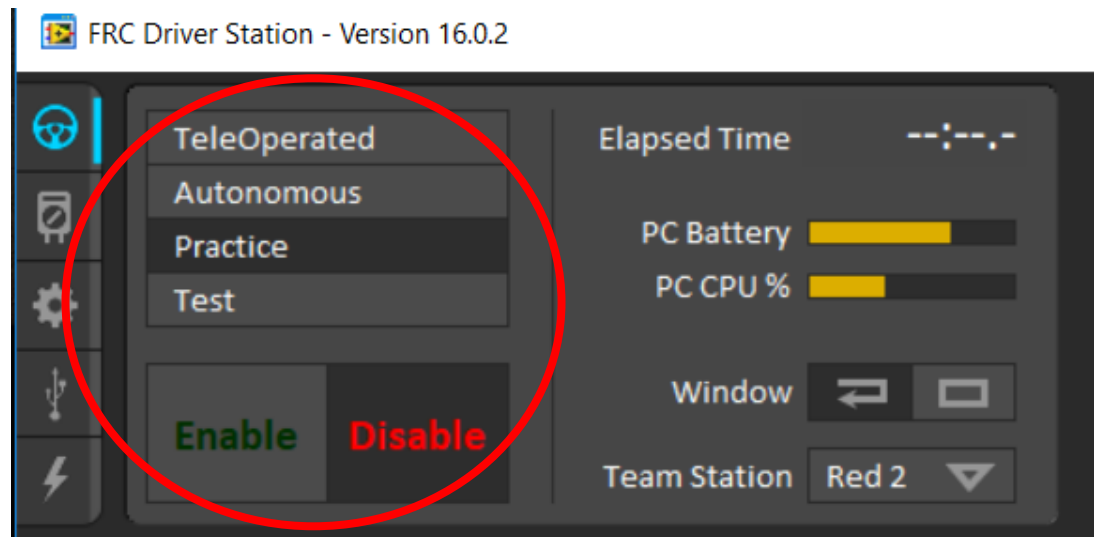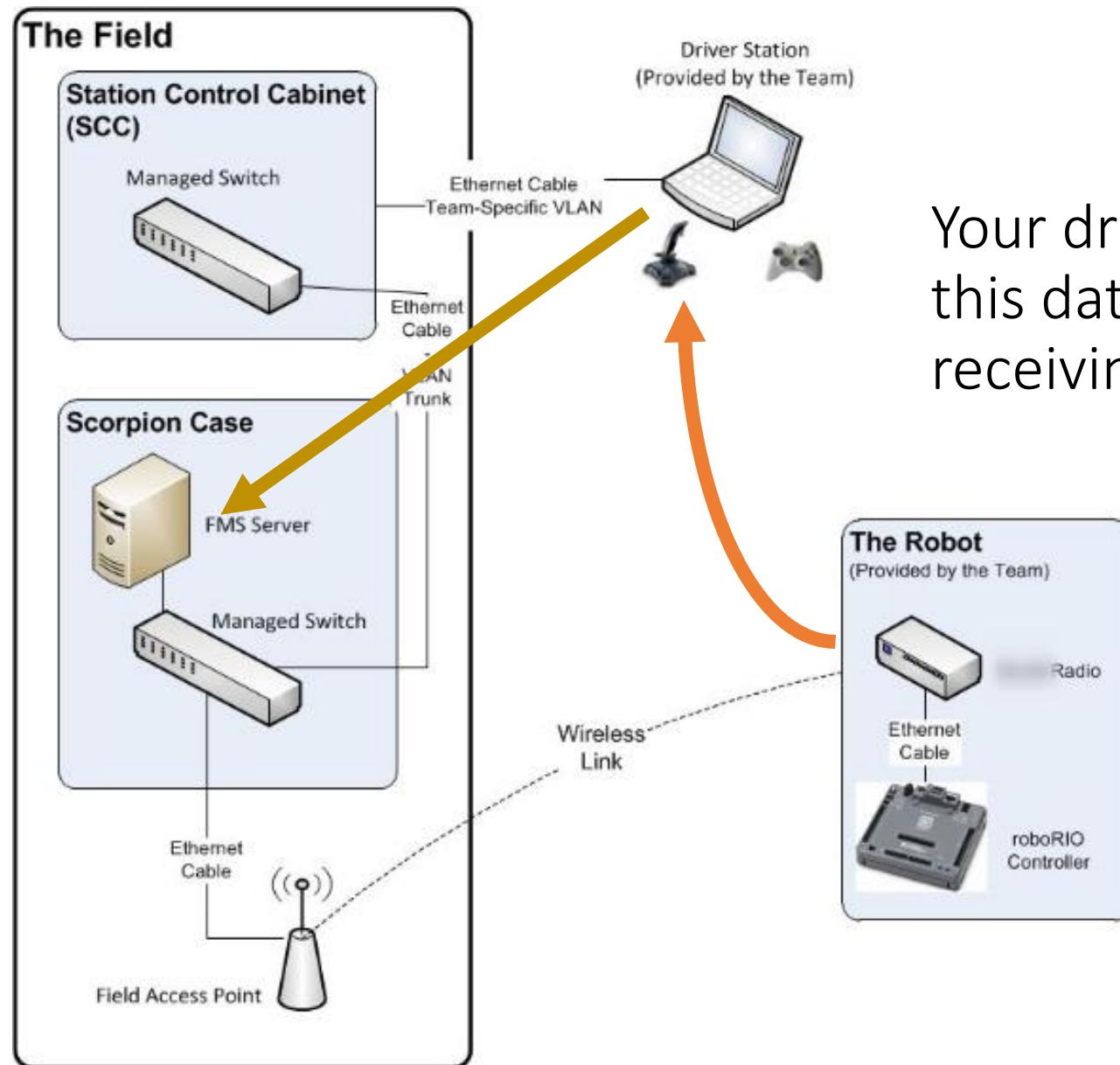# Changing Game States

# Changing Game States

These are the states that can be sent:

• Disabled or Enabled

• Autonomous or Teleop

• E-Stopped

**These are the commands the FMS can give your robot**

# Wait! How do you know stuff about my robot then?



Your drivers station sends this data to the FMS after receiving it from the robot

# The field on communication

- The field does **not** communicate with your robot

- The field does **not** block communications between robots and drivers stations
  - With the exception of packets on Firewall blocked ports – not relevant for regular control packets

# Wireless and VLANS

- The Field Access Point (AP) creates 6 wireless networks (SSIDs) – one for each team on the field.
  - Each network (SSID) is protected with a unique WPA2 key to protect your data
- Each network (SSID) is logically connected to a VLAN ( a virtual private LAN network)
- Each VLAN is connected directly to the specific ethernet cable at your specific drivers station
  - This is why when you connect to the wrong station you will not be able to connect
- VLANs can't talk to each other, except for the FMS management VLAN which can communicate with the driver stations.
  - This is why you can't send packets to other team's robots or drivers stations.

# Defining Networking Structures

- DHCP  (gives IP addresses)

- DNS (names in network)

- Firewall
  - Certain ports blocked
  - Can't download code on field
  - IP Cameras sometimes try to use these ports!

# Allowed Ports in _2017_!

Table 3-2: Open FMS Ports

| Port | Designation | Bi-directional? |
|---|---|---|
| UDP/TCP 1180-1190 | Camera data from the roboRIO to the Driver Station (DS) when the camera is connected the roboRIO via USB | Yes |
| TCP 1735 | SmartDashboard | Yes |
| UDP 1130 | Dashboard-to-ROBOT control data | Yes |
| UDP 1140 | ROBOT-to-Dashboard status data | Yes |
| HTTP 80 | Camera connected via switch on the ROBOT | Yes |
| HTTP 443 | Camera connected via switch on the ROBOT | Yes |
| UDP/TCP 554 | Real-Time Streaming Protocol for h.264 camera streaming | Yes |
| UDP/TCP 5800-5810 | Team Use | Yes |

Taken from last year's game manual (The Arena)

**Check next year's manual for updates!**

# When you're at the competition

- Commands go through the field
  - UDP packets through the:
    - Driver Station > *SCC > Scorpion Case > Access Point* > Robot
- Drivers station gets state commands from FMS (Field Management System)
- Field defines network structures (gives IP addresses, firewall…)

**These are the only three changes between the function at home and on the field**

With the exception of the firewall and the state commands, everything else should be <u>transparent</u> to you

# Additional Network Objects

- For teams that use Raspberry Pi or IP cameras (ie: Axis) > Recommendation to use static IP addresses

| Field | IP to set |
| --- | --- |
| RoboRio IP address | 10.TE.AM.2 |
| Driver Station IP address | 10.TE.AM.20 |
| Default Gateway (for DS, roborio and for additional devices) | 10.TE.AM.4 |
| Subnet Mask (both on RoboRio and Driver Station) | 255.255.255.0   (Class C) |
| DNS server (both on RoboRio and Driver Station) | 10.0.100.5 |
| Static IP range for additional devices | 10.TE.AM.30-99 |

- Don't forget to define the subnet mask, DNS and gateways too!

- No additional devices permitted on DS side

# Additional Network Objects

- All details in previous slide are from 2017!
  - Check screensteps, rules and messages from us!
- In 2017 – You are permitted a switch between OpenMesh and roboRio
  - Check rules for updates!
  - Must be accessible for us to be able to debug!
- We are not responsible for auxiliary network objects (cameras, Pis)
  - We try to help but we might have to <u>start without them</u>!

# On the Field

# So back to what do we (FTAs and FTAAs) do?
## (on the technical/communications side)

- Getting teams connected to the field

- Monitoring the match

- Helping you understand and solve issues
  - or sending you to the relevant CSAs that can

- Keep track of teams with issues to make sure that they are solved

# Getting teams connected to the field

We help you connect on the field
- Most of the issues are quite simple:
  - You haven't plugged in the Ethernet cable to your DS
  - You haven't plugged in your Ethernet cable on one of the sides on the robot
  - You haven't turned on your robot
  - Windows firewall (or antivirus firewall) is blocking communication with the FMS
  - The computer's network settings are wrong
  - The computer is connected to another network (ie: wifi) and therefore the packets don't know where to go
- Some issues are more complex
  - That's why we're trained to help solve problems
  - We can get advice from FIRST HQ and CSAs
  - Make sure electronics is in places where we can see them!

# When you don't connect

- Some issues can not be solved or understood on the field
  - On the field we are limited by:
    - Technical restrictions
    - Time limitations
    - Tools we have available
- In these cases we help you find the assistance (usually CSAs) you need to solve the issue for your next matches
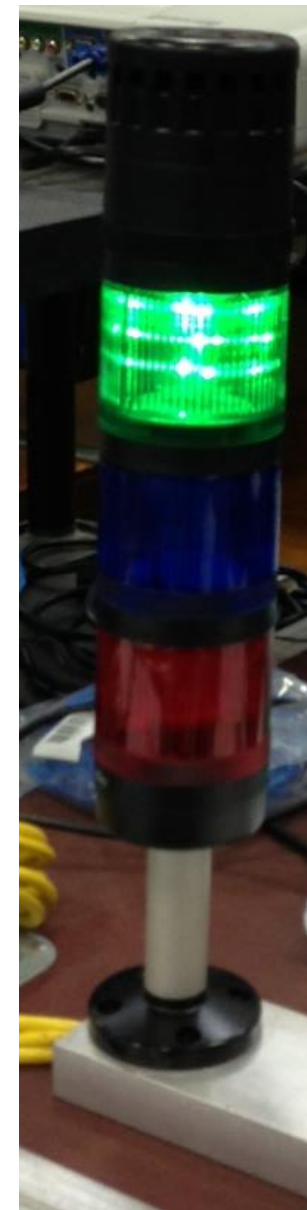- We update FIRST HQ too

Again :
Almost all of us were students and mentors on teams and we know how much work you put into your robot and we want you to succeed!

**We are here to help!**
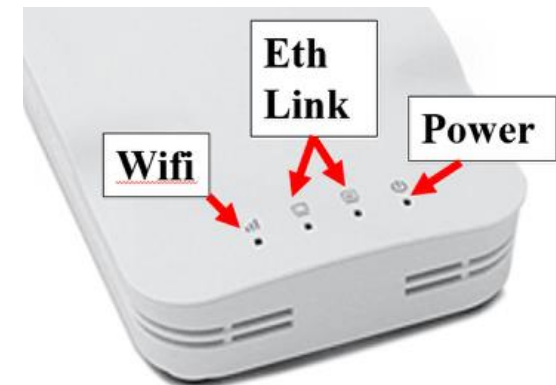
# Monitoring the match



Remember: Data from your Driver Station

# Monitoring the match

*When your robot isn't talking, our only option is to look at the lights*

- If you disconnect we try to understand why:
  - It is almost always a problem with the robot, but we want to help you find it so that you can succeed
  - We look at the last messages sent, and the length of time robots are down, etc…
  - We look at the RSL, radio and roboRIO status lights and more
    - It's important to put electronics in places we can see them
    - It's important to make the lights as visible as possible!
      - Help us help you
  - When you see us running around the field perimeter to look at a robot that has disconnected – that's why

# Understanding and Solving Robot Issues

# Solving Robot issues

- The problem could be mechanical!

- Wiring!
  - Problematic wiring
  - Pull test

- Radio problems?
  - Connected to VRM? (to 12V 2A)
    - Stabilizes voltage
  - Connected to the right place on the PDB
    - Check fuses – make sure they are ok and seated correctly

- Control System Advisors (CSAs)
  - Use their help!

# Driver's Station Log Viewer

Driver Station Log File Viewer

Choose one log file

| Name | Seconds |
|---|---|
| 2013_02_06 14_36_07 Wed | 592 |
| 2013_02_06 14_46_13 Wed | 330 |
| 2013_02_06 14_52_05 Wed | 246 |
| 2013_02_06 14_56_22 Wed | 218 |
| 2013_02_06 15_00_11 Wed | 418 |
| 2013_02_06 15_18_07 Wed | 579 |
| 2013_02_06 15_30_17 Wed | 621 |
| 2013_02_06 15_40_49 Wed | 332 |
| 2013_02_08 09_47_44 Fri | 4 |
| 2013_02_08 09_50_12 Fri | 359 |
| 2013_02_08 09_56_33 Fri | 212 |
| 2013_02_08 10_00_16 Fri | 264 |
| 2013_02_08 10_04_49 Fri | 126 |

Path to log files

C:\Users\Public\Documents\FRC\Log Files

Message

Summary:
 FMS Light - 0, Field Time: 13/02/06 14:36:14
Messages : 21
Duration : 09:52.24 sec
cRIO connected 1 times
cRIO boot times -- 2:29:05.923 PM
cRIO disconnected  at 2:38:47.856 PM 2/6/2013
cRIO connected 1 times
cRIO boot times -- 2:29:06.091 PM
cRIO disconnected  at 2:38:54.466 PM 2/6/2013
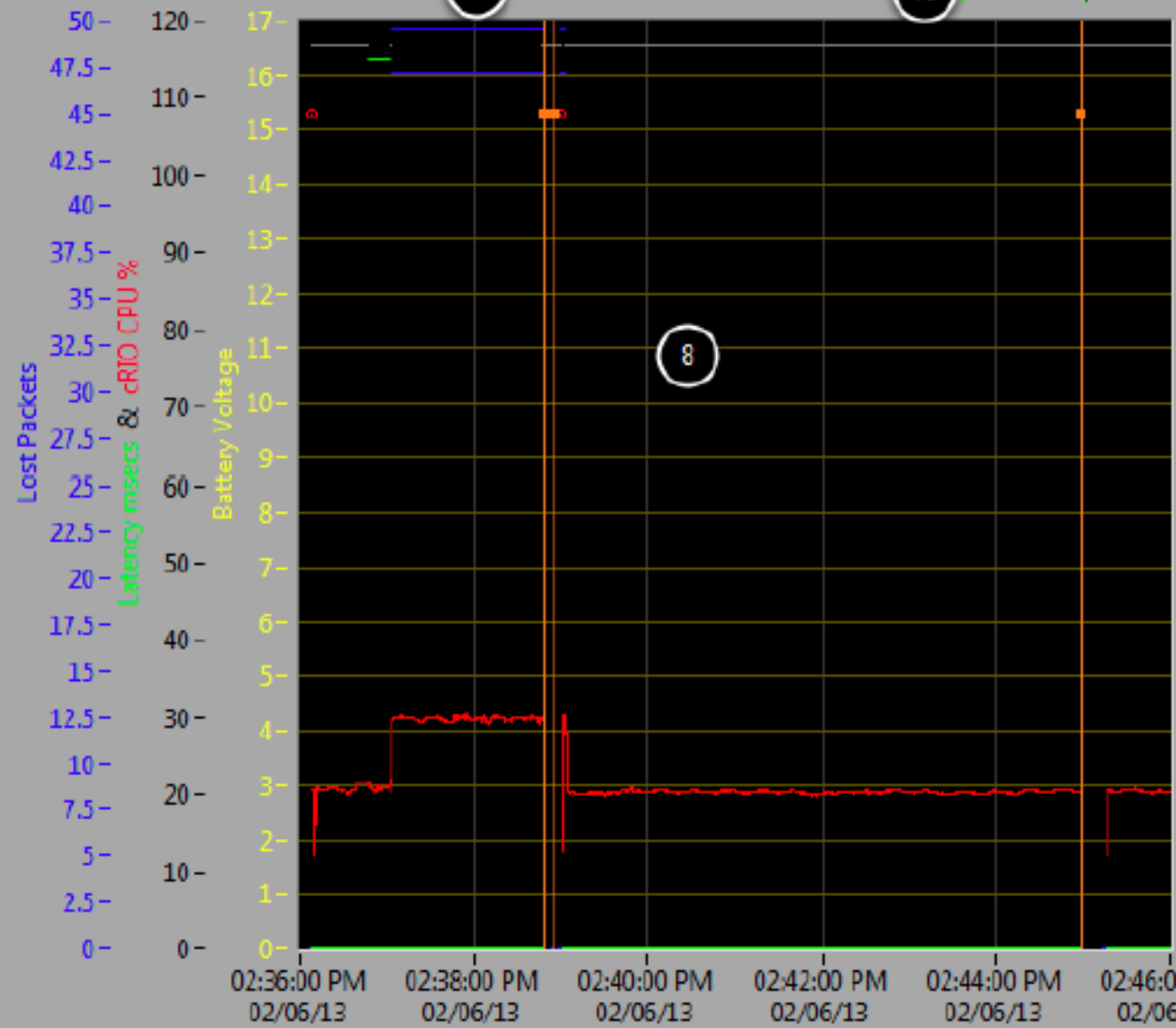cRIO connected 1 times
cRIO boot times -- 2:29:05 011 PM

Data and Events vs Time    Event List          Filter    Default

● Disable  ● Auto  ● Tele          ● Connect  ● Radio+  ● Radio-  ● Disconnect

Trip Time
Lost Packets
Voltage
CPU %
Robot Disable
Robot Auto
Robot Tele
DS Disable
DS Auto
DS Tele

Voltage Filter

AutoScale

Match Length

02:36:00 PM   02:38:00 PM   02:40:00 PM   02:42:00 PM   02:44:00 PM   02:46:00 PM
02/06/13      02/06/13      02/06/13      02/06/13      02/06/13      02/06/13
Time Scale -- 600.00 seconds

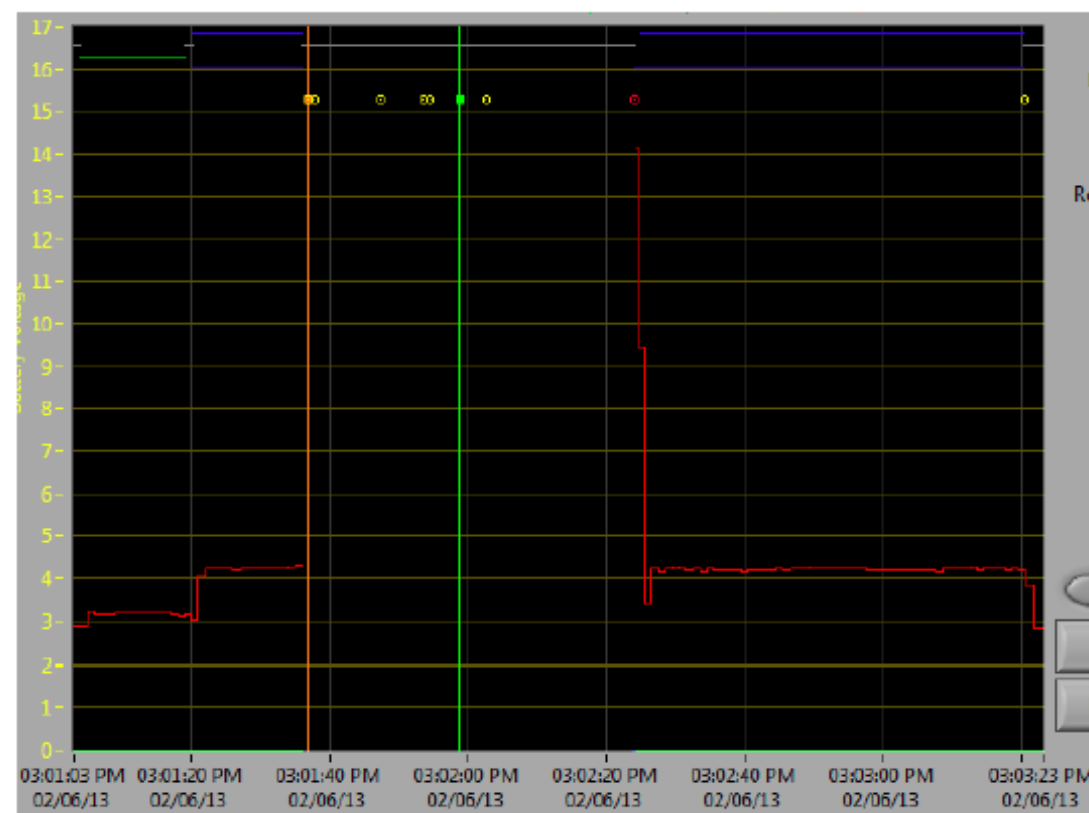FIRST ROBOTICS COMPETITION

FIRST ISRAEL

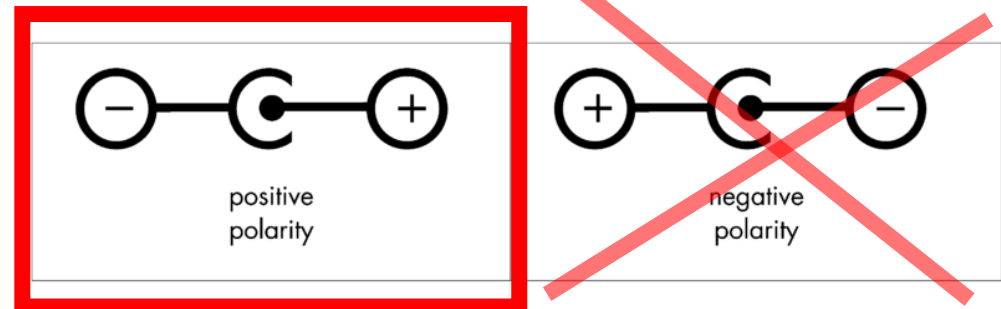| 3:01:36.869 PM | Warning <Code> 44004 occurred at Driver Station<br><time>2/6/2013 3:01:36 PM<unique#>4<br>FRC: The Driver Station has lost communication with the robot. |
|---|---|
| 3:01:37.871 PM | Warning <Code> 44002 occurred at Ping Results: link-GOOD, DS radio(.4)-GOOD, robot radio(.1)-GOOD, cRIO(.2)-bad, FMS-GOOD Driver Station<br><time>2/6/2013 3:01:37 PM<unique#>5<br>FRC: Driver Station ping status has changed. |
| 3:01:47.281 PM | Warning <Code> 44002 occurred at Ping Results: link-GOOD, DS radio(.4)-GOOD, robot radio(.1)-GOOD, cRIO(.2)-GOOD, FMS-GOOD Driver Station<br><time>2/6/2013 3:01:46 PM<unique#>6<br>FRC: Driver Station ping status has changed. |
| 3:01:53.689 PM | Warning <Code> 44002 occurred at Ping Results: link-GOOD, DS radio(.4)-GOOD, robot radio(.1)-GOOD, cRIO(.2)-bad, FMS-GOOD Driver Station<br><time>2/6/2013 3:01:52 PM<unique#>7<br>FRC: Driver Station ping status has changed. |
| 3:01:54.490 PM | Warning <Code> 44002 occurred at Ping Results: link-GOOD, DS radio(.4)-GOOD, robot radio(.1)-GOOD, cRIO(.2)-GOOD, FMS-GOOD Driver Station<br><time>2/6/2013 3:01:53 PM<unique#>8<br>FRC: Driver Station ping status has changed. |
| 3:02:02.512 PM | WARNING <Code> 44007 occurred at FRC_NetworkCommunications <secondsSinceReboot> 3.682<br>FRC: Time since robot boot. |
| 3:02:24.128 PM | ERROR <Code> -44003 occurred at WPI_CameraIssue HTTP Request with Authentication.vi>>WPI_CameraIssue Get.vi>>WPI_CameraGet Image Appea<br><time>21:30:35 02/06/2013<br>FRC: Operation failed due to a communication failure with the camera. |
| 3:02:24.151 PM | Warning <Code> 44003 occurred at Driver Station<br><time>2/6/2013 3:02:24 PM<unique#>9<br>FRC: No robot code is currently running. |

# Robot Radios

OpenMesh

# OpenMesh wireless robot radios

Just like last year: - **Unless something changes!**

- OpenMesh radios are for use in both your workshop and at the competition!

- They belong to you, and they are **your responsibility**!

- Connect to ethernet port close to power connector
  - Port labeled "18-24V POE"

- Be careful with the electricity (12V 2A, through VRM)
  - Must use barrel connector – POE not yet permitted ☹

- Make sure barrel connector doesn't come loose – but no modification!

- For use only on robots!

# Radio Configuration

- It is **mandatory** to configure your OpenMesh radio with the *Radio Configuration Utility* for use at home.

- Download utility from *FIRST* website

- Note options:
  - It's recommended to choose *2.4GHz AP*
  - It is **mandatory** to choose *Israel*!!

- At the competition you will be required to reconfigure the radio in a special competition kiosk
  - You must do this for every event!
    - Yes, even if you have back to back districts!



FRC Radio Configuration Utility

File  Tools

Team Number: 0

WPA Key:

Radio: OM5P_AN

Mode: 2.4GHz Access Point

Country: Israel

Configure

Load Firmware

To program your wireless bridge:
1) Connect power and Ethernet to the wireless bridge.
2) Make sure to use the "802.3af" Ethernet port as shown above.
3) Wait for the Power light to turn and stay solid.
4) Enter your team number, and a WPA key (optional), above
5) Press "Configure", the process should take 15-60 seconds

If asked to reset your wireless bridge:
1) Open the FRC Radio Configuration Utility.
2) Select OM5P-AN as the radio.
3) Unplug power from the radio.
4) Press the "Load Firmware" button.
5) Follow the on-screen prompts.

# Pointers on radio location

- Place the radio as high up as possible (but still protected!)
- Place the radios away from motors and other interference causing devices
- Make sure to place it in a way that we can see your radio's lights

- Avoid cages – radio waves have a hard time passing metals!

# Coming onto the Field
# (and tips for a good event!)

# Coming onto the Field

- Turn on your drivers station laptop **before** the match before yours ends (while in queue)

- When asked to go onto field - Send one student to connect the drivers station first!
  - Connecting a drivers station isn't just putting it there.
  - It is connected when the drivers station laptop is on, logged in, **running the drivers station software** and the **ethernet cable is connected**!

- Place the robot on the field

- **Turn on the robot.**

- Get off the field as soon as possible.

# Tips for getting onto the Field



reset button

Teams that use gyros, encoders and accelerometers that require calibration to starting spot can turn on their robots before reaching the starting spot, as long as they press the reset roboRio button when placed

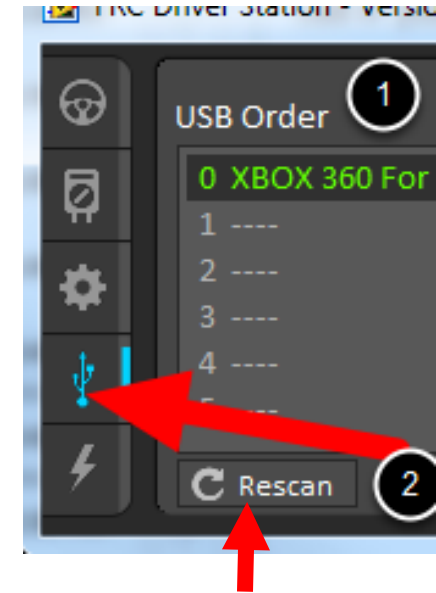This allows the radio to boot (which takes longer than the roboRio)

# Tips for getting onto the Field

- If you have an auxiliary network object that sometimes doesn't connect properly (ie: network camera that sometimes needs to be reset) – have a student wait by the robot until you see that it has connected properly!
    - Otherwise we may not know and may start matches.
    - Remember that auxiliary network devices are your responsibility!
- If you have had a problem that you have been unable to solve that we haven't noticed ( jerky motion, delays between joystick movement and robot movement, problems with the camera feed) – Talk to us. We can understand things better when we see them then when we hear about them and look at logs.
    - We might not be able to solve it but it helps us help you!

# General Tips



- Check your joysticks!
  - When you press a button on your joysticks, you should see the device highlighted in the USB Devices tab of your drivers station!
  - If it doesn't work (or stops working during a match) **press F1 or Rescan!**
    - F1 restarts the joystick subsystem of the Driver station
    - If it doesn't work, disconnect your joysticks and reconnect them, then press F1 again
    - Make sure you are pressing F1. In some laptops you need to press FN and F1

- Xbox controllers with dongles can disconnect!

# General Tips

- Check your camera's compression settings
  - If you are trying to send *tons* of data over the network it could harm your network performance.
  - Use programs like WireShark to measure how much bandwidth you are using!
  - If you are using too much reduce your frame rate, resolution, or increase compression
  - Teams are bandwidth limited

- Don't bring your E-Stop button from home (if you still have it)
  - The old USB Estop buttons don't work anymore and are not necessary – there is an E-Stop button on the field that works!
  - Having another button there can be confusing when you actually have an emergency!
  - You can throw it away – they are useless at home too
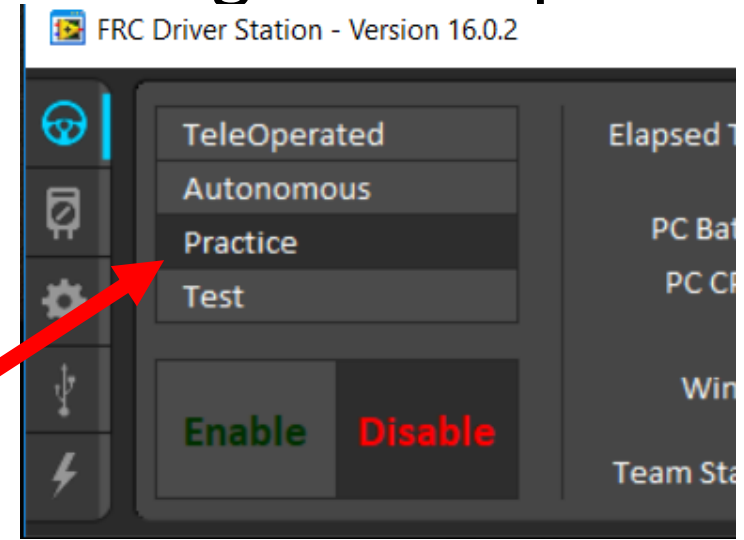    - Use the space bar to e-stop when not on the field!

# General Tips

- Many laptops now either don't have an Ethernet port or have a half sized one that is sometimes unreliable:

- USB to Ethernet dongle - Good investment!
  - Mine cost about 100 NIS

# General Tips

- "It worked on the practice field/pits but not on the competition field":
  - Fact: The FMS doesn't make changes to your communications or code.
  - Fact: if the DS logs don't show that there was significant packet loss the communication was fine
  - Try to understand what is different:
    - Lighting (for image recognition related)
    - Drivers / Operators
    - Did you test the code in "Practice Mode"?
      - Practice mode simulates the changes in game states that the FMS makes. It follows the order of Disabled>Autonomous>Disabled>Teleop>Disabled, like on the field!

# "It's the Field!"

- We have the tools to understand what's going on and we're pretty good at using them
We usually know to say where the problem occurred and when it is or isn't the field.
- The field doesn't care which alliance or driver's station you are. All stations are equal!
  - It does care that you are in the correct driver station though!
- Rematches are only given in specific cases where the field or field staff actually caused unexpected issues with the match
  - A team not planning for the fact that the field has a firewall (which is included in the rules) is an *expected* issue.
  - Giving rematches would not be fair to the other teams who played the match by the same rules
  - Actual errors are virtually impossible with the way the system is designed.

Robots are complex machines which vibrate, move and get beat up, and it's hard to make them reliable.

Sadly, the vast majority of issues I've encountered in my half decade on the field have been issues with team's robots and electronics.

Mechanical wins matches, electronics loses them

# Be prepared!

- Have your robots ready for action!

- That means:
    - Fully charged battery that you intend to play the match with
    - Code downloaded ("Deployed") onto robot
        - You won't be able to transfer code on the field!
    - Pneumatics charged
    - Springs loaded (unless safety issue)
    - The robot is in starting configuration
    - The robot is in legal (frame perimeter or whatever rules relevant) configuration
    - And anything else that may be

- Be on time!

# Help us help you!

- Be ready!
  - Have your computer on and ready when the match before yours ends, and connect it swiftly
  - This helps us see problems that may arise faster - we can't see anything before the drivers station is connected!

- Be Aware!
  - Does something look wrong? Did your robot not connect even though it's been a while? Tell us!
  - Your alliance partner forgot to connect their Driver Station? Use your Gracious Professionalism and remind them!

# Help us help you!

- Let's work together!
  - When we are getting a match ready, we're working on a bunch of problems all at once. We have a system that lets us know who is connected and who isn't.
    - Just standing there with your hands crossed next to the robot for no reason doesn't help, it just distracts us
    - Asking us why your robot isn't up yet if you just turned it on 15 seconds ago is keeping us from taking care of other issues
      - For the record, robots take about 45 -55 seconds to boot and connect, as of 2017 firmwares.
- Problems? Let us know!
  - The MCs don't start the match without approval from the FTAs. If you might have a problem when the MC starts announcing the match and asking if your ready, **let us know**!
    - Thumbs down
    - Banging on the glass if we don't see you
    - Shout!

# Resources



> **Field Management System White Paper**

FIRST released a "White Paper" which explains how the field works.

It's from 2013 but 99% are still relevant

with the exception of mDNS which is now just regular DNS

> **FRC Screensteps website**

- https://wpilib.screenstepslive.com/s/4485
- But googling "FRC Screensteps" also works

# Questions?

- Feel free to contact us
  - frc@firstisrael.org.il
  - Mention that it's for the FTAs

  Or at any event you can always ask me, or any of the other FTAs or FTAAs