

2022 Bell AVR Competition  
Official Game Manual

**EMERGENCY  
FIREFIGHTING  
CHALLENGE**



# 1 - Introduction

Bell is home to pioneers willing to challenge what's possible. From breaking the sound barrier to developing the tiltrotor, Bell engineers have redefined the experience of flight for over 86 years. Today, Bell pushes boundaries with revolutionary commercial and military helicopter, tiltrotor and unmanned aerial vehicle designs. But more importantly, Bell is focused on the future of flight, which lies in the hands of the next generation of inspired engineers who will reimagine designs for transport, emergency medical services, search & rescue operations and more.

The 2022 Emergency Firefighting Challenge is an exciting opportunity to test your technical, teamwork and communication skills. In this competition, good sportsmanship is the result of a disciplined effort to respect yourself, your opponents and contest officials. With that in mind, remember the following sportsmanship statement: "We will be gracious in both victory and defeat. We will uphold the responsibility of sportsmanship by demonstrating leadership, positive attitudes, and respect. We will pursue excellence with excitement, integrity, and honor."

This manual outlines all rules, regulations, and restrictions for this year's competition. Rulings of referees and judges will be based on this manual, but all rulings defer to the final decisions of the Head Referee and their interpretation of both the language and spirit of these rules.



## 2 - Competition Overview

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The Bell AVR Competition consists of two components. During a one-day Event, a Team will participate in both the Firefighting Challenge (4 matches) and a Presentation to determine a combined overall score.

### 2.1 - Emergency Firefighting Robotics Challenge

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Bell County is burning! It's time for the Bell County Fire Department to send its multi-modal robotics fleet into action. A forest fire has started on both sides of the valley, putting the community in jeopardy. If the firefighting team does not get to the critical fires in time, the whole valley could be up in flames. The Firefighting Challenge requires a series of strategic missions to be executed by combining multiple flight operations, ground based vehicle actions, firefighters, mission logistics and the opportunity to program autonomous missions.

The Team's Bell **AVR Drone** is their primary firefighting unit. Areas of the Field which are **Burning** can be **Cleared** by knocking over **Trees**, dumping **Water**, or by firing the **Laser Water Cannon (LWC)**.

The Team also has several **Support Crew** Vehicles, who can assist the AVR Drone's firefighting capabilities by activating various Support Elements.

The Bell Valley County is divided into two Communities - Bell Boroughs and Textron Towers. Each Match is divided into a series of Phases.

- 1) **Phase 1: Initial Burn** - At the start of each Match, one Community will begin to Burn, and one will remain Dormant.
  - The AVR Drone will begin fighting fire in the Burning Community by Clearing Burn Sites.
  - The Support Crew will head to the Dormant Community for Recon and Fire Spread Path interactions.
  - This phase will continue until the initial Burning Community has been Cleared.
- 2) **Phase 2: Re-Ignition** - Once the initial Community has been Cleared, the other Community will begin to Burn.
  - The score from Clearing Phase 1 will be locked in.
  - The AVR Drone will move to this Community to continue its firefighting efforts.
  - The Support Crew can either remain in this Community to continue aiding the AVR Drone, or begin returning back to the Fire Station.



**3) Phase 3: Endgame** - If the Team is able to Clear the second Community, they can choose to enter the Endgame.

- The score from Clearing Phases 1 and 2 will be locked in.
- All Buildings in both Cities will begin Burning with a maximum Fire Score (i.e. all Windows and Gutters will become Active).
- The AVR Drone will have free reign of the Field to Clear Buildings at will until the Match ends.

At the end of the Match, Teams will receive points based on the following:

- Fire Clear Score - How many Fire Score points have been Cleared or prevented
- Support Crew tasks completed
- Autonomous Bonuses
- Parking Vehicles back “home” in the Fire Station

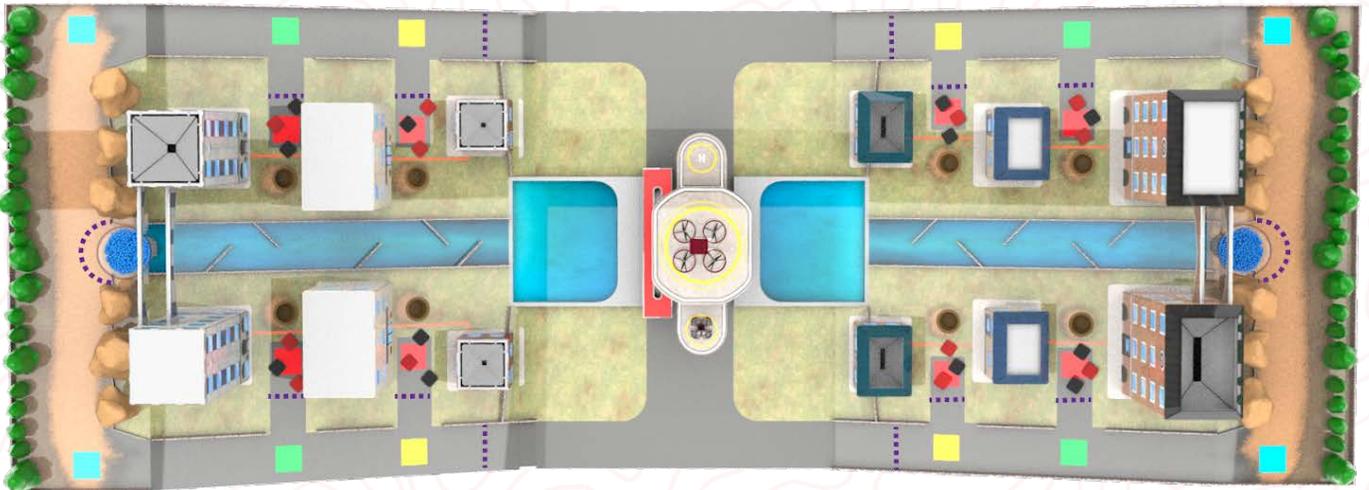
## 2.2 - Judged Presentation

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Throughout the day of the competition, each team will have a scheduled time to make a presentation to the judges. Presentations will be limited to 12 minutes and consist of two parts as described in Section 6.

# 3 - Field Overview

The Emergency Firefighting Challenge is played on a 15' x 15' x 40' [4.57m x 4.57m x 12.19m] netted Field as depicted in the figures below and throughout this Game Manual.



Figures 1 and 2: Top-down and isometric views of the Field.



Figures 3 and 4: Side views of the Field.

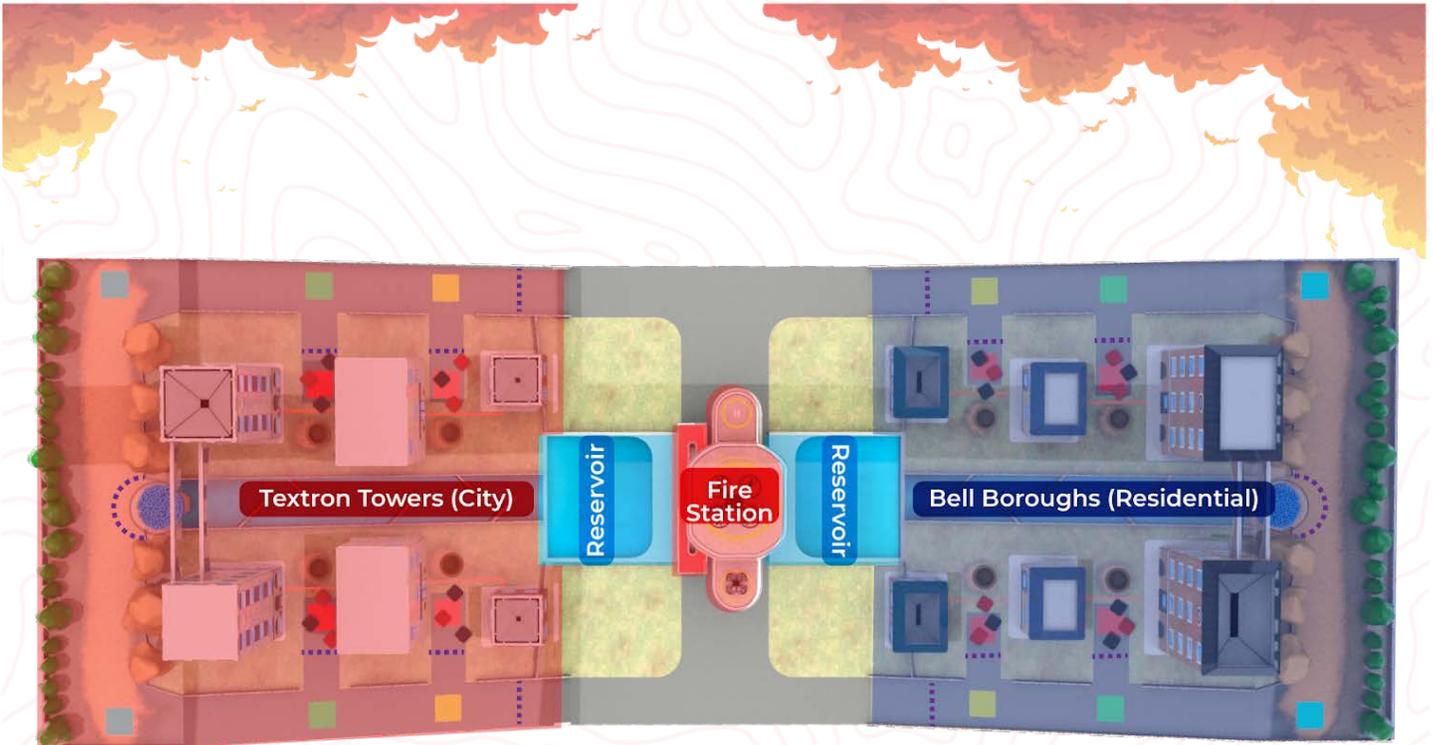


Figure 5: Top-down view of the Field, noting the two Communities, Reservoirs, and the Fire Station.

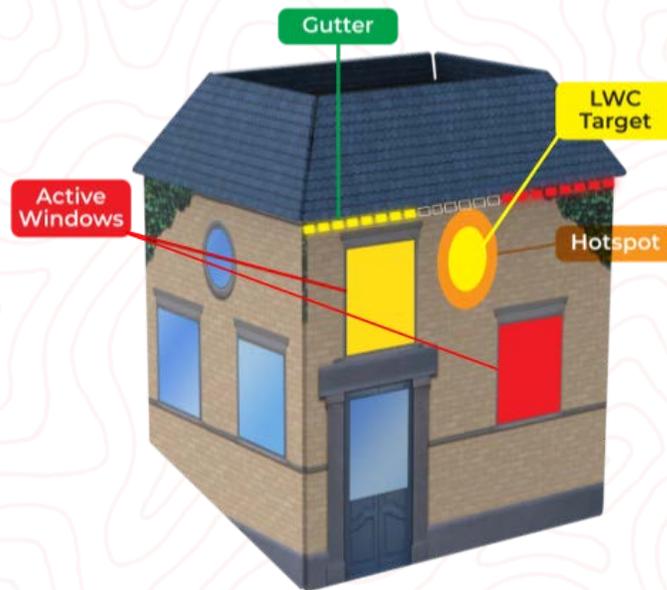


Figure 6: An example Active Building noting two Active Windows, the LWC Target, the Hotspot, and the Gutter.

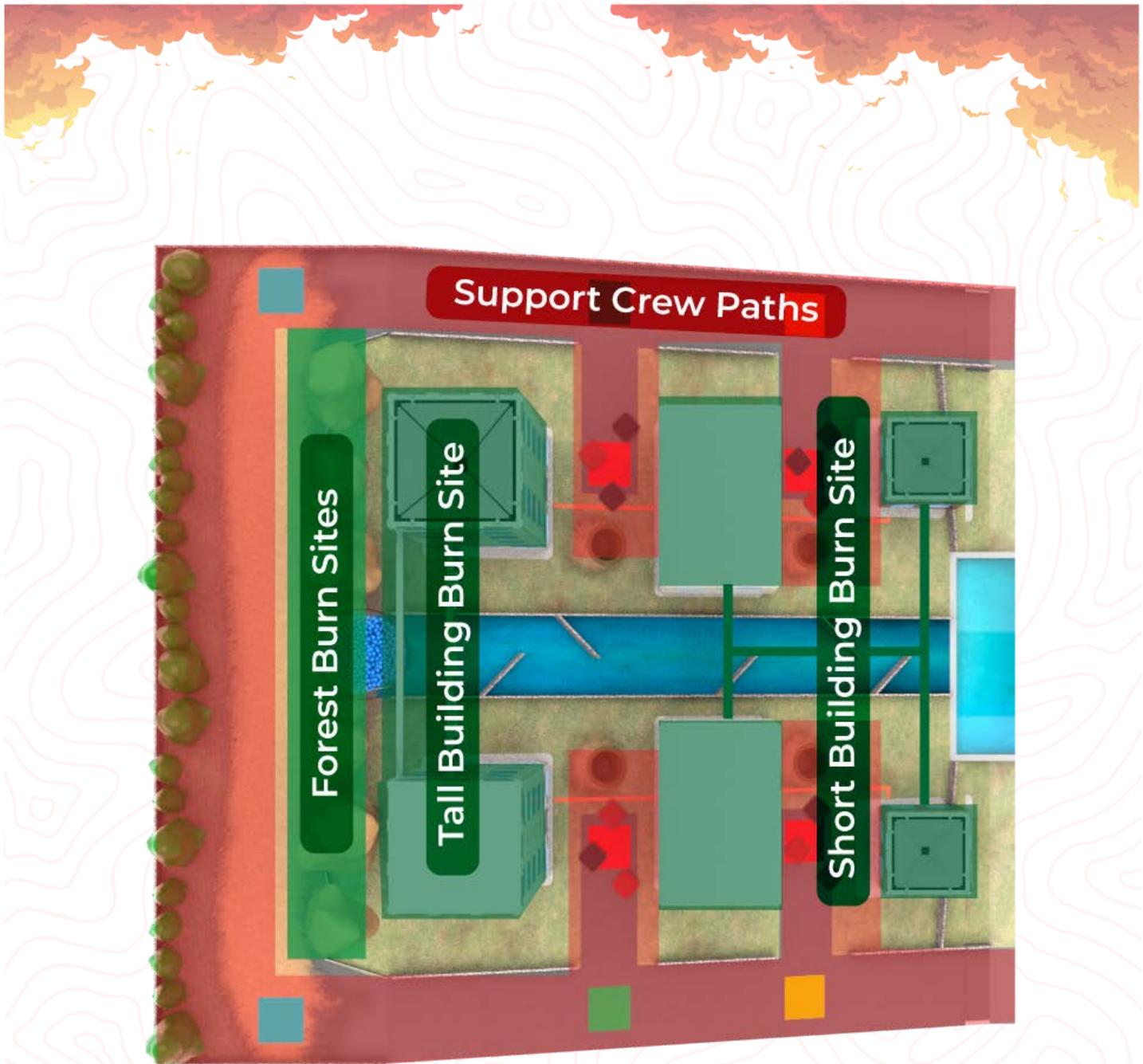


Figure 7: Top-down view of one Community, noting Burn Sites and Support Crew paths.

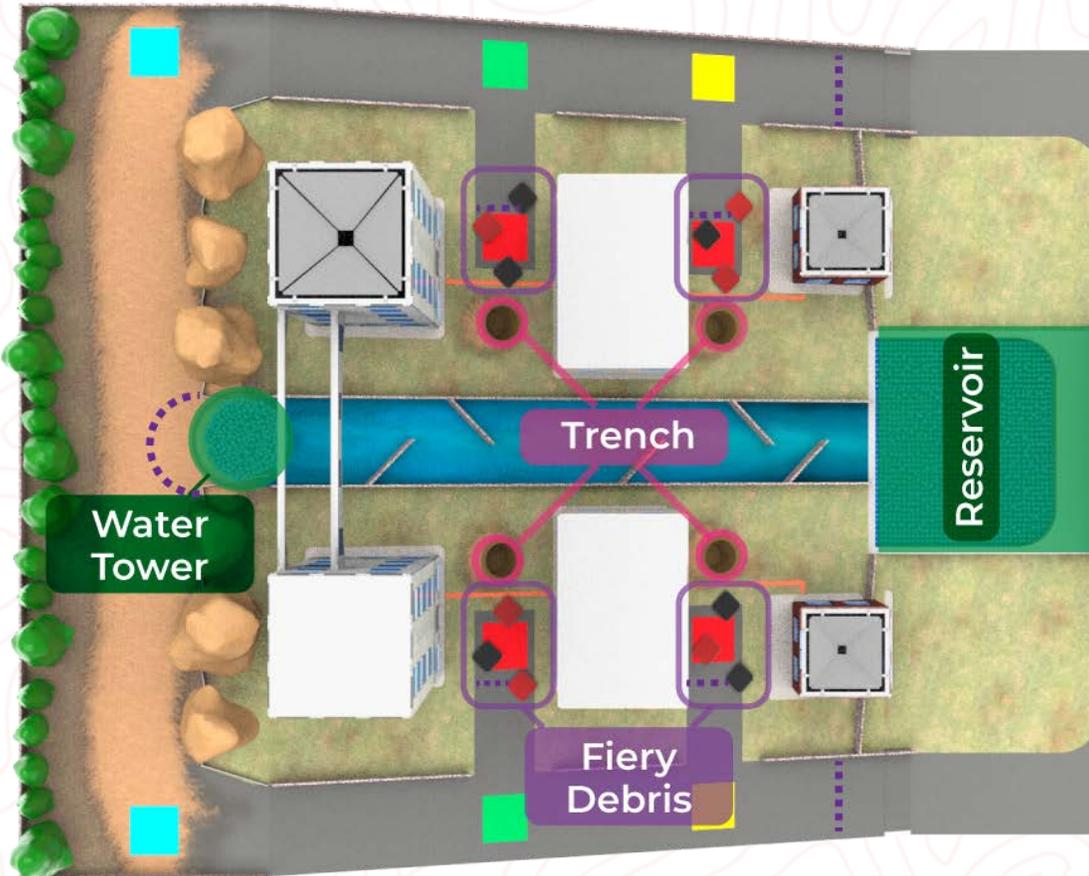


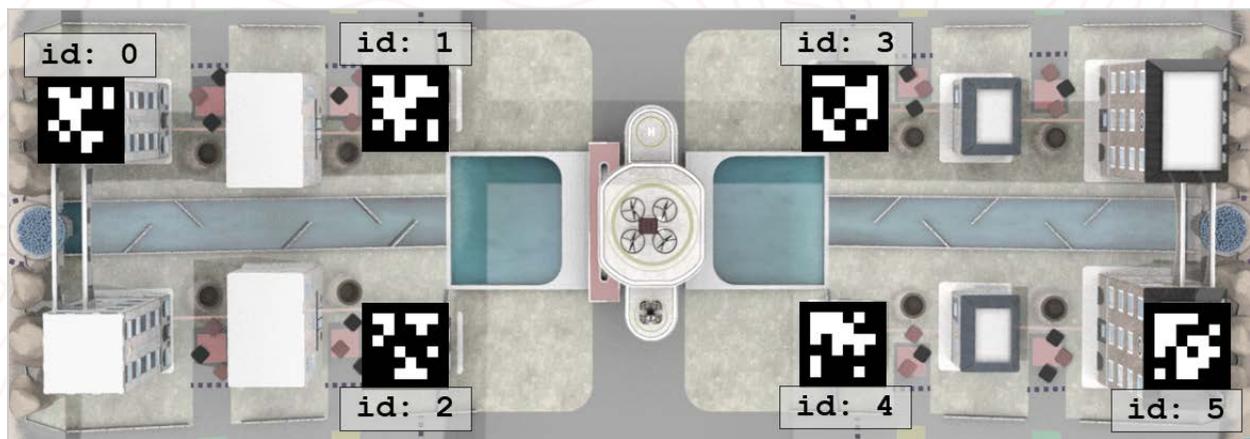
Figure 8: Top-down view of one Community, noting Trenches, Fiery Debris, the Reservoir, and the Water Tower.

# 4 - Definitions

## 4.1 - General Definitions

**Armed** - The state of a Bell AVR Drone's flight controller being in the "Armed" mode (i.e. SWA is in the "down" position), which allows motors to begin spinning. See section 9.

**AprilTag** - A visual fiducial image found on various Field Elements that can be read by the AVR Drone, used for Autonomous Deliveries and improved position orientation. See the Assembly Guide documentation for more information.



*Figure 9: A top-down view of the Field, showing the relative locations of each AprilTags that are on top of each Open-Roof Building. (note - this image is not to scale)*

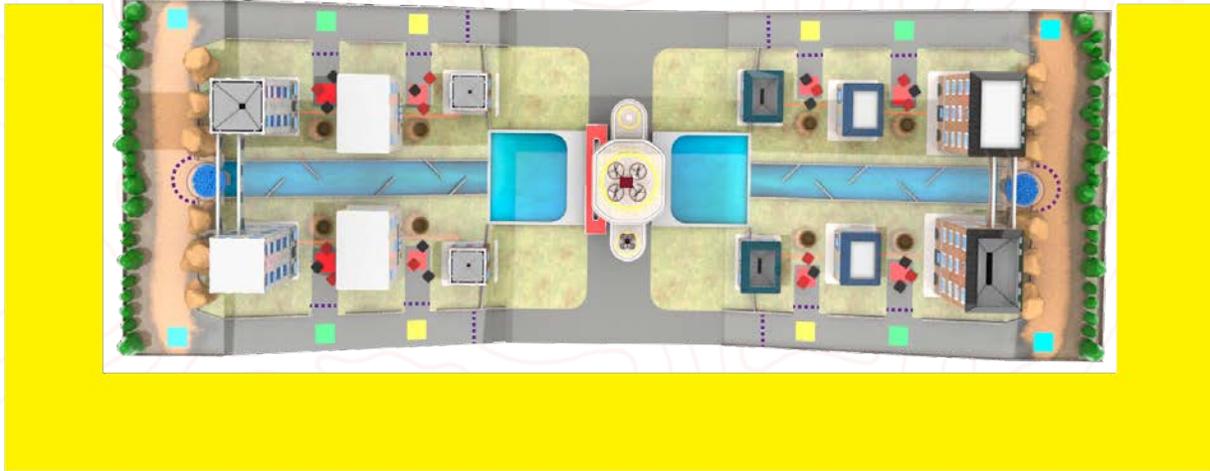
**AVR Drone** - The primary Bell AVR Drone, a physical unmanned aerial vehicle platform built and operated by the Team. See section 8 and the Assembly Guide.

**Disablement** - A penalty applied to a Team / Vehicle. When a Vehicle has been ordered to be disabled, it must be brought to rest and not operated for the remainder of the Match.

**Disqualification** - A penalty applied to a Team for a rule violation. A Team that receives a Disqualification receives zero points for the Match in question. At the Head Referee's discretion, repeated Violations and / or Disqualifications for a single Team may lead to its Disqualification for the entire tournament.

**Drive Team Member** - A Student who stands in the Driver Station during a Match.

**Driver Station** - The area next to the Field where Drive Team Members may stand during a Match.



*Figure 10: A top-down view of the Field, with the Driver Station area highlighted.*

**Event Coordinator** - The overall manager for the volunteers, venue, event management and other event considerations. The Event Coordinator does not interpret rules for the teams, but may be consulted by the Head Referee at the Head Referee's discretion.

**Flight Control Computer (FCC)** - The AVR Drone's Pixhawk 6C that includes onboard sensors to report the movement of the drone to the VMC, interfaces with the Drive Team Member's transmitter via the drone's receiver, and controls the motor speeds via the ESC. See the Assembly Guide for more information.

**Head Referee** - The impartial volunteer responsible for enforcing the rules in this manual as written. Head Referees are the only individuals who may discuss ruling interpretations or scoring questions with Teams at an Event.

**Event** - A one-day competition, consisting of Matches and judged Presentations.

**Field** - The entire 15' x 15' x 40' netted space in which Teams play Matches.

**Field Element** - All elements that make up the Field, including the flooring, netting, Burn Sites, the Fire Station, all Support Elements, the FMS, and all supporting structures, electronics, and accessories.

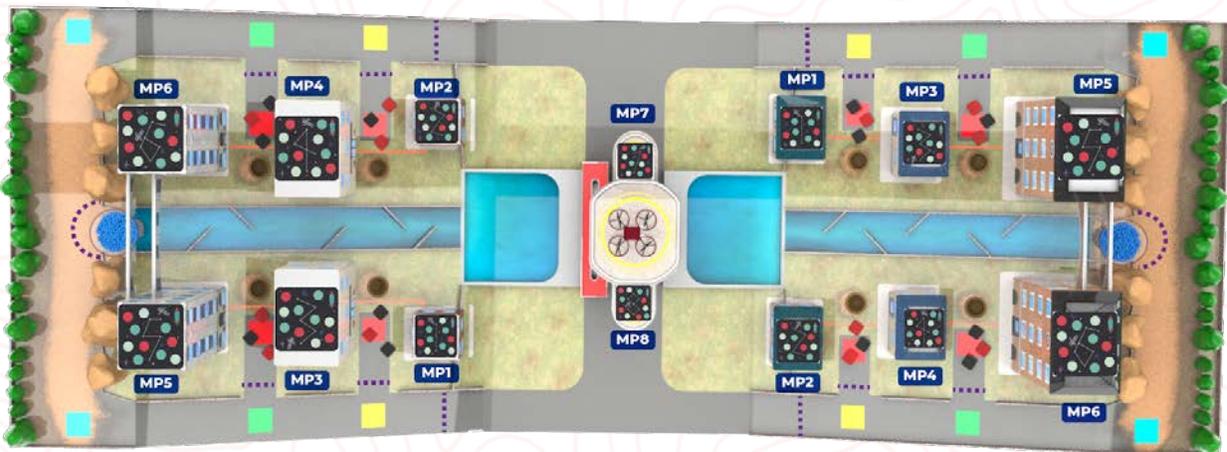
**Field Management System (FMS)** - The sensors, controllers, and other electronics which manage the Field state and real-time scoring during a Match.

**Match** - A set time period during which Teams play a single round of the Emergency Firefighting challenge during a Match Cycle.

**Match Cycle** - The entire time spent by a Team at the Field for a given Match. Match Cycles are ten (10) minutes long, and consist of three periods:

- 3:00 - Setup
- 5:00 - Match
- 2:00 - Reset

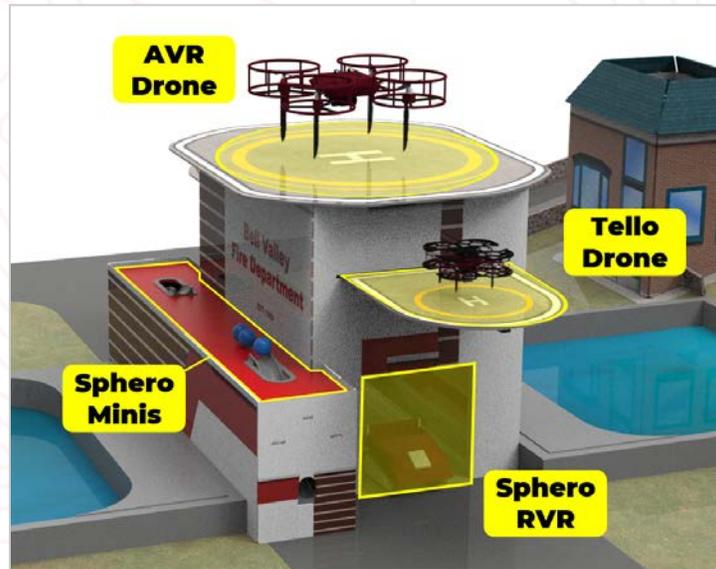
**Mission Pad** - A visual fiducial image found on various Field Elements that can be read by the Tello Drone, used for autonomous operations and improved position orientation during Recon Path navigation. See the Tello documentation, inside the Droneblocks Curriculum, for more information.



*Figure 11: A top-down view of the Field, noting the relative locations of each numbered Mission Pad. The Mission Pads are numbered symmetrically in both Communities when viewed from the “perspective” of the Tello Drone as it starts in the Fire Station. (note - this image is not to scale)*

**Peripheral Control Computer (PCC)** - The set of Adafruit circuit boards that interfaces with the VMC to control the AVR Drone’s external peripherals, such as servos and LEDs.

**Starting Location** - A designated location or 3D volume in which a Vehicle must begin the Match.



*Figure 12: A view of the Fire Station with all Vehicles in their designated Starting Positions.*

**Team** - A group of students representing a single high school or club, who coordinate efforts to prepare for and participate in Matches.

**Vehicle** - An AVR Drone (primary firefighting unit), Tello Drone (reconnaissance unit), Sphero RVR (ground support unit), or Sphero Mini (ground support firefighters).

**Vehicle Management Computer (VMC)** - The AVR Drone's NVIDIA® Jetson Nano™ that is used to interface with external sensors, connect to the Ground Control Operator laptop, and run Team code. See the Assembly Guide for more information.

## 4.2 - Game Specific Definitions

**Active** - A Window or Tree status representing a contribution to a Burn Site's Fire Score; (i.e. the opposite of Cleared). When a Tree is Active, it is upright. When a Window is Active, it is illuminated (representing a Window on fire).

Note: For the sake of colloquial terminology, the "Active" status applies to all "parent" elements of the Window as well (i.e. the Burn Site, Community). For example, if a Building is referred to as "Active", it means that Building has at least one Active Window.

**Autonomous** - A Support Vehicle status. A Support Vehicle is operating Autonomously if it is completing scoring actions using only pre-written code without Drive Team Member input. To signal that their Vehicle is operating Autonomously, Drive Team Members must take their hands off of the controls.

**Autonomous Checkpoint** - An indicator that can contribute to Autonomous Bonus points. See rule 5.5.5.

- Tello Drone - The two Checkpoints for a Tello's Recon Path are the Fire Station and the top of Building 5, where it completes the Recon Path.
- Sphero RVR - Checkpoint Lines can be found at various points around the Field. In order for a Checkpoint Line to be considered successful, the RVR (and any attachments) must be completely past an infinite vertical projection of the line (i.e. just "breaking the plane" doesn't count).

**Autonomous Delivery** - An AVR Drone action for delivering Water to an Open-Roof Building. To complete an Autonomous Delivery, the Team must:

1. Signal to the Auton Referee that they are about to do so
2. Use the drone's onboard CSI camera to correctly detect the AprilTag located on top of the Building
3. Blink the drone's LED strip 3 times during the delivery action

**Blocked** - A Fire Spread Path status. A Fire Spread Path is considered Blocked if its associated Trench has been filled with three (3) Fiery Debris, and if it has been illuminated by the FMS (i.e. has been revealed by a successful Recon Path). See 5.5.4.

**Building** - A type of Burn Site. There are six (6) Buildings in each Community, each with two (2) Windows and a maximum Fire Score of eight (8).

Buildings have two sizes:

**Tall Buildings** - The two (2) Buildings in each Community furthest from the Fire Station, 5 ft [1.5m] tall, connected by a skybridge. In the Bell Boroughs Community, the Tall Buildings are decorated as Apartments; in the Textron Towers Community, the Tall Buildings are decorated as Skyscrapers.

**Short Buildings** - The four (4) Buildings in each Community closest to the Fire Station, 2 ft or 3 ft [0.6m or 0.9m] tall. In the Bell Boroughs Community, the Short Buildings are decorated as Houses; in the Textron Towers Community, the Short Buildings are decorated as Offices.

Buildings have two Roof types (see Figure 13):

**Open-Roof Buildings** - Buildings which have funnel-shaped openings on the top. Open Roof Buildings can receive Water Drops to reduce their Fire Score.

**Closed-Roof Buildings** - Buildings which are closed on the top, and have LWC Targets **on the side facing the Fire Station**. Closed Roof Buildings can receive LWC shots to reduce their Fire Score.

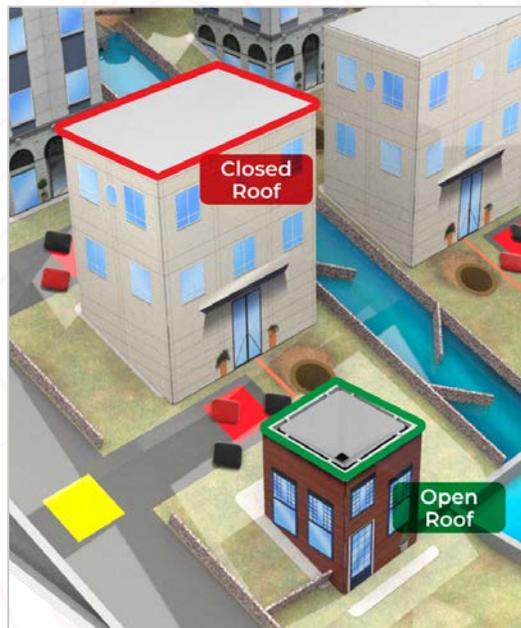


Figure 13: Examples of Open-Roof and Closed-Roof Buildings.

**Burning** - A Community attribute; the opposite of Dormant. A Community is considered Burning if it has at least one Active Burn Site.

**Burn Site** - Field Elements which can become Active, i.e. Forests and Buildings.

**Burn Rate** - A Burn Site attribute. When a Burn Site first becomes Active, its Fire Score (FS) will start at 4 points (i.e. the first [yellow] Window), and then increase by another 4 FS points (i.e. the second [red] Window) after 30 seconds have elapsed.



*Figure 14: Example of a Burn Rate progression, and a Building moving from a Fire Score of 4 to 8.*

**Community** - One of the two halves of the Field that contain Burn Sites and Support Elements.

**Cleared** - A Window status that represents an extinguished (or never-lit) fire. A Window is considered Cleared if it is not Active, i.e. represents a Fire Score of zero.

Note: For the sake of colloquial terminology, the “Cleared” status applies to all “parent” elements of the Cleared Window, (i.e. Burn Site, Community). For example, if a Building is referred to as “Cleared”, it means that Building has no Active Windows.

**Dormant** - A Community attribute; the opposite of Burning. The Dormant Community is the Community chosen by the FMS not to Burn during the Initial Fire phase.

**Endgame** - Phase 3 of each Match. See section 5.2.4.

**Fiery Debris** - A Support Element that can be pushed into a Trench, and used to Block Fire Spread Paths. Fiery Debris is represented by beanbags that are 5.8" x 5.8", with a weight of 10.6-11 oz [300-310 grams]. See Figure 21.

**Fire Score (FS)** - A Burn Site attribute. A Burn Site's Fire Score is tracked by the FMS, and represented on the field by Active Windows and by the Gutter.

**Fire Station** - A 53in x 33in x 33in Field Element where all Vehicles begin the Match. See Figure 12.

**Forest** - A type of Burn Site. Forests have a maximum Fire Score of 2, which can be reduced by knocking down Trees.

**Gutter** - An LED strip above a Building's two Windows that is used to depict its Fire Score and/or the Tello Recon Path.

**Heating Up** - A Building status. When a Tall Building becomes Heating Up, its Hotspot is enabled by the FMS. See section 5.3.

**Hotspot** - A 5" (101.6mm) diameter heated plate that is controlled by the FMS. There is one Hotspot on each Tall Building, located on the side of the Building that faces the Fire Station. When a Building becomes Heating Up at the beginning of a Phase, its associated Hotspot will turn on. Hotspots are designed to output a maximum surface temperature of 185°F (85 °C). See Figure 6.

**Initial Burn** - Phase 1 of each Match. See section 5.2.

**Laser Water Cannon (LWC)** - A laser pointer peripheral mounted on the AVR Drone that can be used to reduce a Closed Roof Building's Fire Score.

**LWC Target** - A 2.36in (60mm) diameter opening found on Closed Roof Buildings. The LWC contains a light-sensitive sensor assembly that can register when it is "hit" by a laser pointer.

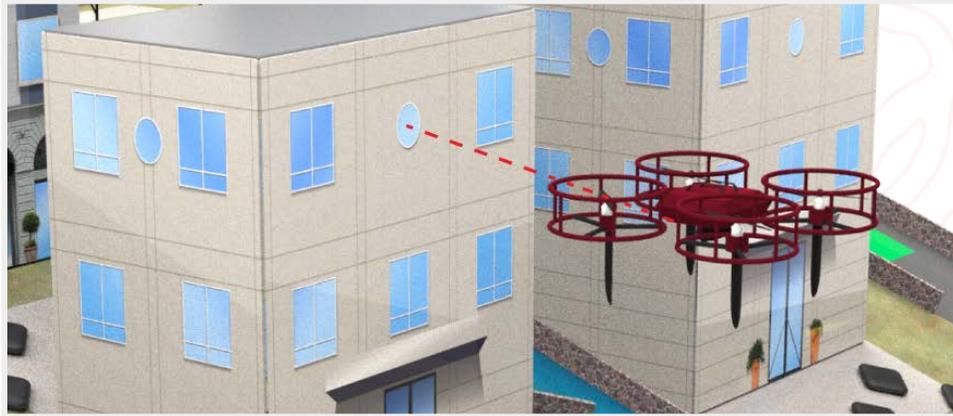


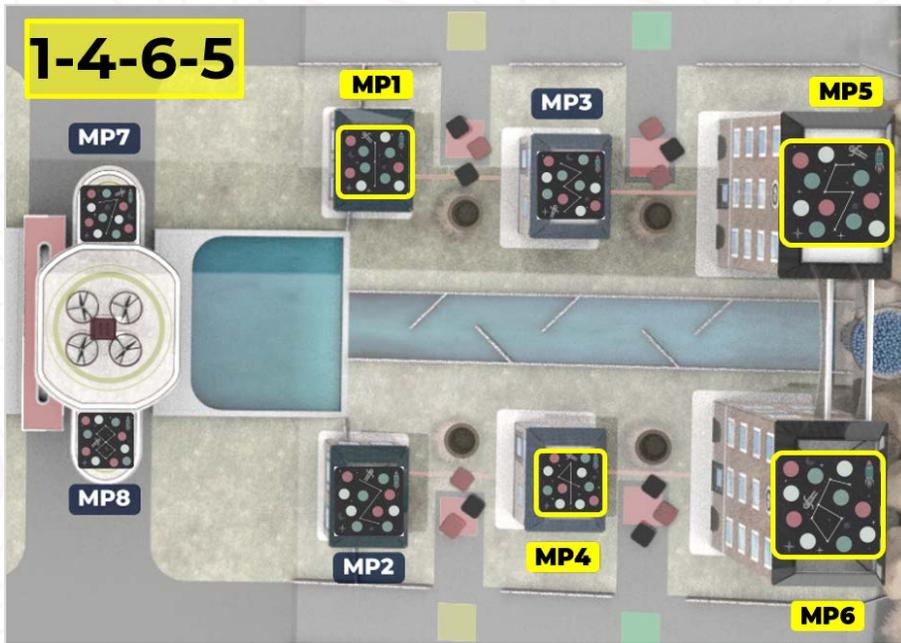
Figure 17: The AVR Drone firing its LWC at an LWC Target.

**Parked** - A Vehicle status at the end of the Match. To be considered Parked, a Vehicle must meet the following criteria:

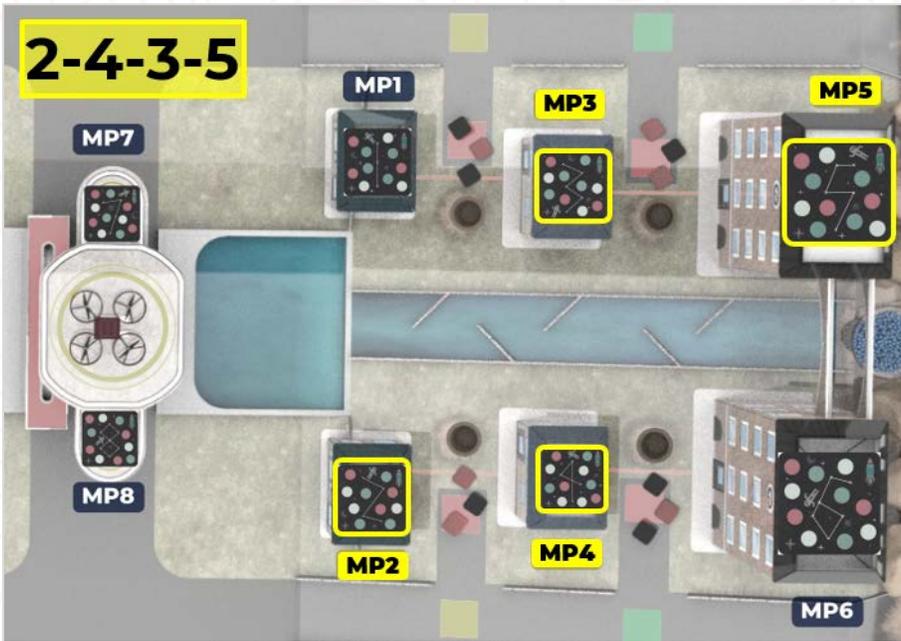
Vehicle	Parking Criteria
AVR Drone Tello Drone	Fully supported by the Fire Station.
Sphero RVR Sphero Minis	Fully contained within the “tunnel” underneath the Fire Station.

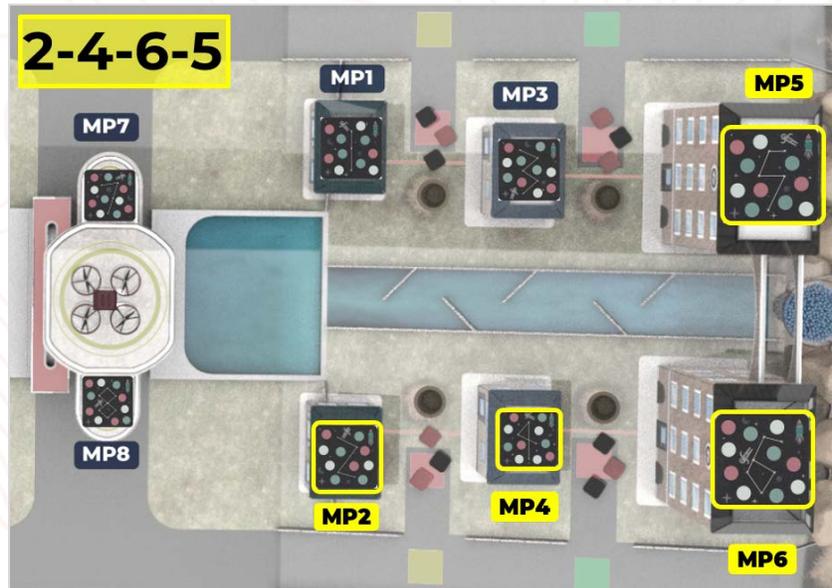
**Recon Path** - One of three possible paths for the Tello Drone to fly through during Phase 1. Recon Paths are defined as a series of Mission Pad “checkpoints” on top of each Building. In order to complete a checkpoint along a Recon Path, its numbered Mission Pad must be detected and displayed by the Droneblocks app or verified by a Head Referee.

**1-4-6-5**



**2-4-3-5**





Figures 18, 19, and 20: The three possible Recon Paths.

**Re-ignition** - Phase 2 of each Match. See section 5.2.

**Reservoir** - A Field Element, roughly 48in x 48in, where Water accumulates and can be collected by the AVR Drone.

**Support Crew** - The Tello Drone (reconnaissance unit) , Sphero RVR (ground support unit) and Sphero Minis (ground support firefighters).

**Support Elements** - The Water Tower, AprilTags, Mission Pads, Fiery Debris, Trenches, and Trees.

**Tree** - A Support Element that partially represents the Forest's Fire Score. Trees are considered Cleared when they are "knocked down", i.e. moved to a roughly horizontal orientation and resting on the field.

**Trench** - A hole, 7in (178mm) in diameter, into which Fiery Debris can be placed. When a Trench receives three (3) Fiery Debris, it is considered filled, and Blocks its corresponding Fire Spread Path.

**Note:** At the Championship event held on December 3rd, additional higher-friction materials will be added between the Fiery Debris and the Trench to improve RVR traction. Teams will have access to these portions of the field for measurement and calibration prior to the event.



Figure 21: A Trench and its associated Fiery Debris.

**Water** - A collective term that refers to a large quantity of Water Drops.

**Water Drop** - A blue 25mm hollow plastic ball that can be used to reduce an Open Roof Building's Fire Score.

**Water Tower** - A Support Element that can be used to release Water into the Reservoir. The Water Tower is activated mechanically, when a Sphero RVR Support Vehicle presses in on the spring-loaded "trap door" mechanism at its base. Water Towers begin the Match filled with Water Drops up to a marked "fill line" on the side of the Water Tower.



Figure 22: A Water Tower.

**Window** - A 5in x 5in (127mm x 127mm) translucent polycarbonate square on Buildings. Windows are lit from behind when they are Active (i.e. increasing a Building's Fire Score).

# 5 - The Game

## 5.1 - Scoring

The “general rule of thumb” explanation for scoring highly can be summarized as:

- Clear Fires quickly, i.e. minimize damage to buildings as the fire spreads
- Progress through Phases, i.e. guarantee as many buildings are “safe” as possible
- Complete Support actions, i.e. work as a crew to be the most effective

**5.1.1** A Team’s score at the end of the Match is determined by adding the following together:

- All Burn Sites’ Fire Clear Scores from all Phases reached.
- Any applicable Support actions, such as Clearing Trees or Fiery Debris, and any applicable Autonomous bonuses for these actions.

**5.1.2 Fire Clear Score (FCS)** - A given Burn Site’s Fire Score at the end of the Match, subtracted from its maximum possible Fire Score.

**5.1.3** When Phases 1 or 2 are Cleared, the total FCS achieved across all Burn Sites during that Phase are locked in.

- By definition, a Cleared Phase means that all Fire Score has been Cleared, so the FCS for that Phase will be 50 points. (8 FS × 6 Buildings) + (2 FS in the Forest)

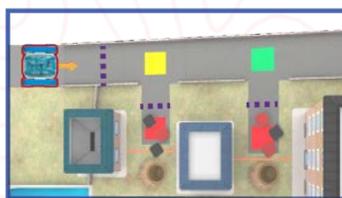
**5.1.4 Support actions** receive points as follows:

	Points	Autonomous Bonus Points Available
Water Tower Emptied	5 (per Water Tower)	+4 (per Water Tower)
Recon Path Completed	10	N/A
Trench filled / Fire Spread Path Blocked	5	+4 (per available Trench / Fire Spread Path)
Support Crew Vehicle Parked	1	+2 (Tello) +2 (RVR)
AVR Drone Parked	5	N/A

- a. **Note:** The Water Tower is considered “Emptied” once it has received twelve (12) impacts to its base from the Sphero RVR. To be considered an “impact”, the RVR must back up fully behind the Water Tower’s purple checkpoint line before impacting the Water Tower again.

**5.1.5 Autonomous Bonus (RVR Support actions & Parking)** - To be eligible for Autonomous Bonus points after completing a scoring action, a RVR must meet the following criteria:

- a. The Autonomous operation must begin fully “behind” the first purple Autonomous Checkpoint line at the base of the Community where the scoring actions are taking place, i.e. near the Fire Station and Reservoirs. (Please use common sense when interpreting this requirement)
- b. The entire scoring action must have been completed without breaking the Autonomous operation, i.e. without any human interaction.
- i. For filling a Trench, this means that any partially-filled Trenches will no longer be eligible for an Autonomous Bonus, since the RVR can no longer put all three Fiery Debris into it as one Autonomous action.
- ii. For emptying the Water Tower, this means that the count of 12 impacts will be reset to zero. Teams resetting midway through an emptied Water Tower should inform a referee if they intend to attempt their 12 impacts again Autonomously, or finish any remaining impacts via human operation.
- c. Note: If multiple scoring actions are completed in sequence without any human interaction between them (i.e. as part of one long Autonomous program), “resetting” back to the Autonomous Checkpoint after each one is not required.



**+0**



**+4**

Figure 24: An example Autonomous progression, as a RVR autonomously passes over the Autonomous Checkpoint Lines while navigating to a set of Fiery Debris. If successful in Blocking this Fire Spread Path Autonomously (i.e. depositing Fiery Debris in the Trench), then it would receive a bonus of +4 points.

- d. The RVR can receive an Autonomous Bonus for Parking if it continues operating Autonomously after completing another Autonomous task (i.e. Water Tower and/or Trench) and returns to a Parked position without any human interaction.

**5.1.6 Autonomous Bonus (Tello Parking)** - The Tello can receive an Autonomous Bonus for Parking if it returns to a Parked position Autonomously after successfully completing its Recon Path.

- a. As noted in rule 5.5.2, the Recon Path itself must be completed Autonomously in order to receive points. There is no Autonomous Bonus available for Parking if the Recon Path has not been completed.
- b. The Recon Path completion and this second Parking operation are considered separate tasks; i.e. human interaction in between them is permitted (such as to reposition the Tello on top of the Tall Closed Roof Building, or to choose another Autonomous program).
- c. The Tello does not need to re-trace the original Recon Path for this task.

**5.1.7 Scoring example.** In this example match, the Team:

- Completed Phase 1
- Did not complete Phase 2
- Partially completed some of the Support / Parking actions
- Used some degree of autonomy for Blocking a Fire Spread Path and Parking

	Phase 1	Phase 2	Endgame
Fire Clear Score (FCS)	50	35	0
<b>Total:</b>	<b>50</b>	<b>35</b>	<b>0</b>

	Qty	×	Points Each	=	Total Points	+	Auton Bonus	=	Total
Water Towers Emptied	1	×	5	=	5	+	0	=	5
Recon Path Completed	1	×	10	=	10	+	0	=	10
Fire Spread Paths Blocked	1	×	5	=	5	+	2	=	7
Support Crew Vehicles Parked	4	×	1	=	4	+	2	=	6
AVR Drone Parked	1	×	5	=	5	+	0	=	5
							<b>Total:</b>		<b>33</b>

	Phase 1		Phase 2		Endgame		Support		Total
<b>Total Match Score:</b>	<b>50</b>	+	<b>35</b>	+	<b>0</b>	+	<b>33</b>	=	<b>118</b>

## 5.2 - Phase Detail

### 5.2.1 Introduction

- a. Each Match follows the same Phase progression, which is managed by the FMS:  
Phase 1: Initial Burn → Phase 2: Re-Ignition → Phase 3: Endgame
- b. Spectators and Drive Team Members will be alerted to which Phase is currently active by LEDs on Active Buildings becoming illuminated.
- c. Progress through each Phase is triggered by Team actions. There is no maximum or minimum time limit for each Phase, and there is no guarantee that all Phases will be triggered in a given Match.
- d. Progress through each Phase is one-way. For example, once Phase 2 has been triggered, the Team cannot choose to go back to Phase 1.

### 5.2.2 Phase 1 - Initial Burn

- a. At the start of the Match, one Community will begin Burning, and one will be Dormant.
  - i. Each Team will play two (2) of their four (4) Matches with each Community as the initial Burning Community. This will be verified with the Head Referee prior to each Match.
- b. In the Burning Community, the FMS will choose Burn Sites to become Heating Up / Active with the following parameters:
  - i. The Forest will become Active with a maximum Fire Score (i.e. all Trees will be upright).
  - ii. One (1) of the two Tall Buildings, randomly selected, will begin Heating Up (i.e. its Hotspot will be turned on).
  - iii. Two (2) of the Short Buildings will become Active with a Fire Score of four (4) (i.e. one Window will be lit). These two Buildings will be randomly selected from the two pairs of Short Buildings on either side of the Active Community (i.e. there will be one Open Roof and one Closed Building, and those two Buildings will be adjacent to each other).



Figure 25: Example Phase 1 starting condition. The two Houses closest to the Drive Team are Active, with 1 Active Window (i.e. FS of 4) each, and the Closed-Roof Apartment is Heating Up.

- c. The Support Elements in the Dormant Community will be enabled for the Support Crew to interact with and prepare for the Re-Ignition Phase.
- d. The Initial Burn phase will continue until the Match has concluded, or until all Burn Sites in the Burning Community have been Cleared.

### 5.2.3 Phase 2 - Re-Ignition

- a. Upon completion of the Initial Burn phase, the previously-Dormant Community will become Active. This transition will happen automatically by the FMS once the initial Community is fully Cleared (i.e. becomes Dormant).
- b. Three (3) of the Buildings in the newly-Active Community will begin Burning with a Fire Score of four (4) (i.e. one Window will become Active).
  - i. These three buildings will be randomly chosen from one of the two sets of three Buildings that are “in a row” (i.e. connected by Fire Spread Paths). They will follow the same Burn Rate progression as in Phase 1.

- c. The Re-Ignition phase will continue until the Match has concluded, or until all Burn Sites in the second Burning Community have been Cleared.

#### 5.2.4 Phase 3 - Endgame

- a. To trigger the Endgame phase, both Communities / Phases must have been fully Cleared.
- b. At the start of the Endgame phase, all Buildings will become Active with a maximum Fire Score of eight (8).
- c. Support Elements have no effect during the Endgame if they have been activated in an earlier phase. Teams may continue to complete unfinished Support actions during the Endgame to receive points (e.g. Blocking Trenches, Parking Vehicles, or Clearing Trees).
- d. Scoring for the Endgame will be equivalent to the Team's FCS for this phase.

### 5.3 - Fire Score and Burn Sites

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**5.3.1** The **Field** is divided into two (2) **Communities**. See Figures in Section 3 and 4. Each **Community** has seven (7) **Burn Sites** - six (6) **Buildings** and one (1) **Forest**. **Buildings** have eight (8) possible **Fire Score** points, depicted by two (2) **Active Windows** (i.e. four FS points per Window). **Forests** have two (2) possible **Fire Score** points, depicted by **Active Trees**.

**5.3.2** When a Building first becomes Active, one (1) Window will be illuminated, and its Gutter will reflect a FS of four (4). After the Burn Rate time has elapsed (30 seconds), its second Window will be illuminated, and its Gutter will increase by four (4) FS points.

---



Figure 27: Example progression of Fire Score through an Active Burn Site.

**5.3.3** When a Forest first becomes Active, it will begin at its maximum Fire Score of two (2).

**5.3.4** At the beginning of each Phase, one Building will become Heating Up, i.e. its Hotspot heating element will turn on.

- a. The Hotspot is functionally equivalent to having a Fire Score of 2. To Clear a Hotspot, the AVR Drone will need to perform the same actions as it would if one Window was halfway Active (i.e. 4x LWC shots or 8x Water Drops, depending on the type of Building).
- b. If the Hotspot is not Cleared before 1:00 has elapsed, the Building will immediately escalate to a maximum Fire Score, i.e. both of its Windows and its Gutter will become fully Active.

## 5.4 - The LWC, Water, and Trees

**5.4.1** To reduce the Fire Score in a Closed Roof Building, the LWC Target must be hit by the **Laser Water Cannon (LWC)** on the AVR Drone.

- A successful LWC hit will be depicted by a blue indicator on the Building briefly flashing.
- 1 LWC hit = -0.5 FS, i.e. it takes 8 hits to Clear one Active Window.
- LWC hits are tracked by the FMS, and depicted by the Gutter.

**5.4.2** To reduce the Fire Score in an Open Roof Building, the AVR Drone must deliver **Water** into the roof's opening.

- 1 Water Drop = -0.25 FS, i.e. it takes 16 Water Drops to Clear one Active Window.
- Water Drops will be counted by the FMS, depicted by the Gutter, and have an expected tolerance of +/- 2%
- When Water is delivered to a Burn Site, there will be a brief period of processing time for the Water to be counted by the FMS. This is expected to be no more than 5 seconds from the time Water Drops enter the Building.



**5.4.3** If Water is dropped into an Open-Roof Building using an **Autonomous Delivery**, the value of each Water Drop is doubled (i.e. it takes 2 Water Drops to Clear one Active Window).

- To signal that an Autonomous Delivery is about to occur, the Drive Team Member should alert the Head Referee, and demonstrate through the AVR GUI that the AVR Drone is completing an AprilTag reading / action (including flashing the Drone's LEDs three times).

**5.4.4** The AVR Drone begins the Match with 16 Water Drops as a pre-load. Additional Water may be retrieved from the **Reservoir**.

- a. The Reservoir will begin the Match filled with roughly 1500 Water Drops, with an expected tolerance of +/- 100 Water Drops.
- b. Additional Water can be added to the Reservoir by triggering the Water Tower.

**5.4.5** To reduce the Fire Score in the Forest, **Trees** must be Cleared.

- a. 1 Tree = -0.333 FS, i.e. it takes three Trees to Clear one Fire Score from the Forest.
- b. In the Community which begins Phase 1 as Dormant, Trees may only be Cleared by Sphero Minis. **Trees which are knocked over by any Vehicle other than a Sphero Mini will not be considered Cleared by the FMS.**
- c. In the Community which begins Phase 1 as Burning, Trees may be Cleared by Sphero Minis or by propwash from the AVR Drone flying over it.
- d. Once a Tree has been Cleared, it is considered Cleared permanently.

## 5.5 - Support Crew and Support Elements

**5.5.1** All notes in this section refer to active Support Elements, i.e. Support Elements found in the Community which is Dormant during the Initial Burn.

**5.5.2** At the beginning of Phase 1, one of the three possible **Recon Paths** will be randomly chosen by the FMS, and displayed by illuminating the Buildings in question. For a Recon Path to be successfully completed by the Tello Drone, the following criteria must be met:

- a. The Auton Referee must verify that the correct Mission Pads, in the correct order, have been located by the Tello and displayed in the Droneblocks app. Any incorrect Mission Pads will result in the Recon Path being void.
- b. The Tello must have started the path while fully supported by the Fire Station, and ended the path fully supported by the tall Closed Roof Building (i.e. Apartment or Skyscraper).
- c. The Recon Path may only be completed by Autonomous operation of the Tello Drone. Manual operation is permitted for other Tello movements (e.g. returning to the Fire Station or resetting after a crash).

**5.5.3** Once an Auton Referee verifies that the Recon Path has been successfully completed, a set of Trenches will become illuminated, signaling that their corresponding Fire Spread Paths can be Blocked.

- a. If the Recon Path has not been completed before 2:00 has passed in the Match, the appropriate Trenches / Fire Spread Paths will become illuminated automatically. (this time constraint does not overrule the Recon Path - i.e. points are still awarded if the Tello takes longer than 2:00 to complete the Recon Path)
- b. There are two possible sets of Trenches that can be randomly chosen by the FMS to be illuminated. See Figure 30.

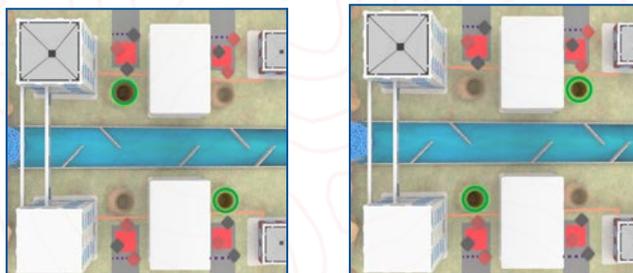


Figure 30: The two possible “Blockable” Trench scenarios.

**5.5.4** For a **Fire Spread Path** to be Blocked (i.e. **Trench to be filled**), the following criteria must be met:

- a. Its Trench must be illuminated, or a Head Referee must have indicated that it is an available Trench.
- b. The Trench must have three (3) Fiery Debris in it.

**5.5.5** To signal **Autonomous** operation of a Sphero RVR or a Tello Drone, the Drive Team Member must verbally signal to an Auton Referee and visibly take their hands off of the controls (i.e. place their mobile device down or take their hands off of the laptop).

## 5.6 - Gameplay Rules

Accidental, momentary, or minor violations of the following rules will result in a warning. Intentional, egregious, or score-affecting violations will result in a Disqualification. Repeated warnings may escalate to a Disqualification at the Head Referee's discretion. Rules which refer to setup actions (e.g. 5.6.4) must be met in order for a Match to start.

- 5.6.1** Teams may not utilize external influences to activate interactive Field Elements. Examples include, but are not limited to:
- Using a laser pointer held by a human outside of the Field to hit LWC targets.
  - Using a human spotter outside of the Driver Station to view areas of the field that are difficult for Drive Team Members to see.
  - Activating a Trench's weight sensor with anything other than Fiery Debris.
- 5.6.2** Drive Team Members must stay in the Driver Station for the duration of the Match.
- 5.6.3** Drive Team Members may not fulfill more than one of the following roles during any given Match:
- Primary AVR Drone pilot - using the radio transmitter
  - AVR Drone Ground Control Operator - using a laptop with QGroundControl and/or the AVR GUI
  - Tello Drone pilot - using a laptop with the DroneBlocks app
  - Sphero RVR driver - using a laptop or mobile device with the Sphero Edu app
  - Sphero Mini driver - using a laptop or mobile device with the Sphero Edu app
- 5.6.4** All Vehicles must meet the following criteria at the beginning of the Match:
- Fully supported by the Fire Station and/or the Field floor.
  - Fully contained within an infinite 3D vertical projection of their designated Starting Location in the Fire Station. See Figure 12.
- 5.6.5** During Phase 1, the AVR Drone may not enter the airspace above the Dormant Community.
- 5.6.6** Teams may begin the Match with up to sixteen (16) Water Drops preloaded in the AVR Drone. Preloaded Water Drops must be fully supported by the AVR Drone and/or the Fire Station.

**5.6.7** LWC hits will only be counted towards decreasing a Building's Fire Score if the LWC is fired from an aerial AVR Drone, i.e. one which is actively flying.

- a. The primary trait that referees will monitor in order for an AVR Drone to be considered "flying" is whether the Drone is contacting any horizontal or sloped surfaces of the playing field, such as the roof of the Fire Station, the floor, the ramps on either side of the field, or the roof of any Buildings.
- b. This contact includes both the main body / landing gear of the AVR Drone, and any additional mechanisms which are attached to the Drone's airframe.
- c. This does not include contact with vertical faces of Buildings, provided that the Head Referee determines that the AVR Drone is still "flying" at the time of contact. (e.g. bumping into a Building is permitted, but attaching the AVR Drone to a Building's vertical face with a suction cup would not be considered "flying")
- d. During times when the AVR Drone is ruled to be stationary / non-aerial, any LWC hits will be considered to have a value of "0", i.e. the Gutter / Windows will not decrease, and the Building's Fire Score will stay the same.
  - i. Note: The Building's blue indicator light may still flash if a hit is registered. This light operates separately from the Gutters / Windows.
- e. This contact will be judged by a human Head Referee during the Match, whose decision on any edge cases not covered by the above rules will be final. To mitigate any risk of confusion or controversial judgment calls mid-Match, Teams are strongly encouraged to use "common sense" when interpreting this rule.

# 6 - Presentations

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## 6.1 - Overview

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- 6.1.1** The presentation portion of the competition is designed to challenge Students to think critically about their lessons learned throughout the competition. The presentation will consist of a description of the team's design process and lessons learned.
- 6.1.2** Teams will be given 3 minutes to set up and 12 minutes to present.
- The first 3 minutes of set up are not scored.
  - The 12 minutes of scored time are divided into 9 minutes for presentation material and 3 minutes for Q&A from the judges.
  - Teams will be cut off from their presentation at 9 minutes, although they may end the presentation early. Teams will be cut off again at the 12-minute mark to end the Q-and-A session.
- 6.1.3** It is expected that at least 3 students on the team speak during the presentation. Points will be deducted for less than 3 students taking part in the presentation portion prior to the Q&A.
- All members of the team, regardless of whether they are given speaking roles, must be present during the presentation.
- 6.1.4** Teams must bring the following to their presentation:
- AVR Drone, Sphero RVR, Sphero Minis (if graphics have been added)
  - Engineering Notebook (encouraged but optional)
  - Visual aids including PC laptop (with HDMI connection) if showing a slide presentation.

NOTE: Engineering Notebooks are optional but add significant point value to the Presentation score. For Teams that have Engineering Notebooks, they are to be submitted at the beginning of the Event Day as part of Team Check-In. Judges will evaluate the notebooks during the day but will provide them back to the Team for the Presentation Session.

## 6.2 - Details

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- 6.2.1 Each Team can use any visual aids they deem necessary (e.g., PowerPoint, Prezi, videos, collages, etc).
  - a. Video shown during a presentation may not exceed 2 minutes in length.
- 6.2.2 For Teams keeping an Engineering Notebook, guidelines are provided in Appendix C. Usage of the Engineering Notebook during the Team presentation is encouraged.
- 6.2.3 The design process portion of the presentation should include any specific design process, communication/planning methods, and project management strategies used (e.g., rapid prototyping, agile, etc.)
- 6.2.4 Teams should include any winning strategies they devised for the competition.

## 6.3 - Presentation Scoring

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- 6.3.1 Teams will be scored based on eight categories, which cover a number of aspects of the presentation, including content and style. More points will be awarded for extra research, truly innovative thinking, and synthesis between competition experiences and professional engineering skills.
- 6.3.2 Judges will be instructed to score subjectively on a 0-14 or 0-27 point scale.
- 6.3.3 The full rubric for presentations is shown in Appendix B.
- 6.3.4 **Note:** For the Championship event on December 3, the available point values for each section of the Presentation rubric have been modified. The overall Presentation score now has a maximum of 125 points, and the relative weight for the “Quality and Content of Engineering Notebook” portion has been increased.

# 7 - Tournament Logistics

- 7.1 Teams will compete in four (4) Matches over the course of a one-day Event.
- 7.2 Prior to each Match, Teams will inform the Head Referee which scenario they would like to play (i.e. which Community begins Burning during the Initial Burn). Teams will get two (2) Matches with each Community.
- 7.3 Teams will be ranked based on the sum of their Match scores and Presentation score (i.e. the Presentation can be thought of as an additional “Match”, in terms of rankings).
  - a. If there are any ties based on this sum, the first tiebreaker will be the Team with the highest Presentation score, followed by the highest single Match score.
- 7.4 The Team’s lowest Match score will be excluded from the rankings total.
  - a. The Presentation score cannot be excluded.
  - b. For example, in the set of scores listed below, the score for Match 4 would be excluded from the rankings.

Match 1	140
Match 2	130
Match 3	120
Match 4	110
Presentation	100

- 7.5 The Head Referee has ultimate authority on all rules decisions.
  - a. The Head Referee may not review any photo or video match recordings to determine a score or ruling.
  - b. The Head Referee is the only individual permitted to explain a rule, Disqualification or warning to the teams.
  - c. The Head Referee must give the rule number of the rule violated when issuing a Disqualification or warning to a Team.
- 7.6 Any Team is permitted to immediately appeal the Head Referee’s ruling after the Match. If a team member wishes to dispute a score or ruling, they must do so prior to their next Match.

**7.7** Match replays, i.e. playing a Match over again from its start, are at the discretion of the Event Coordinator and Head Referee and will only be issued in the most extreme circumstances. Some example situations that may warrant a Match replay are as follows:

- a. Game Elements not starting in the correct positions.
- b. Game Elements detaching or moving beyond normal tolerances (not as a result of vehicle interactions).
- c. The Field is reset before a score is determined.

**7.8** Teams must be ready to play when they arrive at the field and set up their equipment within the allotted setup time. Failure to do so promptly may result in a Disqualification at the Head Referee's discretion.

## 7.9 Championship Qualification Criteria

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**7.9.1** The 2022 Bell AVR Championship Event will be held on December 3, 2022, at the Bell Flight Research Center in Arlington, Texas.

**7.9.2** Each Qualifying Event held in November will have one (1) qualification spot for the Championship Event. This spot will be awarded to the 1st Place Team at the event, i.e. the Team who has scored the most points towards their rankings, per 7.3 and 7.4.

**7.9.3** If the 1st Place Team has already qualified, the spot will be awarded to the next highest-ranked Team, and so forth.

**7.9.4** Each event region (Texas, Michigan, and DC / Mid-Atlantic) may also have one (1) "wildcard" spot. This spot will be awarded to the Team from each region's events with the highest single-event score who has not already qualified.

**7.9.5** Additional open spots for the Championship event may be filled by RECF and Bell staff. These teams will be selected by considering various factors including on-field performance, awards won, vehicle design, presentation quality, and/or availability. Teams that are available to attend the Championship event and would like to be considered for an invitation should add themselves to the Championship Waitlist no later than November 22nd, 2022.

7.9.6 Example qualifying results from a region with 2 events:

	Event 1	Event 2	Outcome
Team A	500	500	Qualifies by winning Event 1
Team B	450	490	Qualifies by coming 2nd at Event 2, where the winning team has already qualified
Team C	470	480	Qualifies by the region's wildcard, for having the highest event score out of teams who have not already qualified
Team D	450	400	Does not qualify



# 8 - Vehicle Specification and Build Guidelines

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## 8.1 - General

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- 8.1.1** Vehicles found in violation of one or more of these rules during a Match may be Disabled or Disqualified at the Head Referee's discretion, and will not be permitted to play in any further Matches until they have corrected the violation
- 8.1.2** AVR Drones must be expected to pass a "wall test". As a general rule of thumb, if the drone approaches a wall from any angle, any other part of the drone (such as propeller guards) should be the first thing to contact the wall. See rule 9.1.5.
- Similarly, if a drone is flying towards a netted cage, propeller guards must be the first thing to contact the net, mitigating risk of propeller entanglement.
- 8.1.3** The AVR Drone must clearly and legibly display a Team's number.
- 8.1.4** There are no dimensional or weight limits for any Vehicle.
- The AVR Drone has a recommended maximum flight weight of 3.2 kg. Exceeding this limit may cause unstable flight, shorter battery life, or other unexpected behavior.
- 8.1.5** The following types of mechanisms and components are strictly prohibited on any Vehicle:
- Those that could potentially damage Field Elements.
  - Those that could potentially damage other Vehicles.
  - Those that pose an unnecessary risk of entanglement with the netted cage.
  - Those that could pose a potential safety hazard to Drive Team Members, event staff, or other humans.
  - Those that could directly interfere with other Teams (e.g. through wireless or visual interference).

## 8.2 - Electronics & Software

**8.2.1** For the following electronic control system components, AVR Drones may only use the items provided in the Team registration kit:

Item	Brand / Part #
Batteries	SMC 4S 5200mah Hardcase
Flight Control Computer (FCC)	Pixhawk 6C
Vision Management Computer (VMC)	NVIDIA® Jetson Nano™ 4GB
Peripheral Control Computer (PCC)	Adafruit Feather M4 Express, Prop Maker Featherwing, Servo/PWM Featherwing, Featherwing Tripler Mini Kit
Prop Motors	Brother Hobby 2812 900kv BLDC motor *
Electronic Speed Controllers	Holybro 4-in-1 50A ESC *
Transmitter / Receiver	FlySky FS-i6S *
FPV Camera	AKK A3
CSI Camera	Seedstudio IMX219-160 8MP
VIO Camera	ZED Mini
5V 650 nm Laser	AVR PIC KY-008
Telemetry Radio (not included in kit)	Any PX4-approved telemetry radio as described on this page: <a href="https://docs.px4.io/v1.9.0/en/telemetry/">https://docs.px4.io/v1.9.0/en/telemetry/</a>

\* denotes a component custom-manufactured or modified for the Bell AVR Competition. Contact [BellAVR@roboticseducation.org](mailto:BellAVR@roboticseducation.org) with any questions.

**8.2.1** Teams may use any additionally commercially available sensors or actuators (e.g. servo motors) provided that they abide by the following criteria:

- Components may only receive power from the onboard battery listed in 8.2.1.
- Components may only be controlled by / interface with the existing PCC, VMC, or FCC as described in 8.2.1.

- c. Components must not violate any other rules (e.g. create safety hazards, create wireless interference, etc).

**8.2.2** Exposed wiring of any kind is prohibited. All wiring connections must be covered by either heat shrink or electrical tape.

**8.2.3** Teams & vehicles may only use the following forms of wireless communication:

- a. WiFi between the VMC and the Ground Control Operator laptop or wireless router.
- b. WiFi between the Tello and a Drive Team Member's laptop or mobile device.
- c. Bluetooth between the Sphero RVR and a Drive Team Member's laptop or mobile device.
- d. Bluetooth between the Sphero Minis and a Drive Team Member's laptops or mobile devices.
- e. 5.8GHz radio between the FPV transmitter and receiver.
- f. 2.4GHz radio between the FCC's receiver and a Drive Team Member's transmitter.
- g. 900-915MHz or WiFi between an optional telemetry receiver and transmitter.

**8.2.4** Software created before the current season begins (e.g. from previous seasons) is only permitted if the source code is made publicly available to all Teams via a post on BellAVRForum.org, a public Github repository, or something similar.

**8.2.5** The LWC laser may only be activated using one of the two timing options found in the default AVR code. Any modification of this timing, such as a permanent "on" mode, could be considered a safety violation, i.e. escalate to a violation of rule 9.1.1.

Mode	Time ON (s)	Time between Shots (s)
Blip	0.10	0.50
Fire Laser	0.25	0.75

- a. This code can be found in the PCC module: ([link](#))

## 8.3 - Hardware

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- 8.3.1** The AVR Drone's primary airframe must be built from the carbon fiber components included in the AVR Drone Kit (i.e. configured as a quadcopter).
- 8.3.2** Carbon fiber frame components included in the AVR Drone Kit may not be modified in any way.
- 8.3.3** Rules 8.3.1 and 8.3.2 do not apply to assembly hardware (e.g. screws, standoffs) or 3D printed parts. Teams may modify, customize, add, or remove 3D printed parts at will.
- 8.3.4** There are no material restrictions on additional mechanisms or accessories added to the AVR Drone, Sphero RVR, or Sphero Minis, provided that no other rules are violated.
- 8.3.5** The only permissible accessory that may be added to the Tello Drone is the propeller guard included in a Team's Registration Kit, and the 3D printed attachment found in the Assembly Guide.

# 9 - Safety & Conduct

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## 9.1 - General Safety

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- 9.1.1** If Vehicle operation or Team actions are deemed unsafe during a Match, the offending Team may receive a Disablement or Disqualification at the Head Referee's discretion.
- If a Team or any of its members (Students or any Adults associated with the Team) are disrespectful or uncivil to event staff, volunteers, or fellow competitors, they may be Disqualified from a current or upcoming Match.
  - Team conduct pertaining to this rule may also impact a Team's eligibility for judged awards.
- 9.1.2** Competitors must follow all relevant FAA (Federal Aviation Administration) safety regulations to guarantee the safety of students, spectators, and teachers.
- 9.1.3** All competitors must wear safety glasses when at the Field. This includes both in the Driver Station, and when interacting with Vehicles inside of the Field.

## 9.2 - Flight Safety Rules

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- 9.2.1** Unless it is inside of a netted Field, the AVR Drone must never:
- Have Propellers mounted
  - Be Armed
- 9.2.2** The AVR Drone may only be Armed if all of the following conditions are met:
- The AVR Drone is inside of a netted Field
  - There are no humans inside of the Field
  - The AVR Drone has legal Propeller Guards attached (see rule 8.1.2). Flying the AVR Drone outside of a netted area is considered to be a violation of rule 9.1 and could result in Disqualification from an event.
  - There are no exceptions to these rules.
- 9.2.3** If an AVR Drone crashes, is Disabled, or otherwise becomes unresponsive during a Match, no action may be taken by Teams to continue flying.

# 10 - Honors and Awards

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There are three (3) Competition Awards and four (4) Judge's Awards. Competition Awards are based on a Team's performance during the event. All Teams are eligible for Judge's Awards. Judge's awards will be evaluated by presentation judges, referees, event staff, and other volunteers.

## 10.1 - Competition Awards

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**10.1.1** Competition Awards will be given to the 1st, 2nd, and 3rd place Teams, based on their ranking at the end of the event as described in section 7.3.

## 10.2 - Best Overall Design Award

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**10.2.1** The Best Overall Design Award will be given to the Team that demonstrates the best overall design for their AVR Drone and Sphero RVR.

**10.2.2** This award will be evaluated primarily by judges of the presentation event, in conjunction with the referees who observe each Team in competition.

**10.2.3** Judges will consider uniqueness of design, aesthetics and form factor of the platform, intentionality of design decisions, functionality of systems and modules, innovative controls, and reliability/durability.

**10.2.4** Teams must submit an Engineering Notebook in order to be considered for this award.

## 10.3 - Exemplary Team Award

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**10.3.1** The Bell AVR Competition prides itself on the simultaneously competitive and collaborative environment it cultivates for participants. Because of this, an award will be given to the Team that best demonstrates professionalism, passion, and respect to both fellow competitors and event staff.

**10.3.2** This award will be judged by the behavior of students in the competition arena, pit area, and the venue as a whole. It will be based on a combination of spirit and sportsmanship.

**10.3.3** This award will be given to the team most enjoyable to compete against, and will recognize Teams that demonstrate Team spirit, coordinate colors/cheers, assist and support both competitors and teammates, and demonstrate superior professionalism.

## 10.4 - Presentation Award

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**10.4.1** This award will be given independent of on-Field performance, and is instead based solely on the Team's performance in the presentation event and the submittal of their Engineering Notebook for the judges' review.

**10.4.2** This award will be evaluated solely by the presentation judges.

**10.4.3** This award will recognize the Team with the cleanest presentation, including:

- a. Helpful and well-crafted media
- b. Well-spoken and confident presenters
- c. Clear indication of practice and effort
- d. Clear structure of the presentation
- e. Quality and thoroughness of ideas
- f. Content and quality of the Engineering Notebook (especially as referenced / included in the presentation)

## 10.5 - Judge's Choice Award

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**10.5.1** The Judge's Choice Award will be given to an outstanding Team who doesn't necessarily fit into the category of one of the other three Judge's Awards.

**10.5.2** This award will recognize Teams that stand out among their peers, either in superior subject matter expertise, attitude, communication and teamwork ability, or other qualities that the judges deem worthy of recognition.

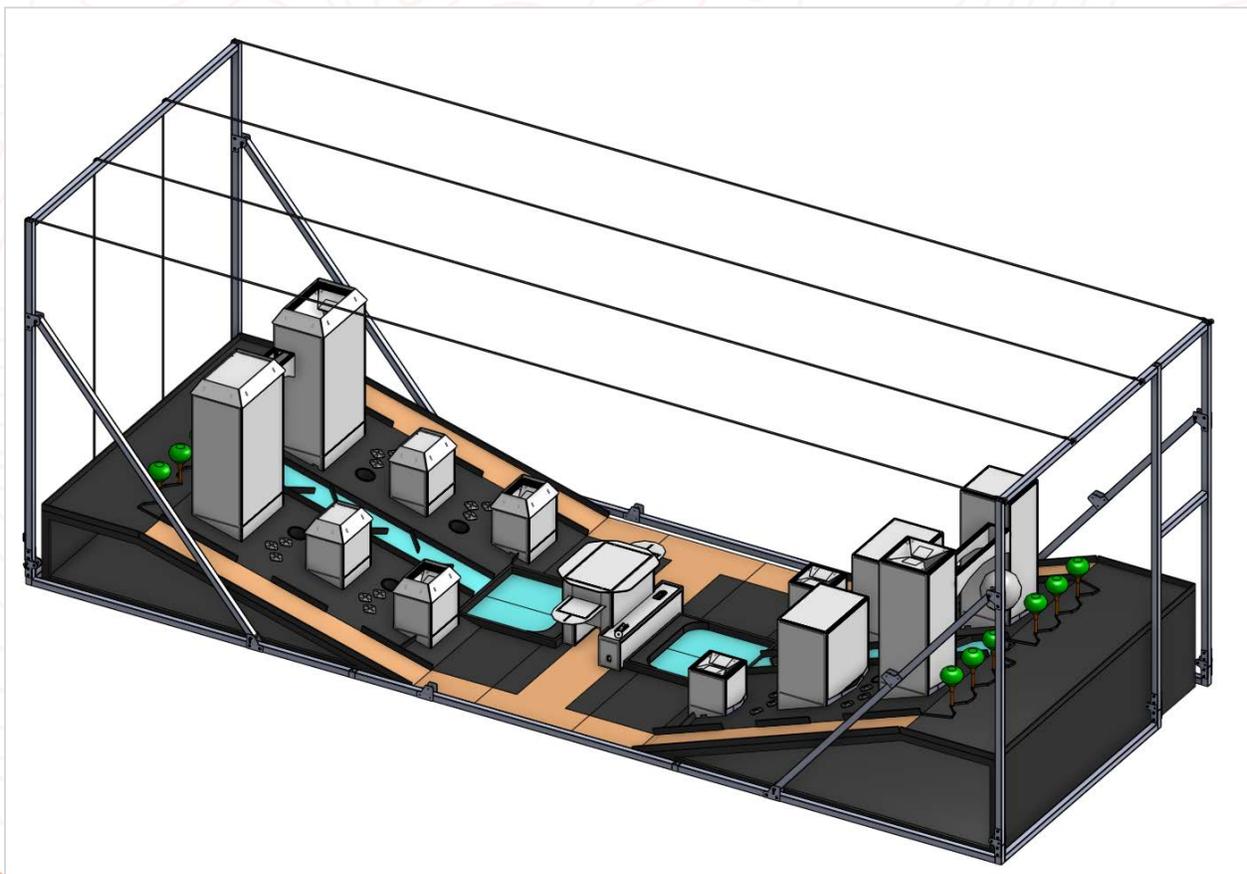
# Appendix A - Field Specifications

This section outlines the dimensions and specifications that are most important to teams competing in the Emergency Firefighting Challenge. Though many of the critical dimensions are included in this section, it may be necessary to consult the provided 3D CAD model of the field for additional details.

Field components may vary slightly from event to event. This is to be expected; Teams will need to adjust accordingly. It is good design practice to create mechanisms capable of accommodating variances in the field elements.

Links to CAD files for the full field can be found in [OnShape \(link\)](#).

To download, right click on "BAVR-22-0-000.X Full Field" in the project tree. Select Export and pick your desired file format.



# Appendix B - Presentation Rubric

Team Number: \_\_\_\_\_ Judge Name: \_\_\_\_\_ Score

## Design Approach and Process

Comments: /14

## Demonstrated Engineering Skills

Comments: /14

## Game Winning Strategy

Comments: /14

## Lessons Learned

Comments: /14

## Teamwork and Communication

Comments: /14

## Quality of Materials and Presentation

Comments: /14

## Demonstrated Effort and Research

Comments: /14

## Quality and Content of Engineering Notebook

Comments: /27

Overall Total: /125



# Appendix C - Engineering Notebook

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The engineering notebook is not mandatory but highly recommended, not just for the point value, but for learning a discipline for future projects.

The engineering notebook is a documentation of the Team, Team plans, and the vehicle and drone designs. This documentation should include sketches, discussions and team meetings, design evolution, processes, obstacles, and each Team member's thoughts throughout the journey for the entire season.

Teams may use either classic pen and paper to create the notebook (Spiral notebooks, lab notebooks, loose pages, or a combination of any or all of these), or they may keep an electronic version on a computer or tablet or on a shared resource such as Google Drive. Notebooks should contain notes of all team meetings, sketches of changes and modifications, any engineering calculations used in the design, and photographs of the build and the team activities. For those teams who elect to take on autonomous challenges, the notebook should include a copy of the programming code that was created on the Vehicle Management Computer (VMC) to activate the Peripheral Control Computer (PCC).

Notebooks submitted for judging **MUST** be printed on paper and submitted in a single 3 ring binder with a ring diameter of no more than 3 inches. Handwritten material may be scanned for inclusion in the final notebook. All materials must be fastened to pages, no loose materials will be accepted. The Team Number **MUST** be printed on the outside of the notebook.

Engineering Notebooks are to be submitted at the beginning of the Event Day as part of Team Check-In. Judges will evaluate the notebooks during the day but will provide them back to the Team for the Presentation Session.



## Suggested Guidelines for Engineering Notebooks:

1. Title page
2. Summary page with important pages noted and reasons why they are important (Summary is ONE page only)
3. Table of contents (Labeled tabs for the notebook are nice but not required)
4. Sections:
  - A) Team bios including role and contributions to the team (First Names only)
  - B) Safety Processes
    - i. Meeting Discussion
    - ii. Workshop Safety
    - iii. Flight Safety
  - C) Vehicle designs – This would be the design and development of elements beyond the basic VRC drone kit and the Sphero kits (RVR and Sphero Minis). This should include initial designs and implementation and then changes over the course of development showing application of the engineering design process.
  - D) Game strategies – This would be the determinations of where the team will focus the strategy as they play. This should include any decisions and developments made over time.
  - E) Artistic elements – Any extra efforts to make the designs realistic (Vehicles finished to have a firefighting look, Sphero Minis to look like people.....)
  - F) Team meeting/ work session documentation - this can include:
    - i. Date, time, and location of meeting/ work session
    - ii. Attendees including coaches and mentors (if any)
    - iii. Meeting/ session goals (if defined)
    - iv. Accomplishments – including lessons learned through training, practice, and through failure
    - v. Design decisions made including sketches, calculations, notes, and photos. This will include the design items from above but here they are spread throughout the timeline of work vs. the design section where they are all pulled together.
    - vi. Game strategy planning
    - vii. Event and presentation discussions
    - viii. Processes followed including safety processes
    - ix. issues (if any)
    - x. Reflection

The documentation should include enough detail for another person to look at your notebook and be able to follow the steps your team took to get to your final designs.