

## 5 ARENA

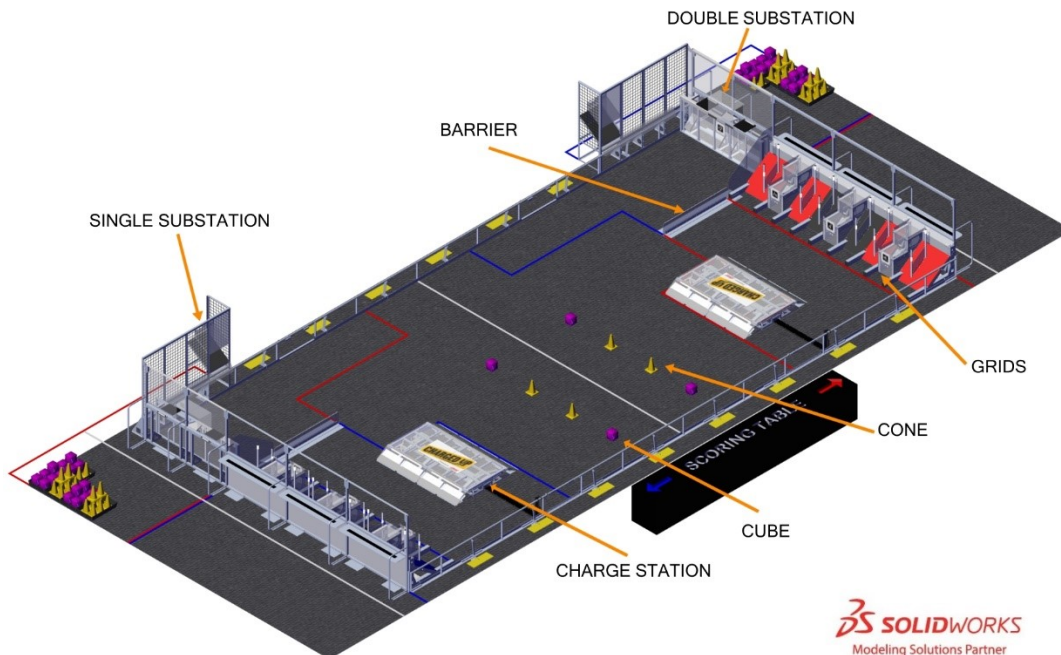
The ARENA includes all elements of the game infrastructure that are required to play CHARGED UP<sup>SM</sup> presented by Haas: the FIELD, GAME PIECES, and all equipment needed for FIELD control, ROBOT control, and scorekeeping.

The ARENA is modular and assembled, used, disassembled, and shipped many times during the competition season. It will undergo wear and tear. The ARENA is designed to withstand rigorous play and frequent shipping. Every effort is made to ensure that ARENAS are consistent from event to event. However, ARENAS are assembled in different venues by different event staff and some small variations occur. For details regarding assembly tolerances, please refer to the [2023 ARENA Layout and Marking Diagram](#). Successful teams will design ROBOTS that are insensitive to these variations.

Illustrations included in this section are for a general visual understanding of the CHARGED UP ARENA, and dimensions included in the manual are nominal. Please refer to the official drawings for exact dimensions, tolerances, and construction details. The official drawings, CAD models, and drawings for low-cost versions of important elements of the CHARGED UP FIELD are posted on the [CHARGED UP - Playing FIELD web page](#) on the FIRST website.

### 5.1 FIELD

Figure 5-1: CHARGED UP



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Each FIELD for CHARGED UP is an approximately 26 ft. 3½ in. (~802 cm) by 54 ft. 3¼ in. (~1654 cm) carpeted area bound by and including the inward- and upward-facing surfaces of the guardrails, inward-facing surfaces of the ALLIANCE WALLS, inward-facing surfaces of the SINGLE SUBSTATION (excluding the PORTALS), and the outermost vertical and diagonal polycarbonate surfaces of the DOUBLE SUBSTATION (excluding the PORTALS).

Figure 5-2 CHARGED UP FIELD boundary

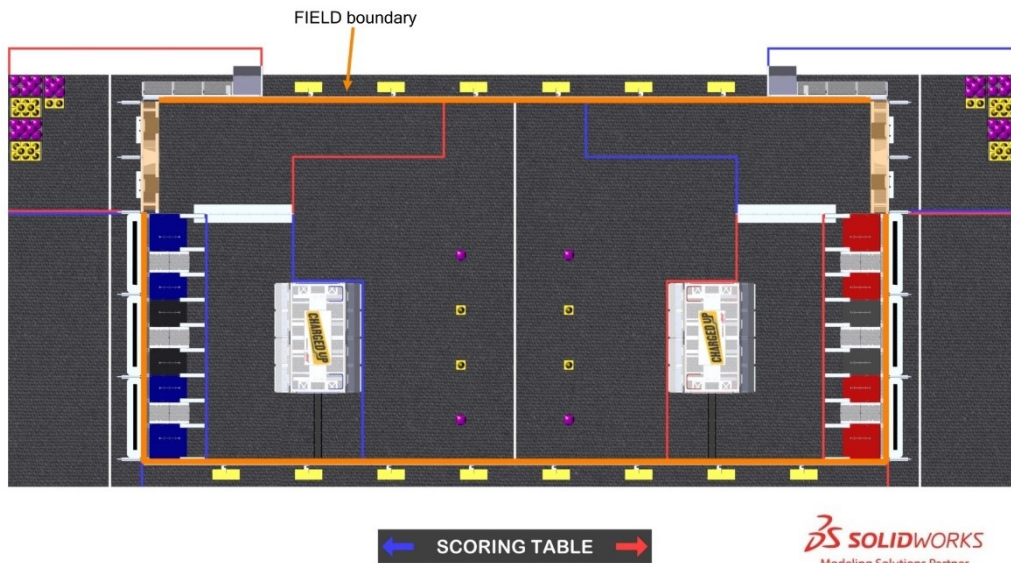
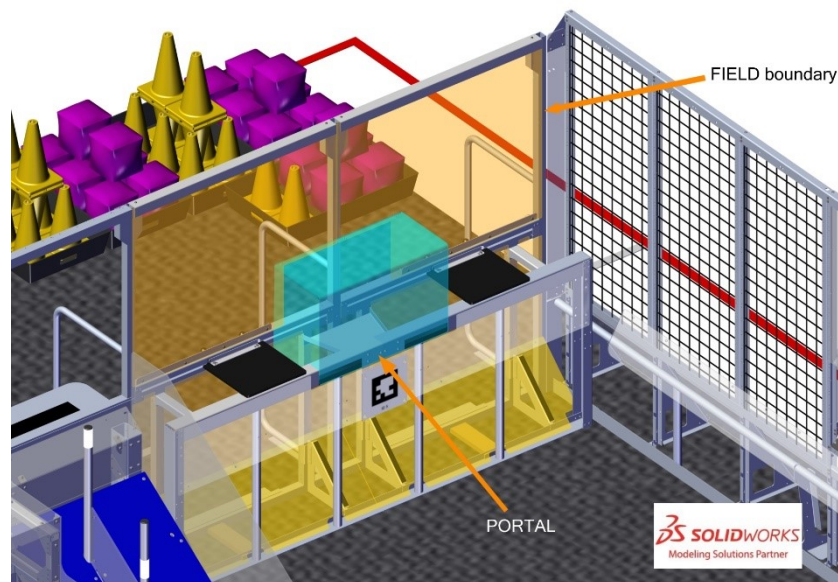


Figure 5-3 CHARGED UP FIELD boundary at DOUBLE SUBSTATION



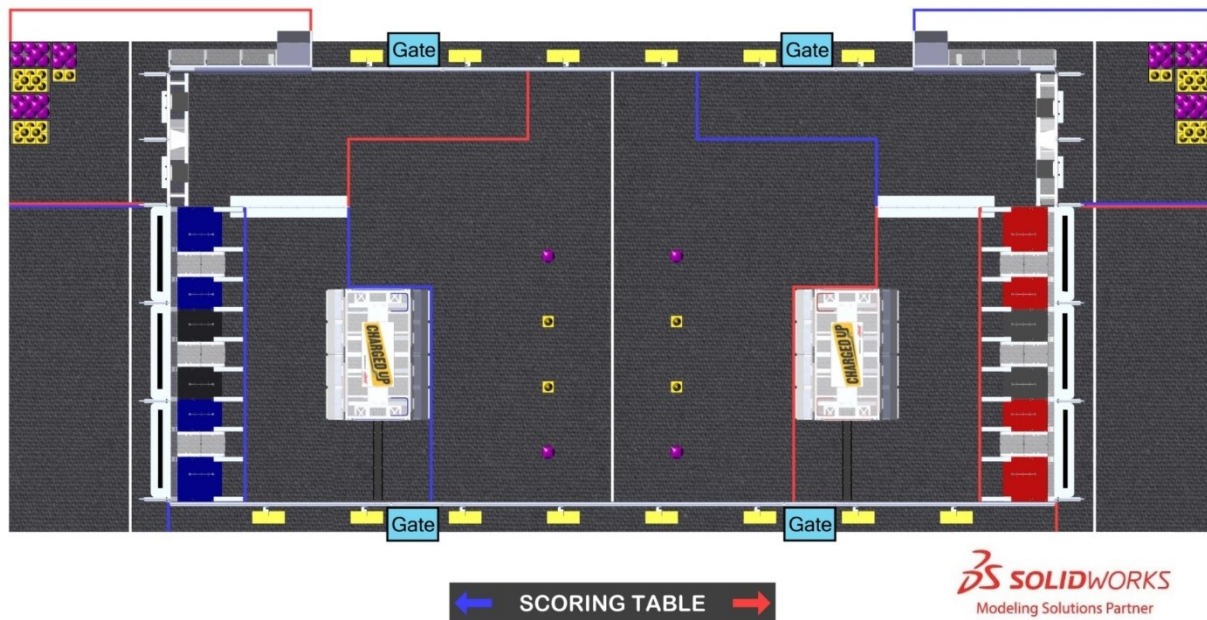
The FIELD is populated with the following elements:

- 3 red GRIDS and 3 blue GRIDS located in front of their corresponding ALLIANCE WALLS,
- 1 red CHARGE STATION and 1 blue CHARGE STATION located in their corresponding COMMUNITIES,
- 1 red SINGLE SUBSTATION and 1 Blue SINGLE SUBSTATION located along the guardrail in their corresponding SUBSTATION AREA,
- 1 red DOUBLE SUBSTATION and 1 blue DOUBLE SUBSTATION each located in line with and adjacent to the opposing ALLIANCE WALL
- 2 BARRIERS, 1 separating each COMMUNITY from the opposing ALLIANCE'S LOADING ZONE.

The surface of the FIELD is low pile carpet, Shaw Floors, Philadelphia Commercial, Neyland II 20, “66561 Medallion” (please note that Neyland II carpet is not available for team purchase and the closest equivalent is [Neyland III](#)). The edge of the carpet is secured to the venue floor using [3M™ Premium Matte Cloth \(Gaffers\) Tape GT2](#) or comparable gaffers tape.

Guardrails form the long edges of the FIELD. Guardrails are a 1 ft. 8 in. (~51 cm) tall system of transparent polycarbonate supported on the top and bottom by aluminum extrusion. There are 4 gates in the guardrail that allow access to the FIELD for placement and removal of ROBOTS. The gate passthrough, when open, is 3 ft. 2 in. (~97 cm) wide. Gates are closed and shielded during the MATCH.

Figure 5-4 Gate locations

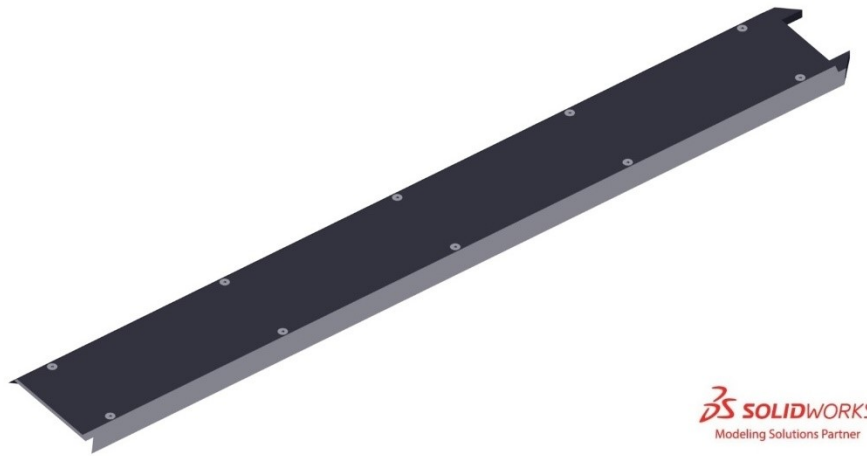


There are 2 versions of guardrails and DRIVER STATIONS used for competitions. 1 design is reflected in the [2023 Official FIRST Field Drawings & Models](#). The other is designed and sold by AndyMark. While the designs are slightly different, the critical dimensions, performance, and expected user experience between them are the same unless otherwise noted. Detailed drawings for the AndyMark design are posted on the [AndyMark website](#). All illustrations in this manual show the traditional FIELD design.

Runs of black HDPE cable protectors extend from the guardrail on the scoring table side of the FIELD to the center of each CHARGE STATION. A cable protector run is made up of multiple floor segments and an exit segment. The total length of the cable protector run is 5 ft. 6 in. (~168 cm). The floor segments are  $\frac{3}{4}$  in. (~19 mm) tall, 7 in. (~18 cm) wide, with ~45° lead in ramps on each leading edge and secured to the carpet using hook fastener which increases the height to approximately  $\frac{7}{8}$  in. (~22 mm). Exit segments mount over the guardrail and are 1 ft.  $\frac{3}{4}$  in. (~53 cm) tall, 6 in. (~15 cm) wide and extend into the field  $1\frac{3}{4}$  in. (~4 cm).



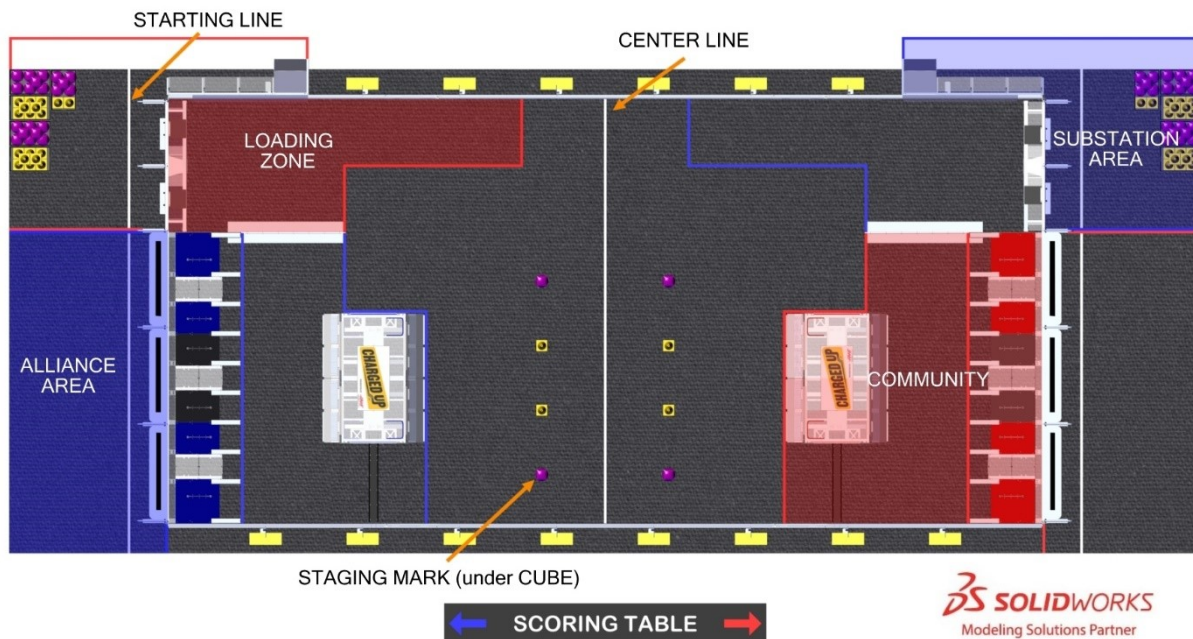
Figure 5-5 Cable protector segment



## 5.2 Areas, Zones, and Markings

FIELD areas, zones, and markings of consequence are described below. Unless otherwise specified, the tape used to mark lines and zones throughout the FIELD is 2-in. (~5 cm) [3M™ Premium Matte Cloth \(Gaffers\) Tape \(GT2\)](#) or comparable gaffers tape.

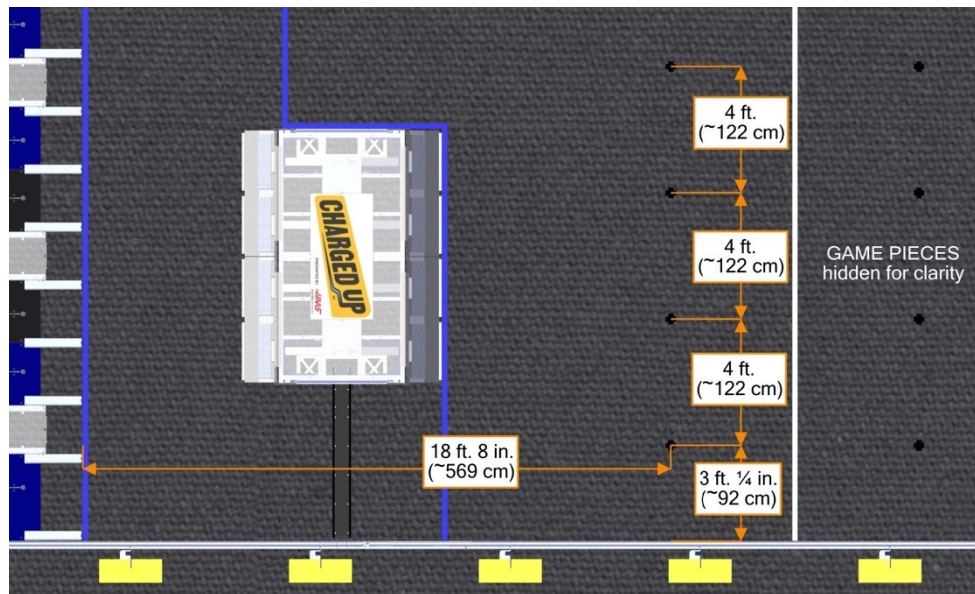
Figure 5-6 Areas, Zones, and Markings



- **ALLIANCE AREA:** a 20 ft. (~609 cm) wide by 9 ft. 10¼ in. (~300 cm) deep infinitely tall volume formed by, and including the ALLIANCE WALL, the edge of the carpet, and ALLIANCE colored tape.
- **CENTER LINE:** a white tape line that bisects the length of the FIELD.

- **COMMUNITY:** an 18 ft. (~549 cm) wide by 11 ft.  $\frac{3}{8}$  in. (~336 cm) to 16 ft.  $1\frac{1}{4}$  in. (~491 cm) deep infinitely tall volume formed by the ALLIANCE WALL, the plane defined by the BARRIER plastic, ALLIANCE colored tape, and the guardrail. The COMMUNITY includes the tape.
- **LOADING ZONE:** an 8 ft. 3 in. (~252 cm) wide by 11 ft.  $\frac{1}{4}$  in. (~336 cm) to 22 ft.  $\frac{1}{4}$  in. (~671 cm) deep infinitely tall volume formed by the DOUBLE SUBSTATION, the plane defined by the BARRIER plastic, the guardrail, and ALLIANCE colored tape. The LOADING ZONE includes the tape.
- **STAGING MARK:** 1 of 8 marks used to identify starting locations for GAME PIECES. Marks are 4 in. (~10 cm) by 4 in. (~10 cm) crosses made from black tape. Marks are spaced 4 ft. (~122 cm) apart from each other. Each set of 4 marks is centered about the width of the COMMUNITY and is located 18 ft. 8 in. (~569 cm) from the far edge of the corresponding GRID tape as shown in Figure 5-7. A small, light mark may be added to each STAGING MARK to distinguish STAGING MARKS from black tape used to patch carpet.

Figure 5-7 STAGING MARK locations

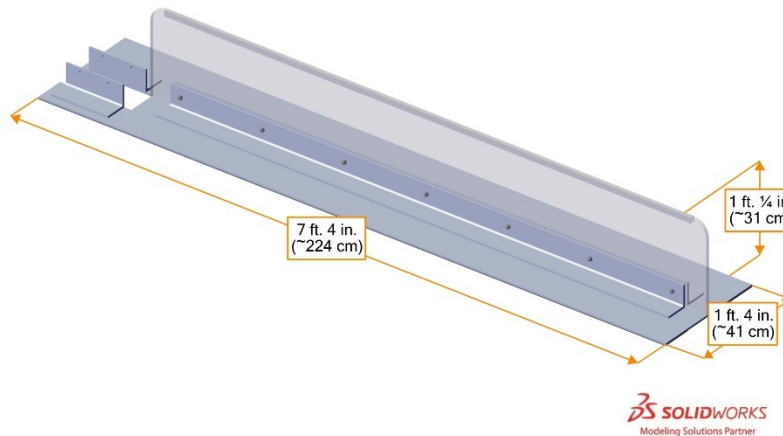


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- **STARTING LINE:** a white tape line spanning the ALLIANCE AREA and SUBSTATION AREA located 2 ft. 4 in. (~71 cm) from the face of the ALLIANCE WALL to the near edge of the tape.
- **SUBSTATION AREA:** a 12 ft. (~366 cm) wide by 18 ft. 7 in. (~566 cm) deep infinitely tall volume formed by and including the DOUBLE SUBSTATION, the edge of the carpet, the guardrail, the SINGLE SUBSTATION and ALLIANCE colored tape. The SUBSTATION AREA includes the PORTALS and the tape.

## 5.3 BARRIER

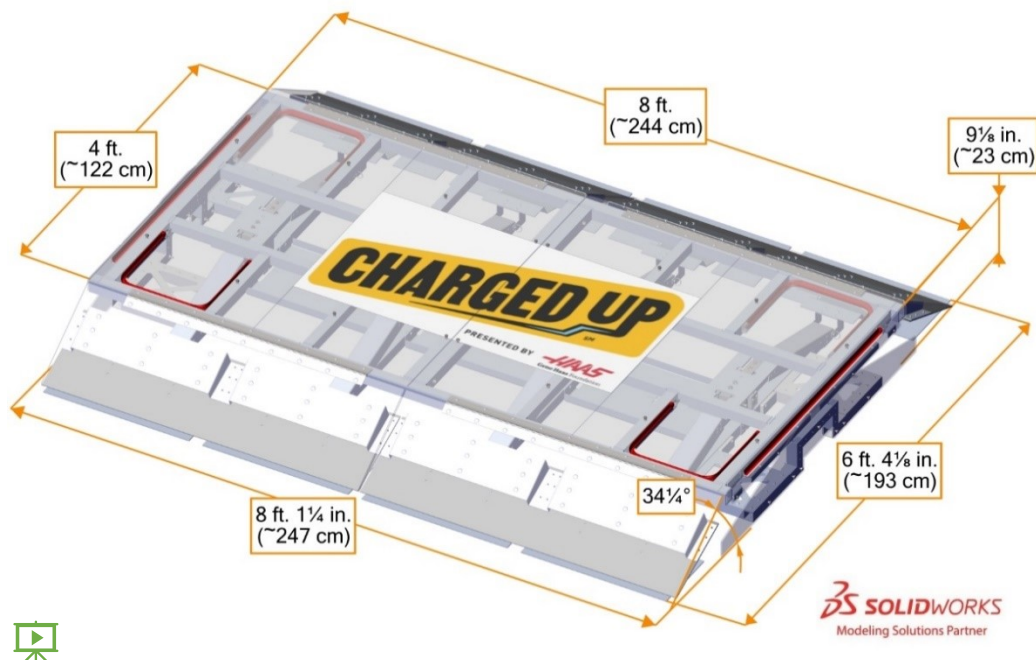
Figure 5-8: BARRIER



A BARRIER is a 7 ft. 4 in. (~224 cm) long assembly that separates each COMMUNITY from its adjacent LOADING ZONE. The BARRIER has a base that is 1 ft. 4 in. (~41 cm) wide and ¼ in. (~6 mm) tall. The base supports a ½ in. (~13 mm) thick, 1 ft. ¼ in. (~31 cm) tall polycarbonate wall. A strip of white tape traces the top of the BARRIER plastic as shown in Figure 5-8.

## 5.4 CHARGE STATION

Figure 5-9 LEVEL CHARGE STATION (click image to see field tour video)

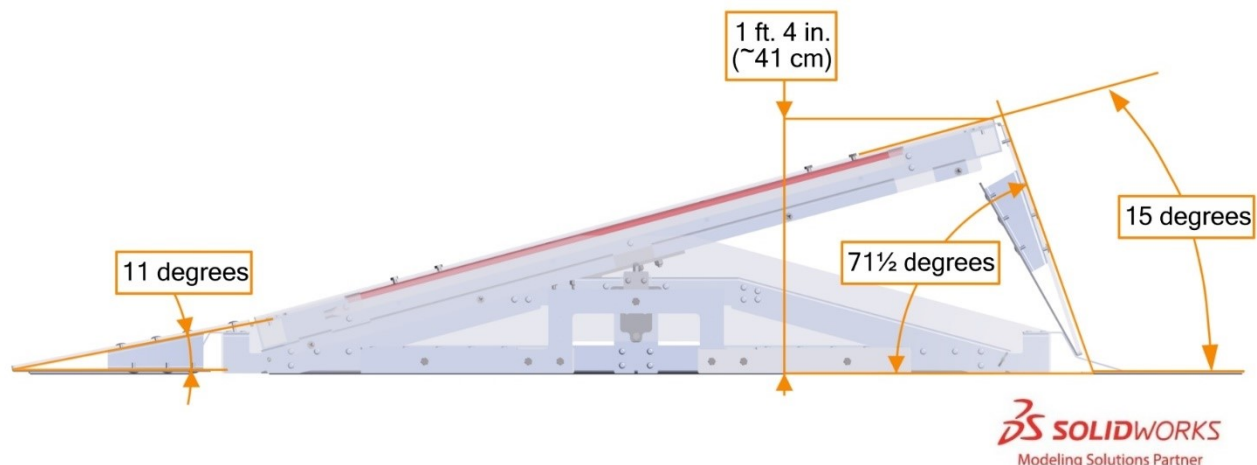


A CHARGE STATION is an 8 ft. 1¼ in. (~247 cm) wide, 6 ft. 4⅝ in. (~193 cm) deep structure that is located in each COMMUNITY such that its center is 8 ft. 2⅝ in. (~251 cm) from the far edge of the GRID'S tape line and centered in the width of the COMMUNITY. Each CHARGE STATION consists of the main pivoting frame, lead-in ramps, and the support structure. The main pivoting frame is mounted to the base frame via a set of 4 double hinges.

The main pivoting surface of a CHARGE STATION is 8 ft. (~244 cm) wide and 4 ft. (~122 cm) deep. It pivots +/- 15° about its long axis. When parallel to FIELD carpet, the top polycarbonate surface is 9⅝ in. (~23 cm) above FIELD carpet as shown in Figure 5-9. When pivoted to 15°, the highest edge is 1 ft. 4 in. (~41 cm) above FIELD carpet. In normal operation, a CHARGE STATION will naturally return to the middle of the LEVEL range. A CHARGE STATION is considered LEVEL if it is within approximately 2½° of parallel to FIELD carpet.

Polycarbonate ramps are located on the long edges of each CHARGE STATION. The ramps are 1 ft. 3⅝ in. (~39 cm) long and span the full width of the CHARGE STATION. The ramps pivot and slide as the main pivoting surface moves. When the CHARGE STATION top is LEVEL, the ramps are tilted at an angle of approximately 34¼° as shown in Figure 5-9. When the CHARGE STATION is fully tilted, the lower ramps are at an angle of approximately 11° and the upper ramps are at an angle of approximately 71½°, as shown in Figure 5-10.

*Figure 5-10 Fully tilted CHARGE STATION*

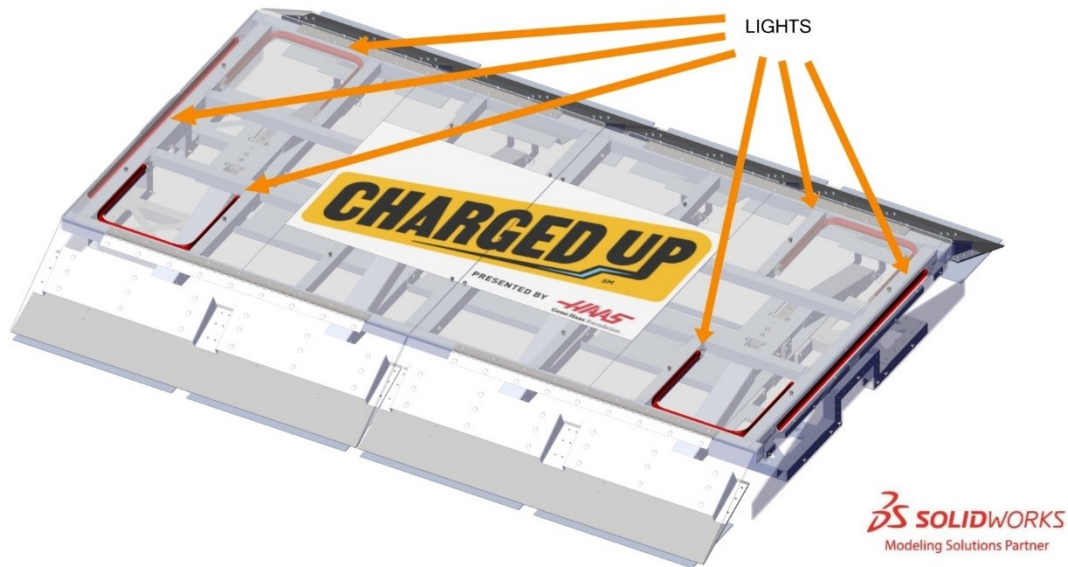


The short edges of the CHARGE STATION feature guards that restrict access to the underside of the structure.



### 5.4.1 CHARGE STATION lighting

Figure 5-11 CHARGE STATION LEVEL lighting example



ALLIANCE colored lights located along the short edges of the CHARGE STATION and at the 4 corners of the top surface indicate if it is LEVEL.

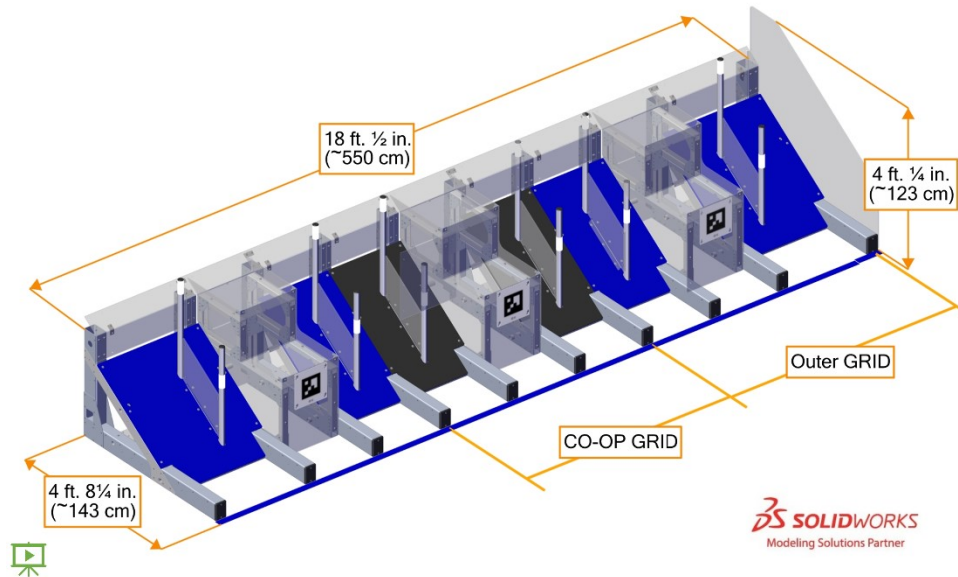
Table 5-1 ENGAGED light states

Light State	Criteria
Off	Outside of a MATCH In MATCH: CHARGE STATION is not LEVEL
ALLIANCE color	CHARGE STATION is LEVEL



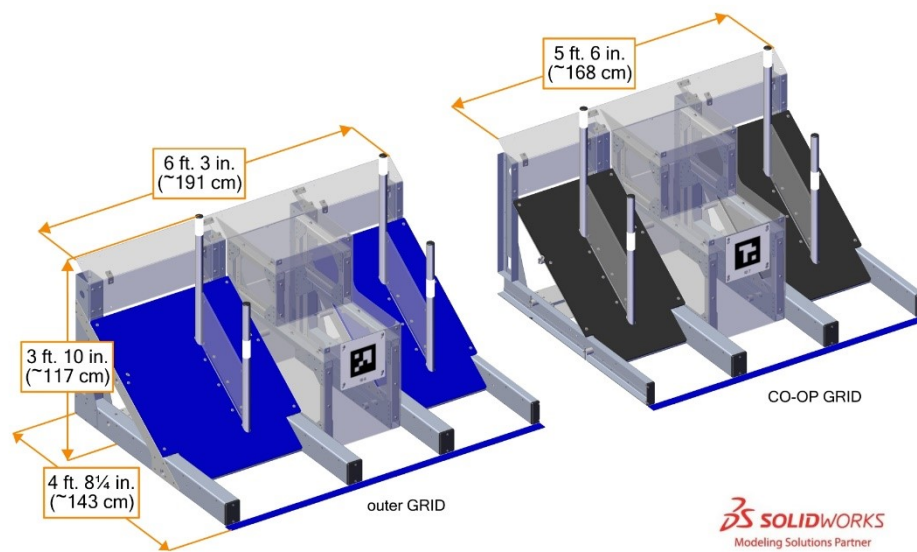
## 5.5 GRIDS

Figure 5-12 BLUE ALLIANCE GRIDS (click image to see field tour video)



A collection of 3 GRIDS consisting of 2 outer GRIDS and a *Coopertition* (CO-OP) GRID is located in front of each ALLIANCE WALL adjacent to the guardrail and BARRIER. The full assembly is 18 ft. ½ in. (~550 cm) wide, 4 ft. ¼ in. (~123 cm) tall, and 4 ft. 8¼ in. (~143 cm) deep. A strip of ALLIANCE-colored tape is included as part of the assembly of GRIDS and defines its front plane.

Figure 5-13 Individual GRID overall sizing



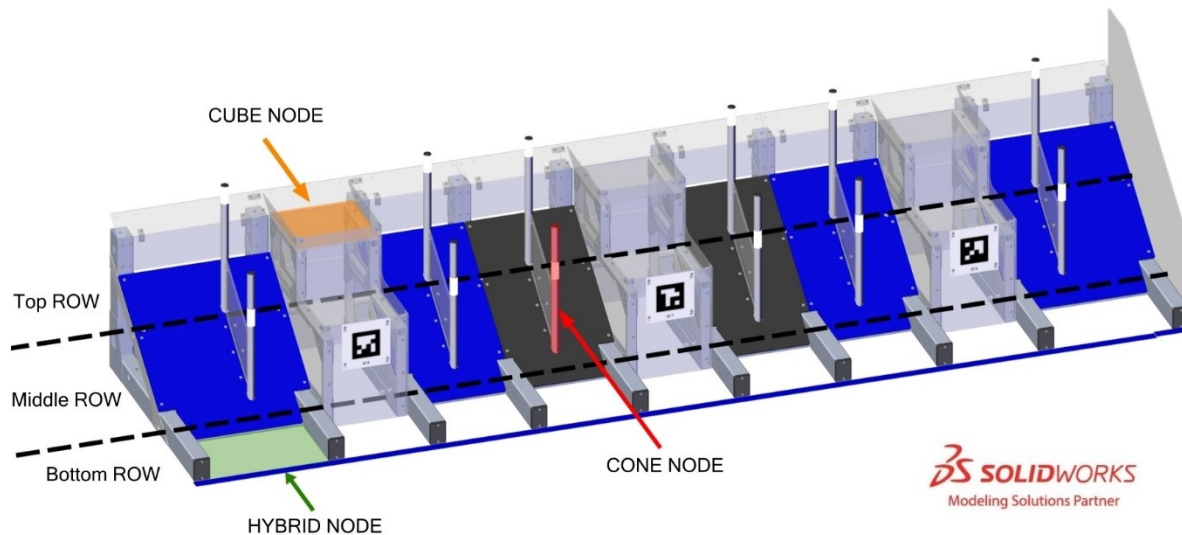
A GRID is a 3 ft. 10 in. (~117 cm) tall, 4 ft. 8¼ in. (~143 cm) deep assembly that includes the ALLIANCE colored tape line. Outer GRIDS are 6 ft. 3 in. (~191 cm) wide. The CO-OP GRID is 5 ft. 6 in. (~168 cm) wide.

Each GRID contains 9 GAME PIECE scoring locations called NODES:

- 3 HYBRID NODES
- 2 CUBE NODES, and
- 4 CONE NODES.

Each set of GRIDS is divided into 3 ROWS. A ROW is a series of 9 horizontally adjacent NODES where GAME PIECES can be scored for a common number of points. The bottom ROW consists of 9 HYBRID NODES. The middle ROW and top ROW each consist of 6 CONE NODES and 3 CUBE NODES.

*Figure 5-14 GRID NODES and ROWS*



A HYBRID NODE is a 1 ft. 4 in. (~41 cm) deep carpeted surface contained within the GRID. The 2 outermost HYBRID NODES in each collection of GRIDS are 2 ft. 1¾ in. (~65 cm) wide and the rest of the HYBRID NODES are 1 ft. 6½ in. (~47 cm) wide. HYBRID NODES have 5 in. (~13 cm) tall dividers between them. A guardrail or BARRIER runs coincident to the left and right outermost edges of a collection of GRIDS which limits access to outermost NODES.

Each CUBE NODE is a polycarbonate shelf that is 1 ft. 6¼ in. (~46 cm) wide and 1 ft. 5 in. (~43 cm) deep. CUBE NODES are surrounded by 3 in. (~8 cm) tall vertical walls, with the exception of the rear wall of the top ROW CUBE NODE which is angled. The distance from the FIELD carpet to the top of a middle ROW CUBE NODE wall is 1 ft. 11½ in. (~60 cm). The distance from the FIELD carpet to the top of a top ROW CUBE NODE wall is 2 ft. 11½ in. (~90 cm). The front of a middle ROW CUBE NODE is 1 ft. 2¼ in. (~36 cm) from the front face of the GRID. The front of a top ROW CUBE NODE is 2 ft. 7⅞ in. (~80 cm) from the front face of the GRID.

Each CONE NODE is a 1¼ in. Schedule 40 (1.66 in. (~4 cm) outer diameter) aluminum pipe with a plug installed in the top ([Caplugs part number CCF-RT-13-1](#)). CONE NODES are perpendicular to FIELD carpet. The top of a CONE NODE in the middle ROW is 2 ft. 10 in. (~87 cm) above FIELD CARPET. The top of a CONE NODE in the top ROW is 3 ft. 10 in. (~117 cm) above FIELD carpet. The center of a middle ROW CONE NODE is 1 ft. 10¾ in. (~58 cm) from the front face of the GRID. The center of a top ROW CONE NODE is 3 ft. 3¾ in. (~101 cm) from the front face of the GRID. A polycarbonate fin runs between each

middle ROW CONE NODE and its adjacent top ROW CONE NODE. The textured plastic surface beneath the CONE NODES is angled  $\sim 35^\circ$  from FIELD carpet.

Figure 5-15 GRID top view dimensions

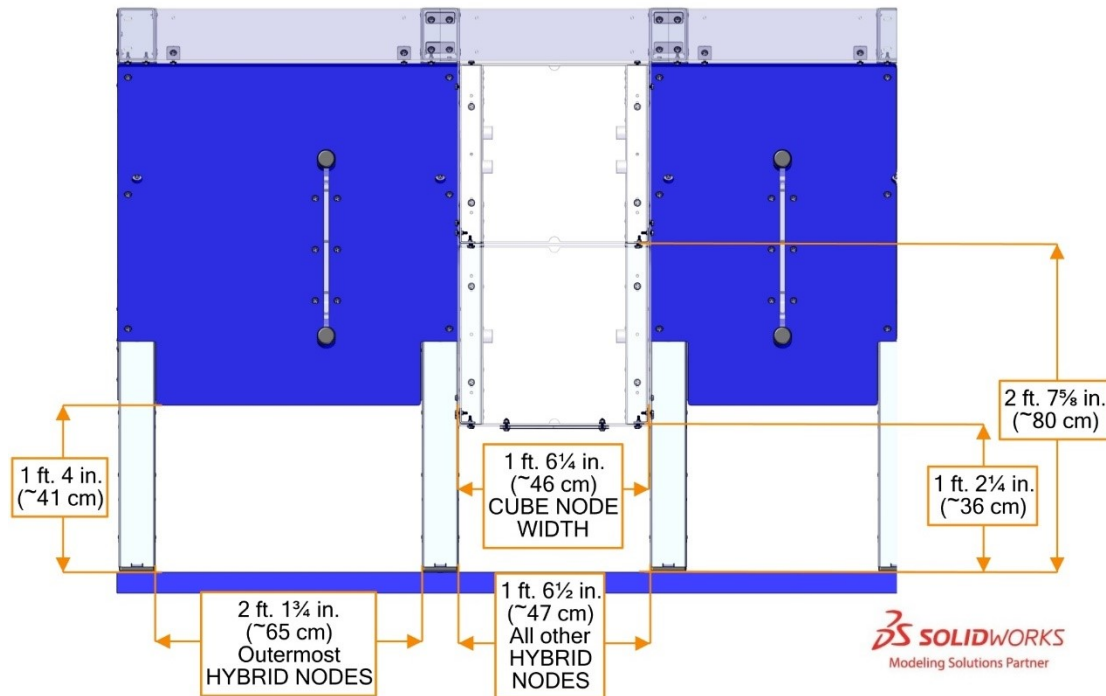
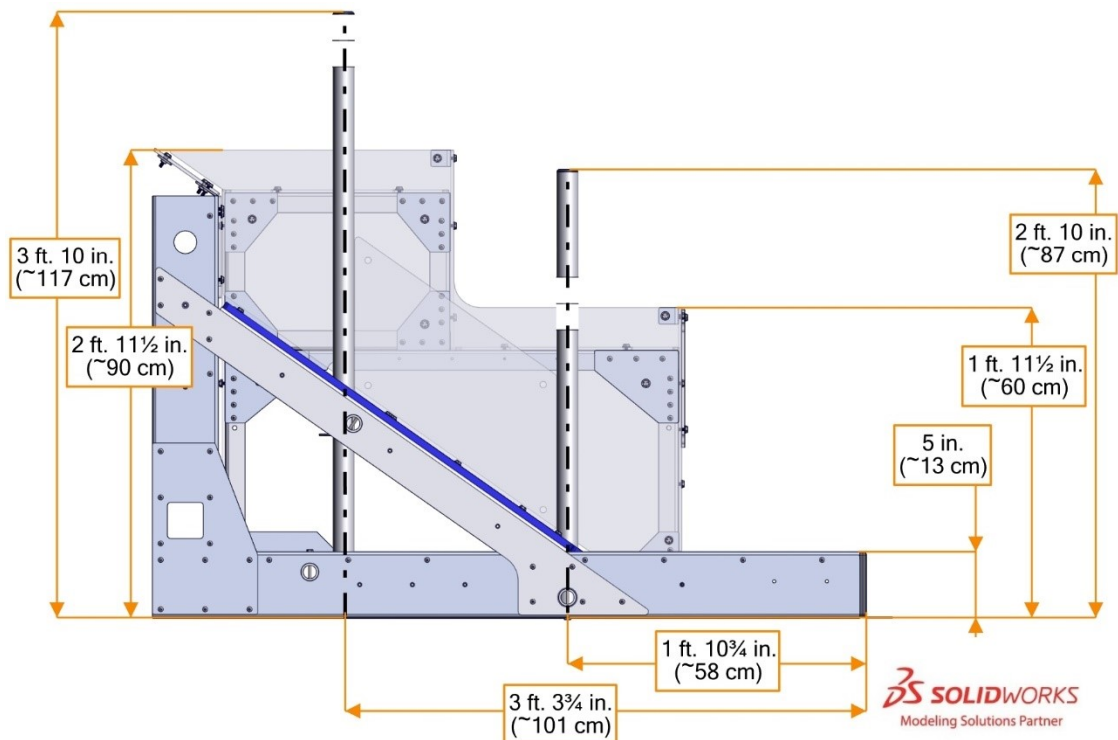


Figure 5-16 GRID side view dimensions





## 5.6 SUBSTATIONS

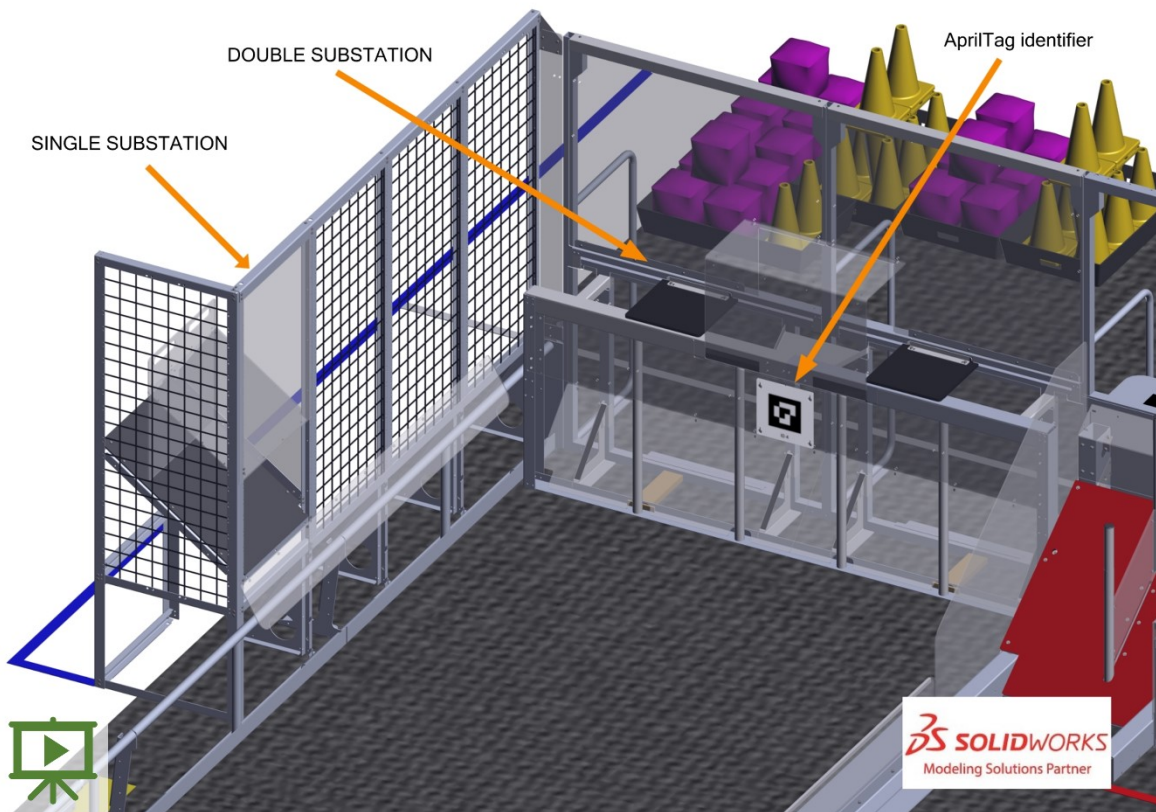
A SUBSTATION is an assembly used to move GAME PIECES from humans to ROBOTS or onto the FIELD. There are 2 types of SUBSTATIONS in each SUBSTATION AREA: a SINGLE SUBSTATION and a DOUBLE SUBSTATION.

Each SUBSTATION contains a PORTAL - a three-dimensional volume through which humans transfer GAME PIECES to ROBOTS or the FIELD.

We recognize that some individuals may need an accommodation in order to use the SUBSTATIONS, please see the language at the start of [Section 8 Game Rules: Humans](#) information.

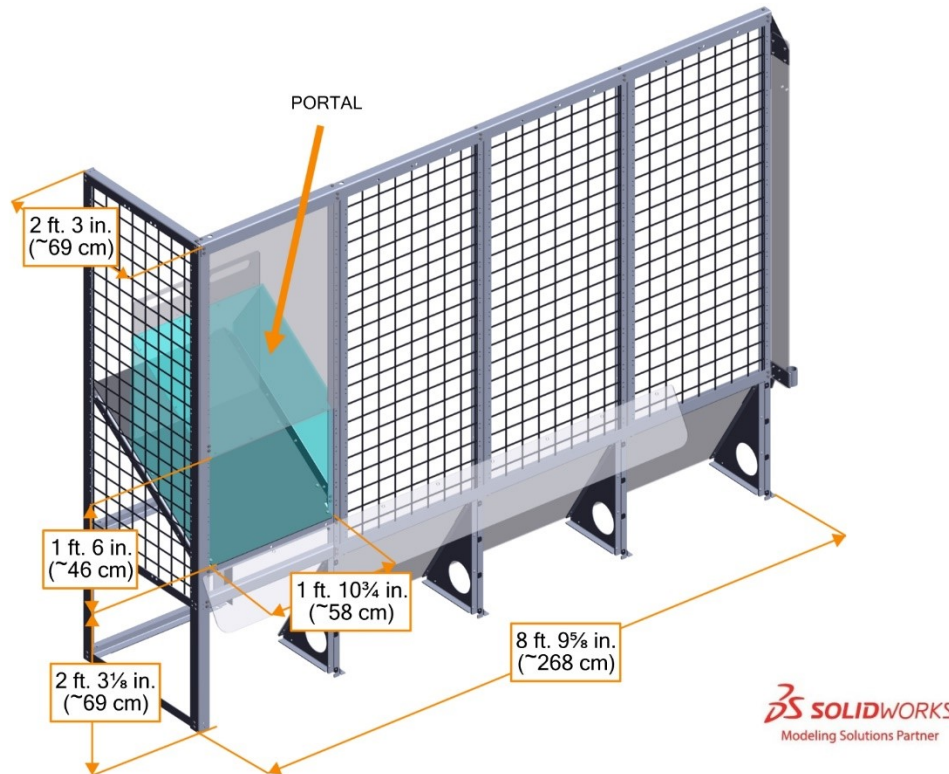
Each ALLIANCE'S DOUBLE SUBSTATION is attached to and in-line with their opponent's ALLIANCE WALL. Each SINGLE SUBSTATION is in-line with the guardrail.

Figure 5-17 SUBSTATIONS (click image to see field tour video)



## 5.6.1 SINGLE SUBSTATION

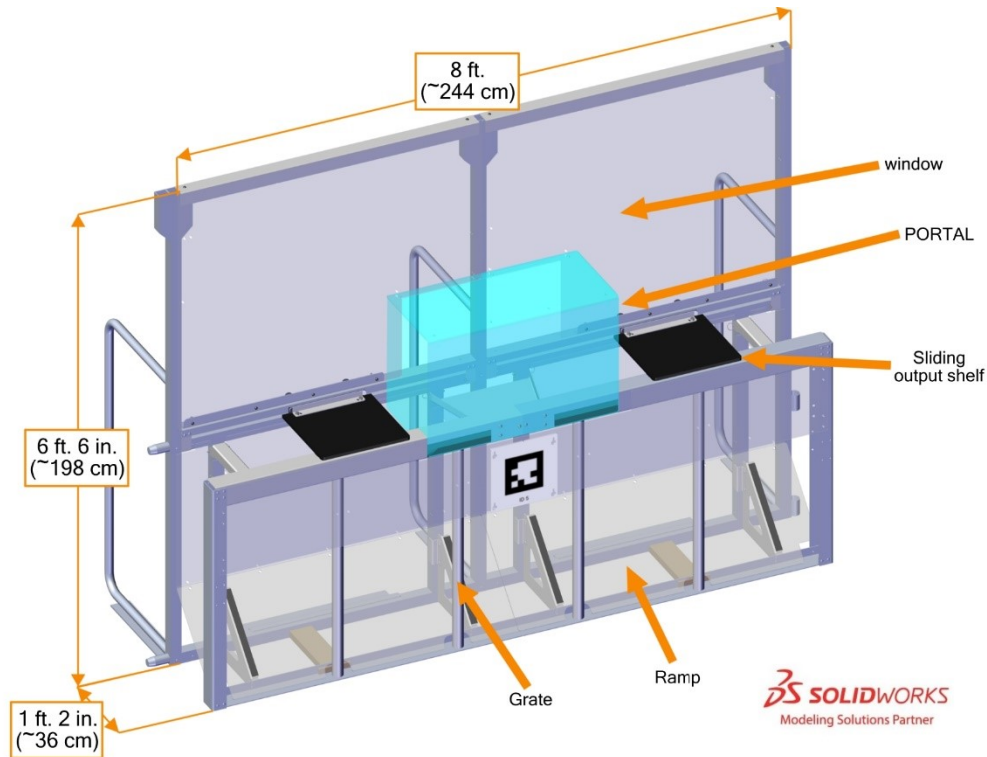
Figure 5-18 SINGLE SUBSTATION



A SINGLE SUBSTATION is 8 ft. 9 5/8 in. (~268 cm) wide, 6 ft. 9 3/4 in. (~208 cm) tall, and 2 ft. 3 in. (~69 cm) deep. The FIELD-facing wall of the SINGLE SUBSTATION sits 3 1/8 in. (~8 cm) behind the guardrail on a traditional FIELD and 4 1/4 in. (~11 cm) behind the guardrail on an AndyMark field. Each SINGLE SUBSTATION is comprised of wire panels ([Uline H-6277BL](#)), an attachment point to the FIELD, and a chute assembly. The chute assembly is a tilted plastic enclosure in which GAME PIECES enter the FIELD through a PORTAL. The FIELD-side opening of the chute is 2 ft. 3 1/8 in. (~69 cm) off the ground, 1 ft. 6 in. (~46 cm) tall, and 1 ft. 10 3/4 in. (~58 cm) wide. Each SINGLE SUBSTATION includes a flap that retains GAME PIECES until opened by a HUMAN PLAYER. The PORTAL for the SINGLE SUBSTATION is defined by the flap, the front face of the SINGLE SUBSTATION, and the sides, top, and bottom plastic of the chute.

## 5.6.2 DOUBLE SUBSTATION

Figure 5-19 DOUBLE SUBSTATION



A DOUBLE SUBSTATION is a 6 ft. 6 in. (~198 cm) tall, 8 ft. (~244 cm) wide assembly that extends 1 ft. 2 in. (~36 cm) into the FIELD. Each DOUBLE SUBSTATION contains a grate with 5 openings, a ramp, a PORTAL, and 2 sliding output shelves.

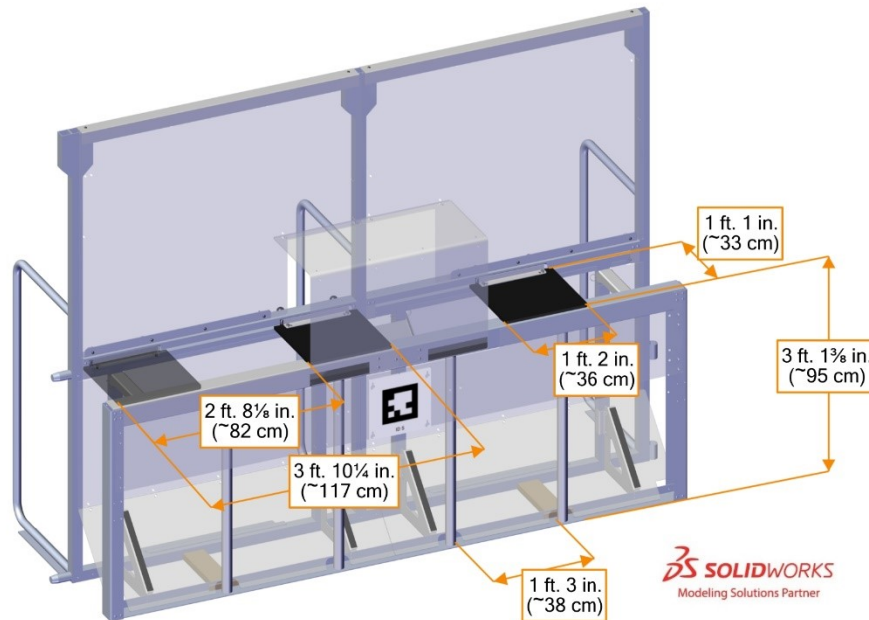
Grate openings are defined by 1¼ in. schedule 40 aluminum pipes which have an outer diameter of 1.66 in. (~4 cm). The distance between pipes is 1 ft. 3 in. (~38 cm). A polycarbonate ramp spans the width of the DOUBLE SUBSTATION, is sloped at a 45-degree angle, and extends from the grate to the back of the DOUBLE SUBSTATION.

The DOUBLE SUBSTATION PORTAL is the volume contained between the window and the bent polycarbonate guard, as shown in Figure 5-19.

Sliding shelves made of ½ in. (~13 mm) thick textured HDPE may be used to move GAME PIECES out of the PORTAL and make them accessible to ROBOTS. Shelves are controlled by HUMAN PLAYERS using handles. The shelves are 1 ft. 2 in. (~36 cm) wide, 1 ft. 1 in. deep (~33 cm) and their top surface is 3 ft. 1⅜ in. (~95 cm) above the carpet. Each shelf can slide from the PORTAL to an edge of the DOUBLE SUBSTATION.

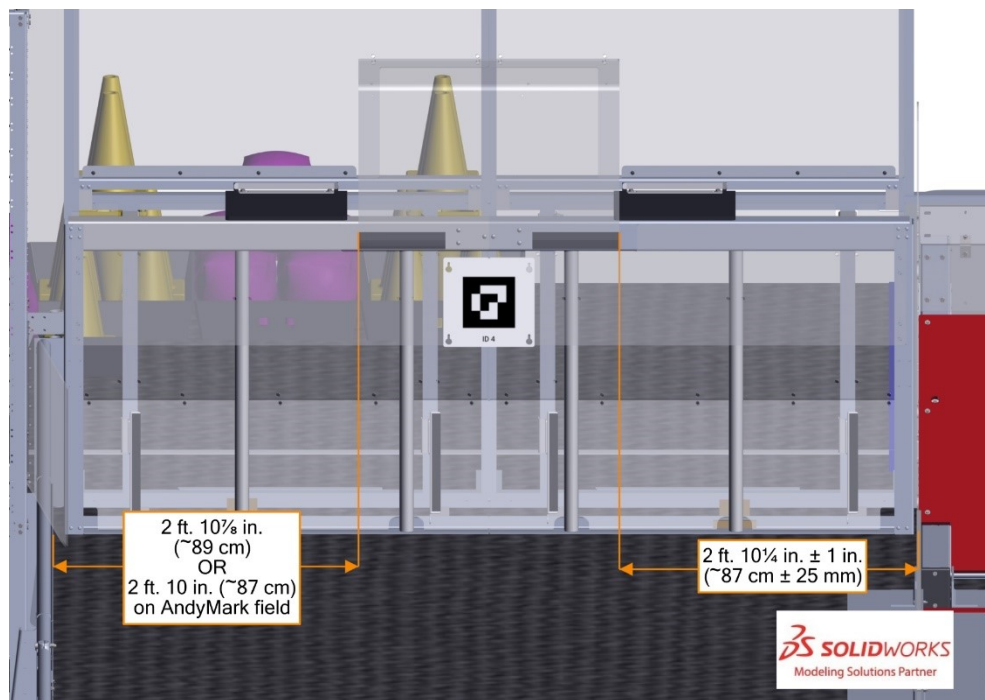


Figure 5-20 Dimensions for DOUBLE SUBSTATION



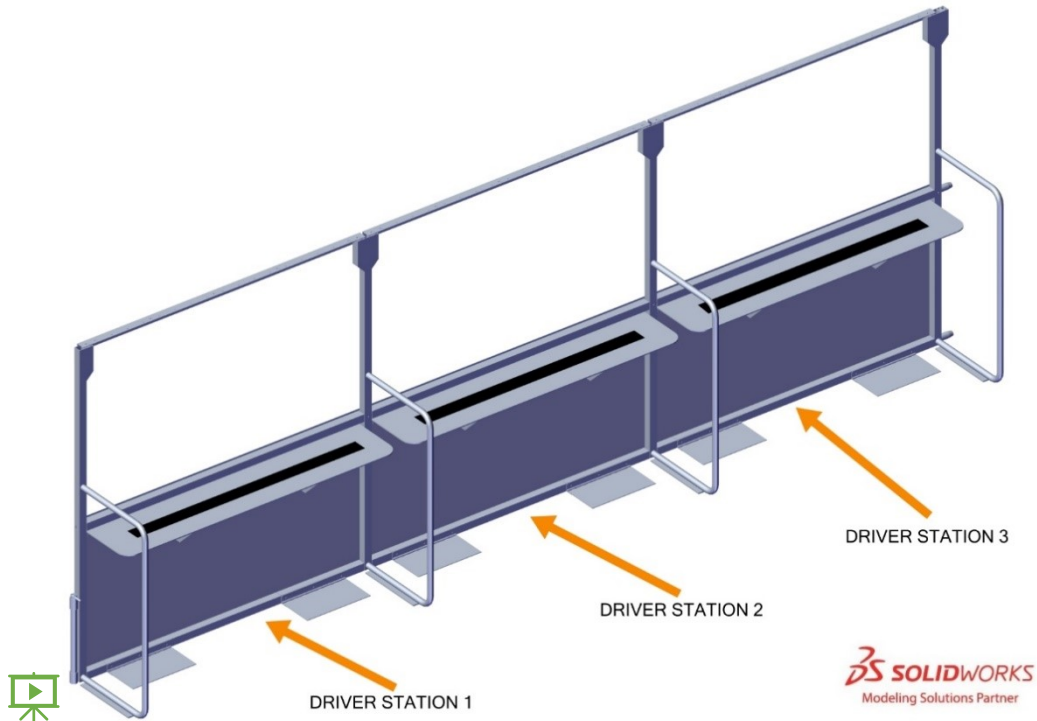
Each DOUBLE SUBSTATION is located between the guardrail and a GRID. The distance from the edge of the PORTAL to the GRID is 2 ft. 10 1/4 in. +/- 1 in. (~87 cm +/- 25 mm). The distance from the edge of the PORTAL to the guardrail is 2 ft. 10 1/8 in. (~89 cm) on a traditional FIELD, or 2 ft. 10 in. (~87 cm) on an AndyMark FIELD, as shown in Figure 5-21.

Figure 5-21 DOUBLE SUBSTATION distance to neighboring elements



## 5.7 ALLIANCE WALLS

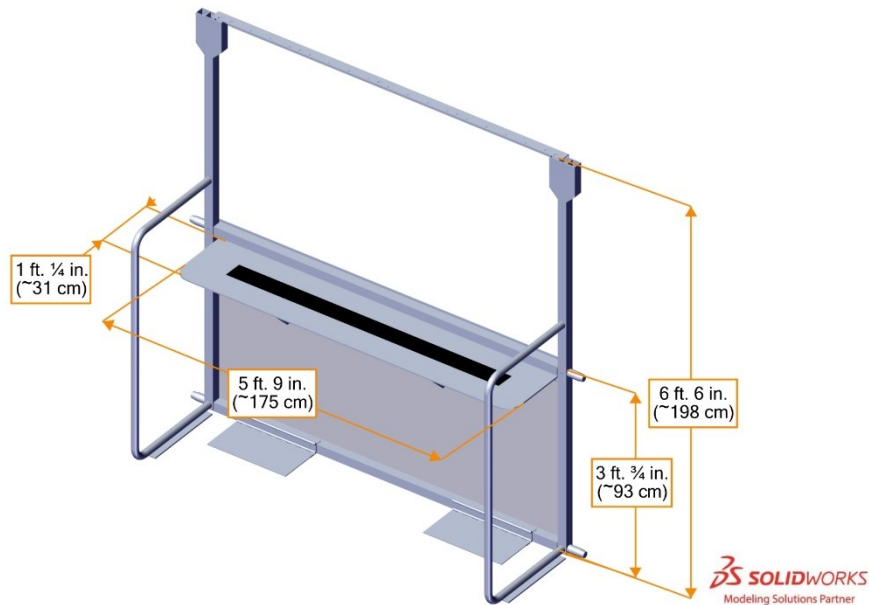
Figure 5-22 ALLIANCE WALL (click image to see field tour video)



The ALLIANCE WALL separates ROBOTS from DRIVE TEAM members in the ALLIANCE AREA. It consists of 3 DRIVER STATIONS.

## 5.7.1 DRIVER STATIONS

Figure 5-23 DRIVER STATION dimensions



A DRIVER STATION is 1 of 3 assemblies within an ALLIANCE WALL behind which a DRIVE TEAM operates their ROBOT. Each DRIVER STATION is made from a 3 ft.  $\frac{3}{4}$  in. (~93 cm) tall diamond plate base topped with a 3 ft. 6 in. (~107 cm) tall transparent plastic sheet and a top rail. An aluminum shelf is attached to each DRIVER STATION to support an OPERATOR CONSOLE. The shelf is 5 ft. 9 in. (~175 cm) wide and 1 ft.  $\frac{1}{4}$  in. (~31 cm) deep. There is a 4 ft. 6 in. (~137 cm) long by 2 in. (nominal) wide strip of hook-and-loop tape ("loop" side) along the center of the support shelf that may be used to secure the OPERATOR CONSOLE to the shelf.

There may be a ramp available at events for DRIVE TEAMS with limited mobility. It is specially designed to allow an individual using a wheelchair to access the DRIVER STATION shelf and/or see onto the FIELD; however, this accommodation is available to anyone with an accessibility concern. Teams should speak to the FTA before MATCHES begin to ensure that it is available for each of the team's MATCHES.

This ramp is available at many Regional and District events. For questions please connect with the local [Program Delivery Partner](#).

Each DRIVER STATION contains the following elements for DRIVE TEAMS:

- 1 Ethernet cable: attaches to the Ethernet port of the OPERATOR CONSOLE and provides connectivity to the Field Management System (FMS)
- 1 120VAC NEMA 5-15R power outlet (i.e. standard US outlet): located on each DRIVER STATION shelf and protected by its own 2-Amp circuit breaker. It can be used to power the OPERATOR CONSOLE. DRIVE TEAMS are responsible for monitoring their power consumption as a tripped breaker in the outlet does not constitute an ARENA FAULT. For some events in regions that don't use NEMA 5-15 shaped outlets, event organizers may install appropriate plug adapters to be used throughout the event.



- 1 Emergency Stop (E-Stop) button: located on the left side of the DRIVER STATION shelf and is used to deactivate a ROBOT in an emergency
- 1 team sign: displays the team number and located at the top of each DRIVER STATION
- 1 team LED stack: indicates ALLIANCE color, ROBOT status, E-Stop status, and is centered at the top of each DRIVER STATION.

The stack includes 2 identical ALLIANCE-colored ROBOT status LEDs above a third amber E-stop LED. LED states are as follows:



- ROBOT status LEDs
  - Solid: indicates that the ROBOT is connected and enabled. This only happens during a MATCH.
  - Blinking: indicates that either the FMS is preset for the MATCH and the ROBOT is not connected yet, or it's during a MATCH and the corresponding ROBOT is BYPASSED, has lost connectivity, or the E-stop was pressed.
  - Off: indicates that the ROBOT is linked and DISABLED prior to the start of the MATCH. This light is also off, regardless of ROBOT connection status, after the MATCH has concluded.
- E-stop LED
  - Solid: the ROBOT is DISABLED due to a press of the team E-stop button, the FIELD E-stop button, or by the scorekeeper via the FMS.
  - Off: the ROBOT is not DISABLED by the FIELD.
- 1 string of LED nodes described in DRIVER STATION LED Strings.
- 1 timer (in DRIVER STATION 2 only): displays the official time remaining in the MATCH. It is marked with white tape along the bottom edge.
- FMS hardware and wiring: mostly located below the DRIVER STATION 2 shelf



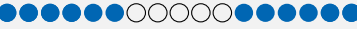

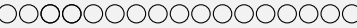


#### 5.7.1.1 DRIVER STATION LED Strings

A string of LED nodes is mounted to the bottom of each DRIVER STATION window frame. The string is used to communicate FIELD safety information, MATCH state, and GRID progress.

If the light string is all green, the FIELD is safe for humans.

Table 5-2 GRID light states ([field tour video](#))

Light String State	Criteria	Example
Off	Outside of a MATCH: FIELD is ready In MATCH: GAME PIECE scoring criteria not met	
Green	Head REFEREE has determined FIELD is safe for humans	

Light String State	Criteria	Example
ALLIANCE color (fills left to right when viewing from DRIVER STATION)	LINK scored (1 LINK = 20% on, 2 LINKS = 40% of lights on, etc.)	
4 outer nodes yellow	DOCKED or ENGAGED scored during AUTO	
ALLIANCE color and center 5 nodes are white	SUSTAINABILITY BONUS criteria met	
Magenta color (fills left to right, center DRIVER STATION only)	COOPERTITION BONUS criteria met	
White	within 3 seconds of the ending of AUTO or TELEOP	
Oscillating ALLIANCE color for 3 seconds	Start of ENDGAME	
5 center nodes yellow	Set of ALLIANCE GRIDS are complete	

Light patterns layer as ALLIANCES score throughout the match.

Figure 5-24 Blue ALLIANCE example light pattern –

ENGAGED in AUTO with 1 LINK achieved

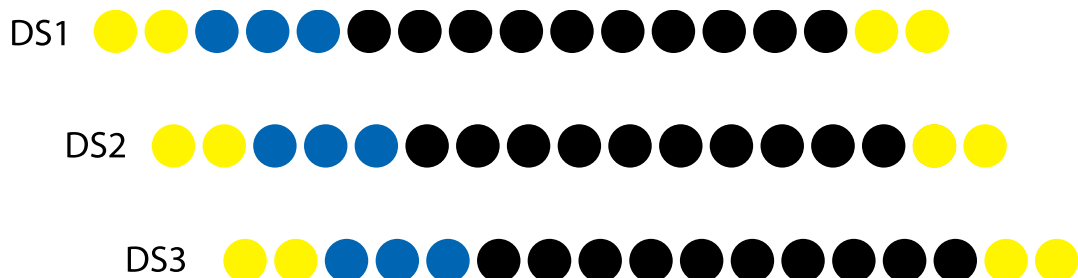
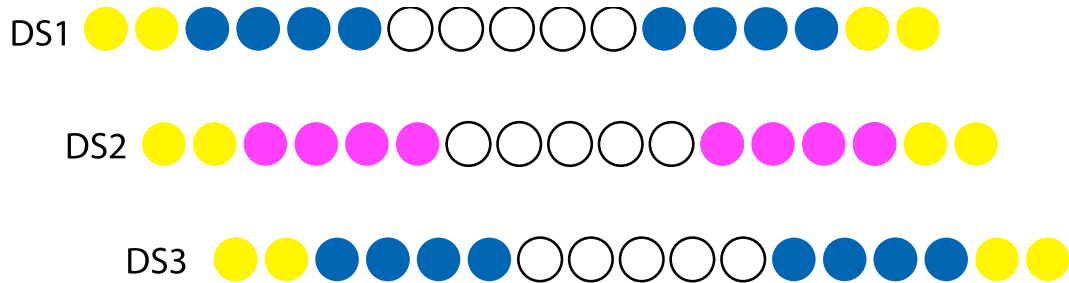


Figure 5-25 Blue ALLIANCE example light pattern –

ENGAGED in AUTO, 4 LINKS and COOPERTITION BONUS achieved

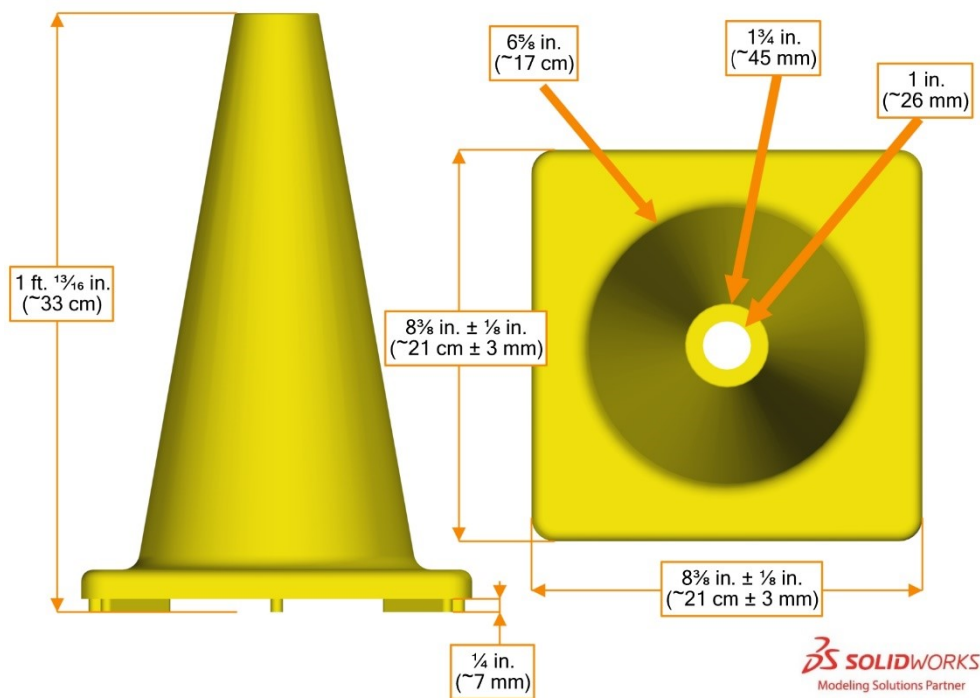


## 5.8 GAME PIECES

There are 2 types of GAME PIECES: CONES and CUBES.

### 5.8.1 CONE

Figure 5-26 CONE



Each CONE is a yellow 1 ft.  $\frac{13}{16}$  in. (~33 cm) tall rubber marker cone and weighs 1lb 7oz (~653 g). Each CONE has an  $8\frac{3}{8}$  in. (~21 cm)  $\pm \frac{1}{8}$  in. (~3 mm) square base with  $\frac{1}{4}$  in. (~7 mm) tall feet. The rubber marker cone is made by Flaghouse (part number 4158) and sold by AndyMark, part number am-4700\_syc.



## 5.8.2 CUBE

Figure 5-27 CUBE



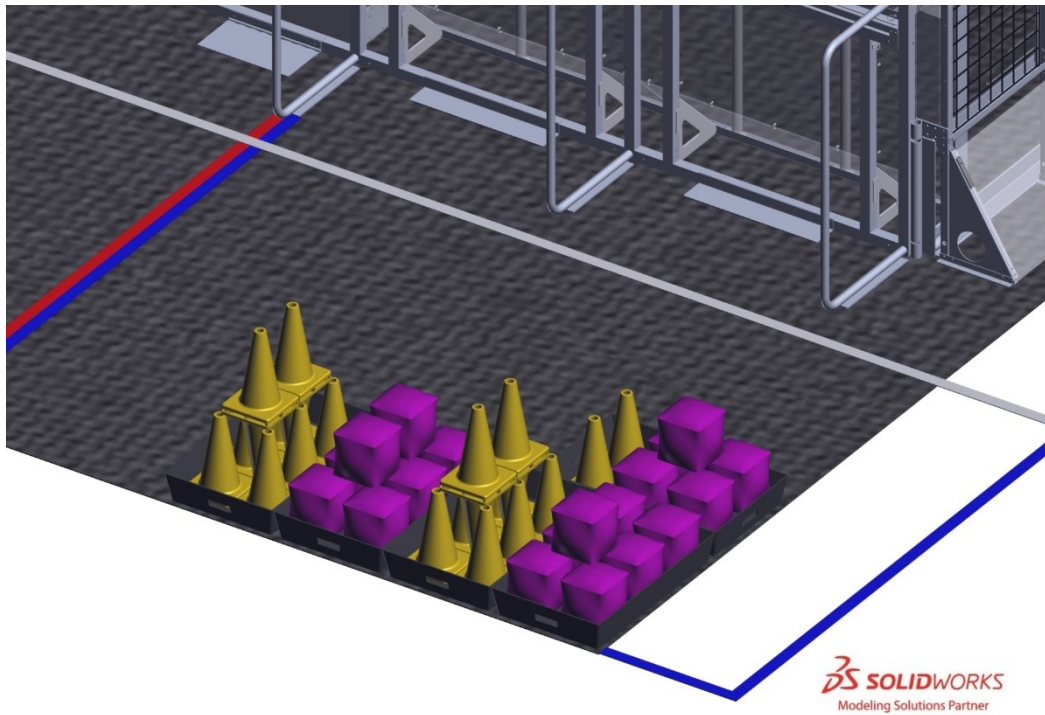
Each CUBE is made of purple PVC fabric and is marked with a *FIRST* logo, as shown in Figure 5-27. A CUBE is a cube-like shape, inflated to 9 ½ in. (~24 cm) +/- ¼ in. (~6 mm) as measured from face to face. A CUBE has rounded corners, may not have flat surfaces, and the length, width, and height of the sides may not be equal dimensions. A CUBE weighs 2.5 oz (~71 g). The inflatable cube is a modified version of a product made by Flaghouse (part number 17810) and sold by AndyMark, part number am-4700\_bpc. CUBES are expected to experience wear during MATCHES, and small holes may be patched with electrical tape. FIELD staff use a device to determine a CUBE'S dimensional compliance as shown in this [video](#).

Note that Flaghouse part number 17810 is not identical to a CUBE. The Flaghouse part varies in color and includes clear vinyl pouches on all sides, whereas a CUBE does not.

## 5.8.3 GAME PIECE Holders

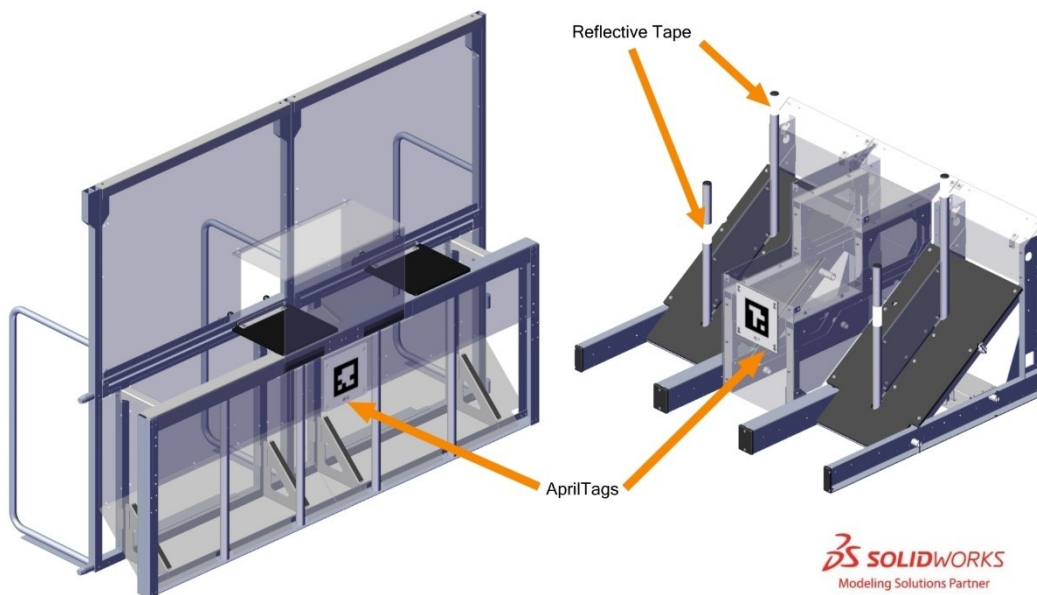
GAME PIECES that begin the MATCH in the SUBSTATION AREA are stored in containers ([Uline part number S-24135](#)) located along the back edge each SUBSTATION AREA.

Figure 5-28 GAME PIECE HOLDERS



## 5.9 Vision Targets

Figure 5-29: Vision targets on a GRID and DOUBLE SUBSTATION



Vision targets are located on each GRID and DOUBLE SUBSTATION. There are 2 types of vision targets:

- reflective tape, and
- AprilTags.

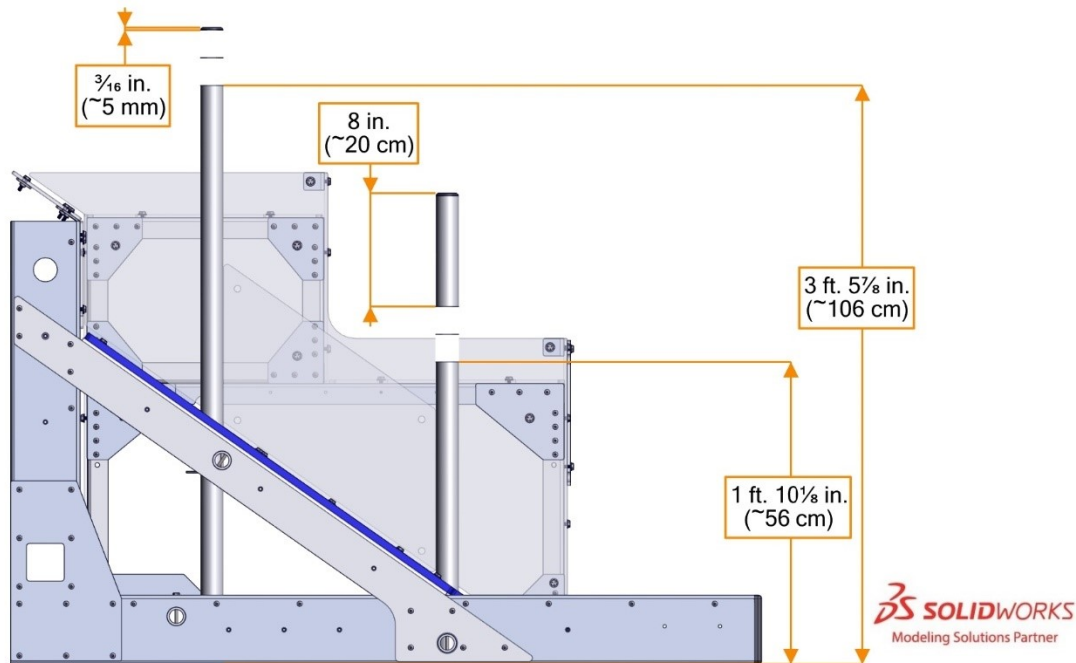
Samples of the reflective tape material are included in each Kickoff Kit.

### 5.9.1 Reflective Tape

Reflective tape vision targets are made of 2 in. (~5 cm) thick strips of [3M 973-10 Diamond Grade Flexible Prismatic School Bus Marking Series White](#) and are used to highlight each CONE NODE.

A 4 in. (~10 cm) tall portion of each CONE NODE is wrapped with reflective tape. The tape is  $\frac{3}{16}$  in. (~5 mm) from the top of Top ROW CONE NODES and 8 in. (~20 cm) from the top of Middle ROW CONE NODES. This results in the bottom of the targets being 3 ft.  $5\frac{5}{8}$  in. (~106 cm) and 1 ft.  $10\frac{1}{8}$  in. (~56 cm) from the FIELD carpet, as shown in Figure 5-30. Note that the reflective tape is likely hidden if a CONE is on the CONE NODE.

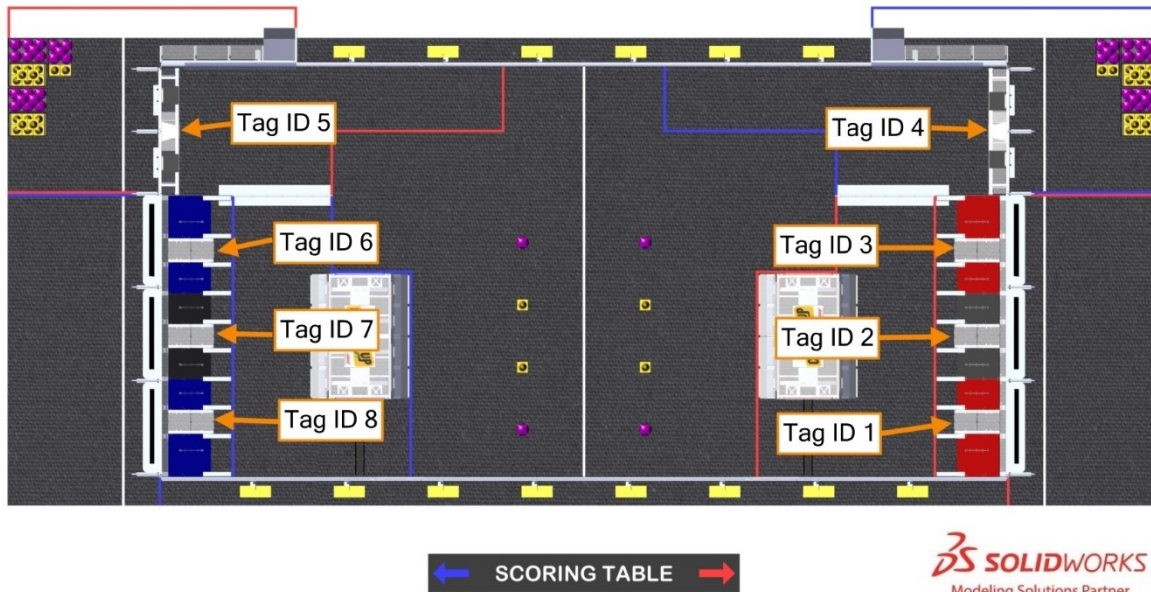
Figure 5-30 GRID retroreflective tape



### 5.9.2 AprilTags

AprilTags are 8 in. (~20 cm) square targets located on the DOUBLE SUBSTATION and GRIDS. There are 8 unique markers on the FIELD, as shown in Figure 5-31.

Figure 5-31 AprilTag locations

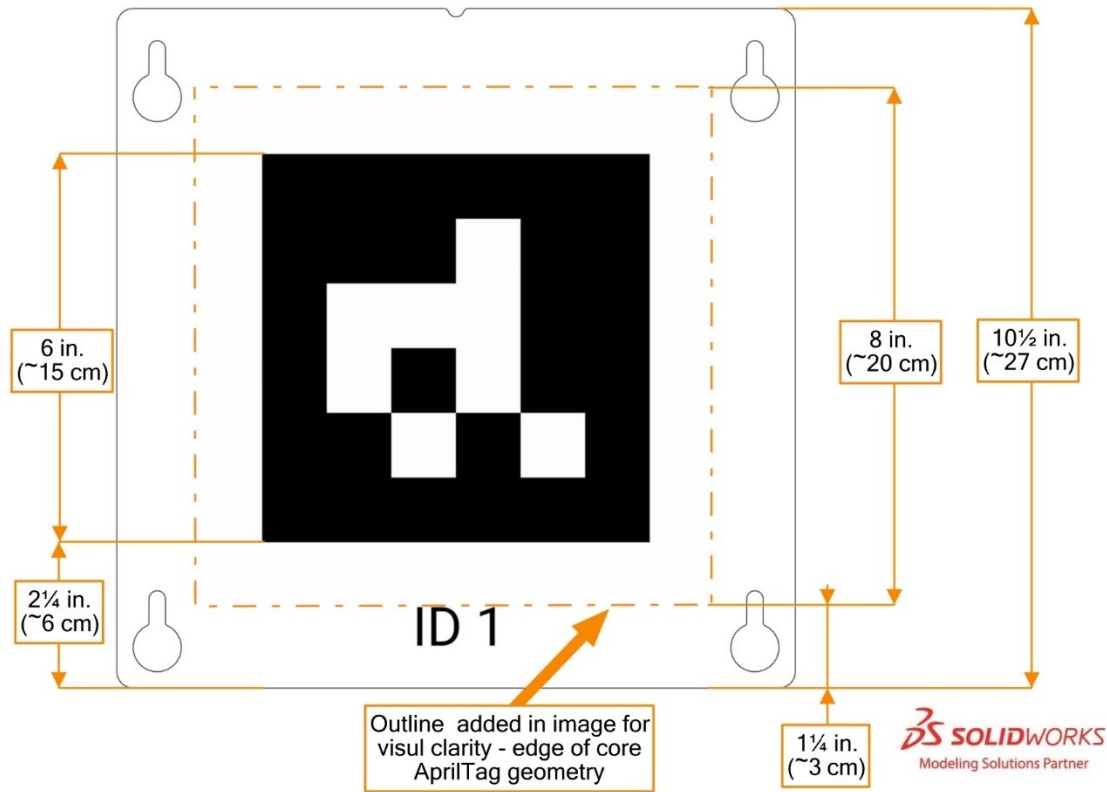


All markers are from the 16h5 tag family, IDs 1-8. AprilTags are mounted to and centered on a 10½ in. (~27 cm) square piece of polycarbonate. The 8 in. (~20 cm) tag is centered on the polycarbonate panel, such that the bottom of the central black square region is 2¼ in. (~6 cm) from the bottom of the panel, and the bottom of the 8 in. (~20 cm.) tag is located 1 ¼ in. (~3 cm) from the bottom of the panel as shown in Figure 5-32. Each marker has an identifying text label.

AprilTags are likely to experience wear and marking during MATCHES and are repaired with gaffers tape.

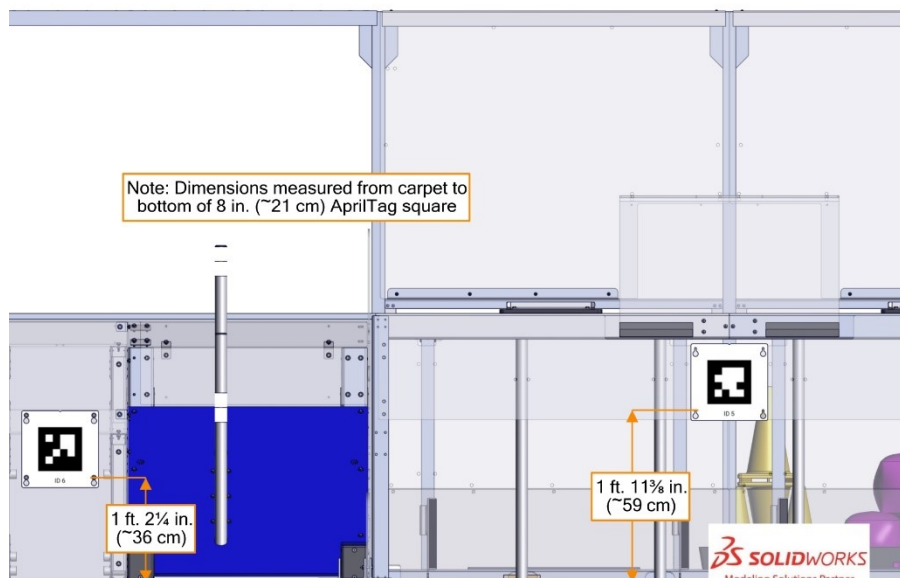


Figure 5-32 AprilTag sizing



GRID AprilTags are centered on the width of the front face of the middle ROW CUBE NODES and elevated such that the distance from the carpet to the bottom of the AprilTag is 1 ft. 2 1/4 in. (~36 cm). Markers on the DOUBLE SUBSTATIONS are centered on the width of the assembly and are mounted such that the distance from the carpet to the bottom of the AprilTag is 1 ft. 11 3/8 in. (~59 cm).

Figure 5-33 AprilTag locating dimensions



For further marker locating information please refer to the [2023 ARENA Layout and Marking Diagram](#). For printable versions of the markers, please refer to the [2023 Playing Field page](#).

## 5.10 The FIELD Management System

The FIELD Management System (FMS) is all electronics responsible for sensing and controlling the *FIRST* Robotics Competition FIELD. The FMS encompasses all FIELD electronics, including computers, REFEREE touchscreens, wireless access point, sensors, stack lights, E-Stops, etc.

When a DRIVE TEAM connects the Ethernet cable from their assigned DRIVER STATION to their OPERATOR CONSOLE, the Driver Station Software on the OPERATOR CONSOLE computer will communicate with FMS. Once connected, the open ports available are described in Table 9-5.

Note that ROBOT code cannot be deployed while connected to the FMS. Additional information about the FMS may be found in the [FMS Whitepaper](#).

The FMS alerts participants to milestones in the MATCH using audio cues detailed in Table 5-3. Please note that audio cues are intended as a courtesy to participants and not intended as official MATCH markers. If there is a discrepancy between an audio cue and the FIELD timers, the FIELD timers are the authority.

*Table 5-3 Audio cues*

Event	Timer Value	Audio Cue
<b>MATCH start</b>	0:15 (for AUTO)	"Cavalry Charge"
<b>AUTO ends</b>	0:00 (for AUTO)	"Buzzer"
<b>TELEOP begins</b>	2:15	"3 Bells"
<b>ENDGAME begins</b>	0:30	"Train Whistle"
<b>MATCH end</b>	0:00	"Buzzer"
<b>MATCH stopped</b>	n/a	"Foghorn"

