

5 ARENA

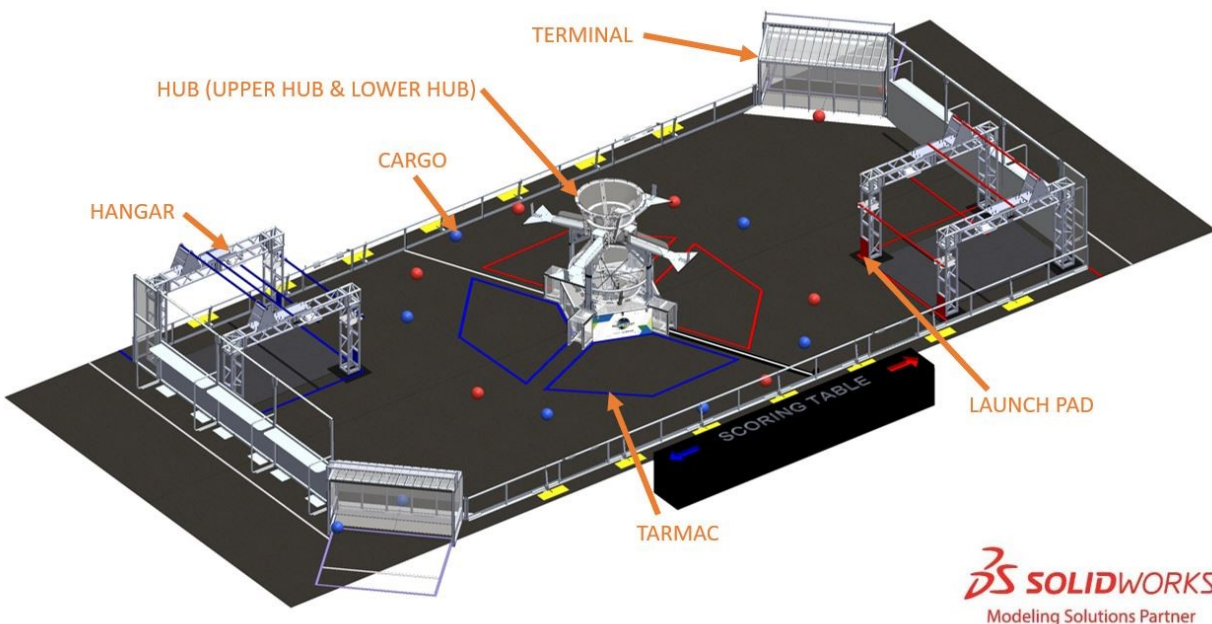
The ARENA includes all elements of the game infrastructure that are required to play RAPID REACTSM: the FIELD, CARGO, and all equipment needed for FIELD and ROBOT management.

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 [2022 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 RAPID REACT 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 RAPID REACT FIELD are posted on the [RAPID REACT - Season Materials web page](#) on the FIRST website.

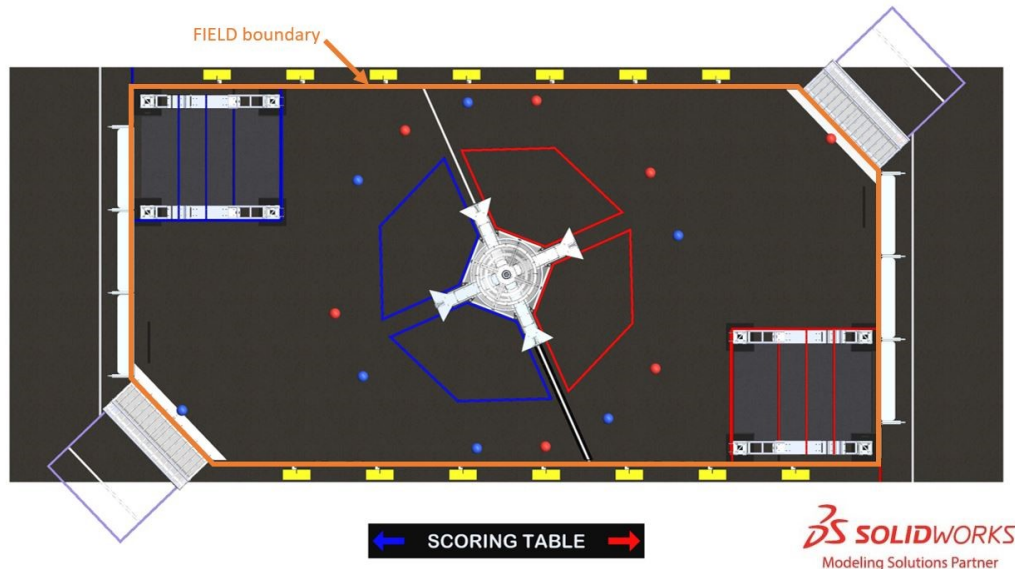
5.1 FIELD

Figure 5-1: RAPID REACT



Each FIELD for RAPID REACT is a 27 ft. (~823 cm) by 54 ft. (~1646 cm) carpeted area bound by and including the inward- and upward-facing surfaces of the guardrails, inward-facing surfaces of the ALLIANCE WALLS, and the front vertical faces of the TERMINALS.

Figure 5-2 RAPID REACT FIELD boundary



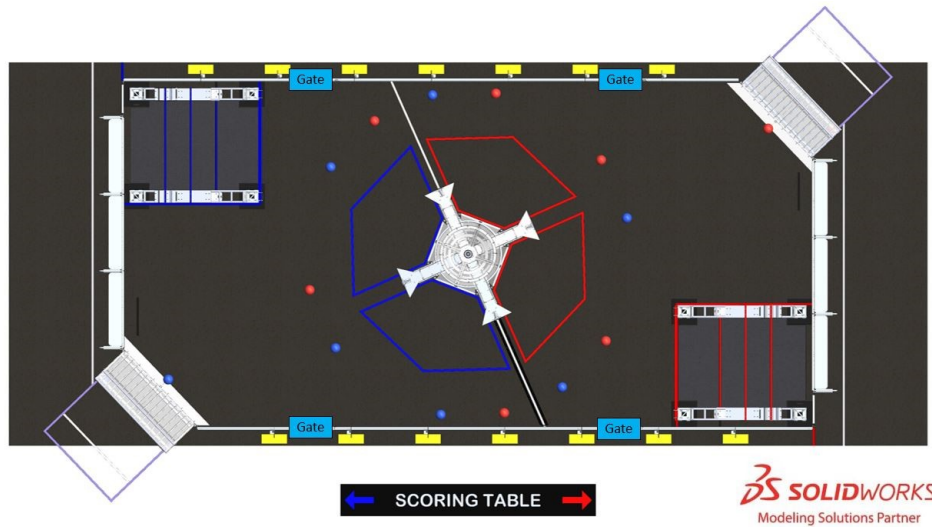
The FIELD is populated with the following elements:

- 1 HUB (including 1 UPPER HUB and 1 LOWER HUB),
- 2 HANGARS (a red HANGAR and a blue HANGAR),
- 2 TERMINALS, and
- 14 CARGO RINGS.

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 5-3 Gate locations



There are 2 versions of guardrails and DRIVER STATIONS used for competitions. 1 design is reflected in the [2022 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. Detailed drawings for the AndyMark design are posted on the [AndyMark website](#). All illustrations in this manual show the traditional FIELD design.

A run of black HDPE cable protectors extends from the guardrail on the scoring table side of the FIELD to the nearest LOWER EXIT of the HUB, straddling the CENTER LINE. A cable protector run is made up of multiple floor segments and an exit segment. The total length of the cable protector run is 10 ft. 10 $\frac{5}{8}$ in. (~332 cm). The floor segments are $\frac{3}{4}$ in. (~2 cm) tall, 7 in. (~18 cm) wide, with ~45° lead in ramps on each leading edge. It is secured to the carpet using hook fastener which increases the height to approximately $\frac{7}{8}$ in. (~2 cm). Exit segments are attached to the guardrail with hook fastener and are 7 in. (~18 cm) tall, 6 $\frac{1}{8}$ in. (~15 cm) wide and 1 $\frac{3}{4}$ in. (~4 cm) deep.

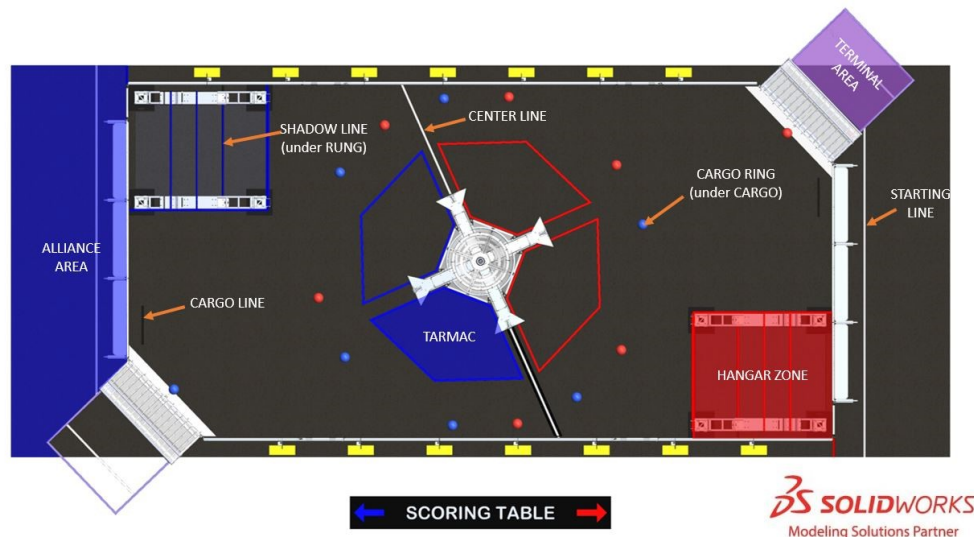
Figure 5-4 Cable protector segment



5.2 Zones and Markings

FIELD 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.

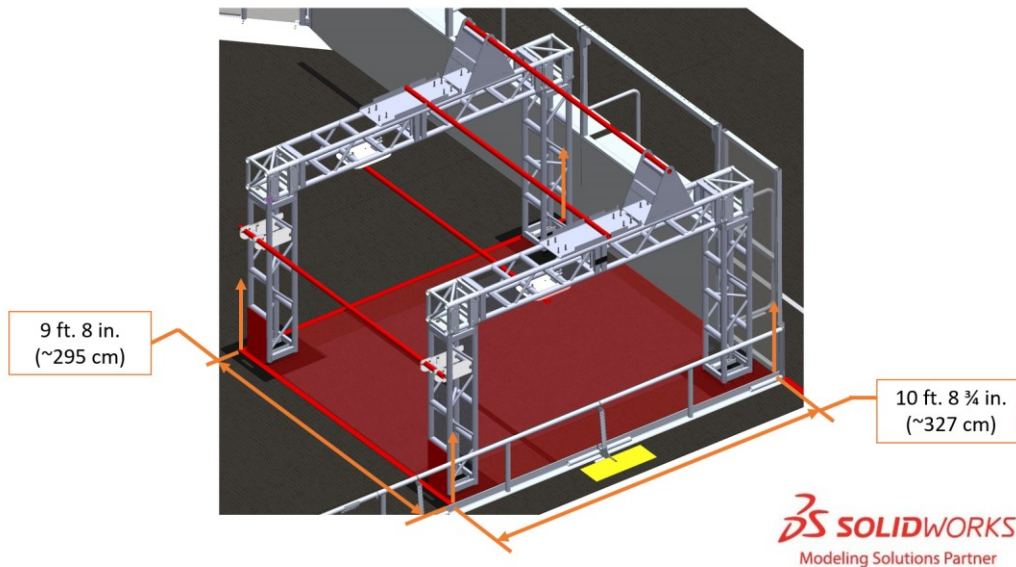
Figure 5-5 Zones and Markings



- **ALLIANCE AREA:** a 30 ft. (~914 cm) wide by 8 ft. 10 in. (~269 cm) deep infinitely tall volume formed by, and including the **ALLIANCE WALL**, the edge of the carpet, and **ALLIANCE** colored tape. It includes neither the **TERMINAL AREA** nor the **TERMINAL**.
- **CARGO LINE:** a 3 ft. (~91 cm) black line that starts 1 ft. (~30 cm) from the intersection of the **TERMINAL** and the **ALLIANCE WALL** and runs parallel to and 1 ft. (~30 cm) from the **ALLIANCE WALL**.
- **CARGO RING:** 1 of 14 small rings used to keep the **CARGO** in place prior to the start of the **MATCH**. Rings are 1/8 in. (~3mm) thick, 1 3/4 in. (~4 cm) diameter O-rings (McMaster Item#: 9452K63). 12 rings are placed around the **HUB**, and 1 ring is in front of each **TERMINAL**. They are secured to **FIELD** carpet with red or blue tape to indicate the color **CARGO** to be placed on it.

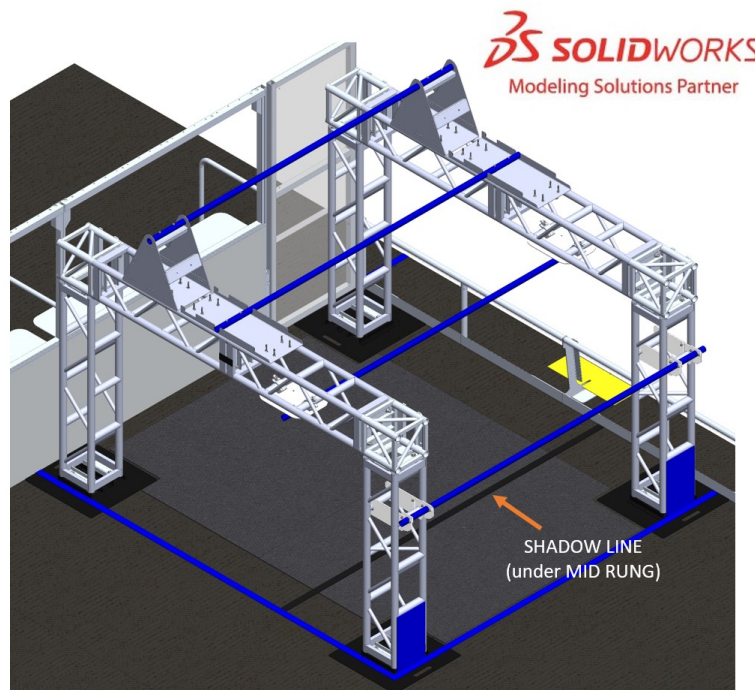
- **CENTER LINE:** a white line that bisects the length of the FIELD at a $\sim 66^\circ$ angle to the guardrail
- **HANGAR ZONE:** a 9 ft. 8 in. (~ 295 cm) wide, 10 ft. 8 $\frac{3}{4}$ in. (327 cm) deep, and infinitely tall volume defined by the ALLIANCE WALL, guardrail, and ALLIANCE colored tape. The HANGAR ZONE includes the tape.

Figure 5-6 HANGAR ZONE



- **SHADOW LINE:** a black line that lies directly below the MID RUNG

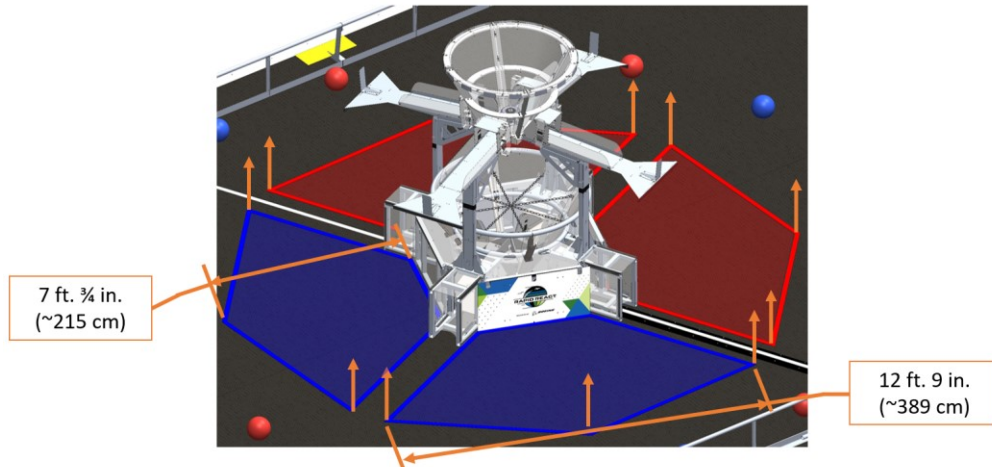
Figure 5-7 SHADOW LINE



- **STARTING LINE:** a white line spanning the width of the carpet and located 2 ft. 4 in. (~ 71 cm) from the back of the DRIVER STATION diamond plate panel to the near edge of the tape.

- TARMAC: 1 of 4 (2 per ALLIANCE) 12 ft. 9 in. (~389 cm) wide by 7 ft. $\frac{3}{4}$ in. (~215 cm) deep infinitely tall volumes bounded by and including the ALLIANCE colored tape.

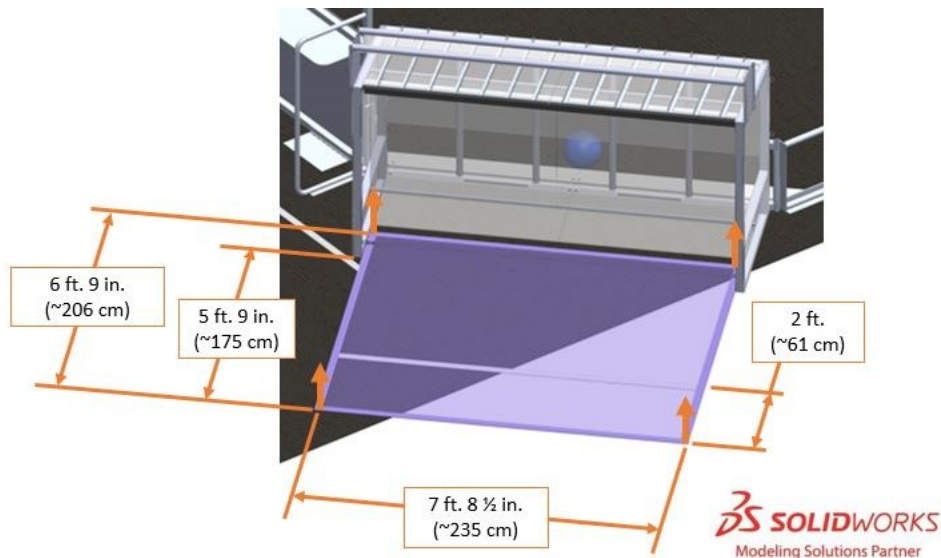
Figure 5-8 TARMACS



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- TERMINAL AREA: 1 of 2 7 ft. $8\frac{1}{2}$ in. (~235 cm) wide by 6 ft. 9 in. (~206 cm) deep and infinitely tall volumes bounded by and including purple tape.

Figure 5-9 TERMINAL AREA

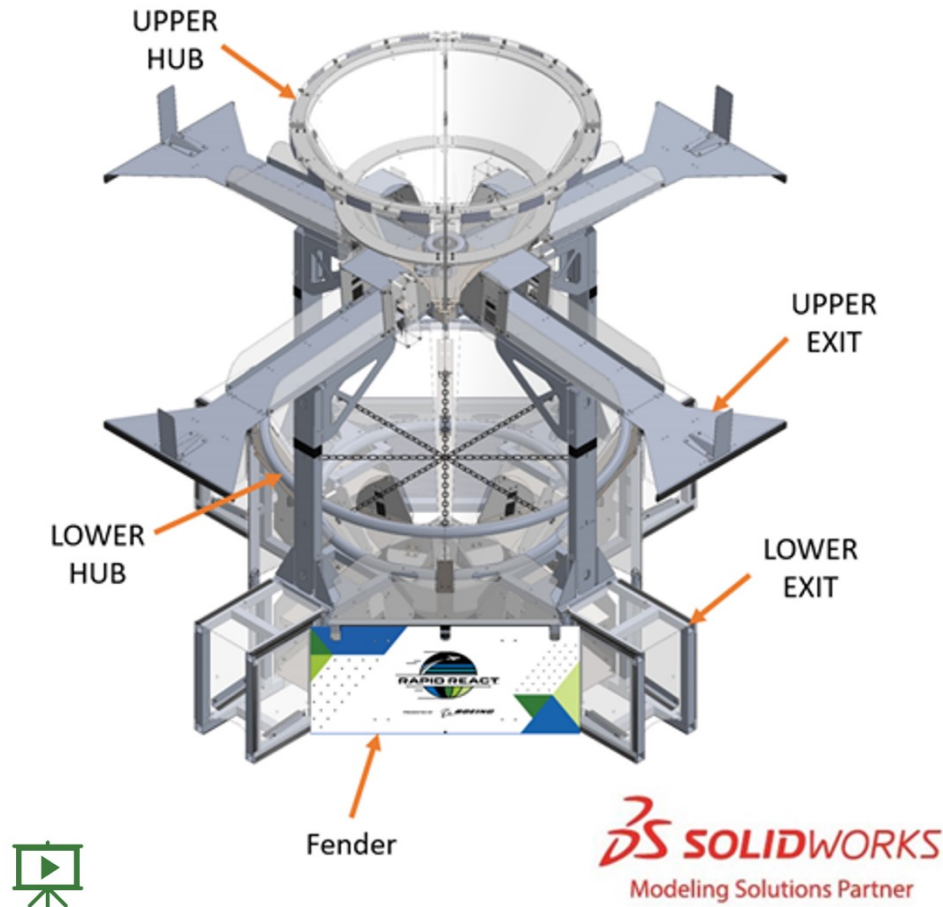


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- TERMINAL STARTING LINE: a white line spanning the width of the TERMINAL AREA and located 2 ft. (~61 cm) from the back of the TERMINAL AREA.

5.3 HUB

Figure 5-10 HUB (click image to see field tour video)



The HUB is centered on the FIELD and shared between ALLIANCES. It consists of 2 funnel-shaped goals (an UPPER HUB and a LOWER HUB), UPPER and LOWER EXITS, and 4 fenders. The HUB is 8 ft. 11 in. (~272 cm) wide by 8 ft. 11 in. (~272 cm) deep by 8 ft. 8 in. (~264 cm) tall.

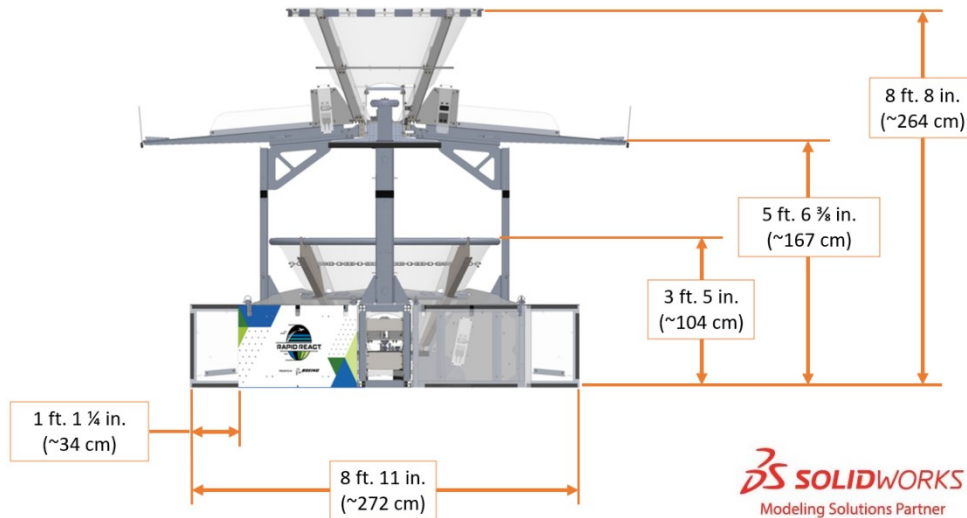
An agitator extends up the center of each HUB and rotates throughout the MATCH. The motors driving the agitator assemblies are supplied with (nominal) 12V each, and their direction may vary from MATCH to MATCH. Generally, the agitator causes a single CARGO dropped into the UPPER HUB to reenter play in approximately 7 seconds and a CARGO dropped in the LOWER HUB to reenter play in approximately 5 seconds.

An UPPER EXIT is 1 of the 4 extensions on which CARGO leaves the UPPER HUB, and a LOWER EXIT is one of the 4 tunnels from which CARGO leaves the LOWER HUB.

4 legs, each centered under an UPPER EXIT, support the UPPER HUB. The maximum ROBOT height defined in G106 is marked with black tape on each leg (i.e. the bottom edge of the tape is 4 ft. 4 in. (~132 cm) above FIELD carpet). A fender is located in between each of the LOWER EXITS.

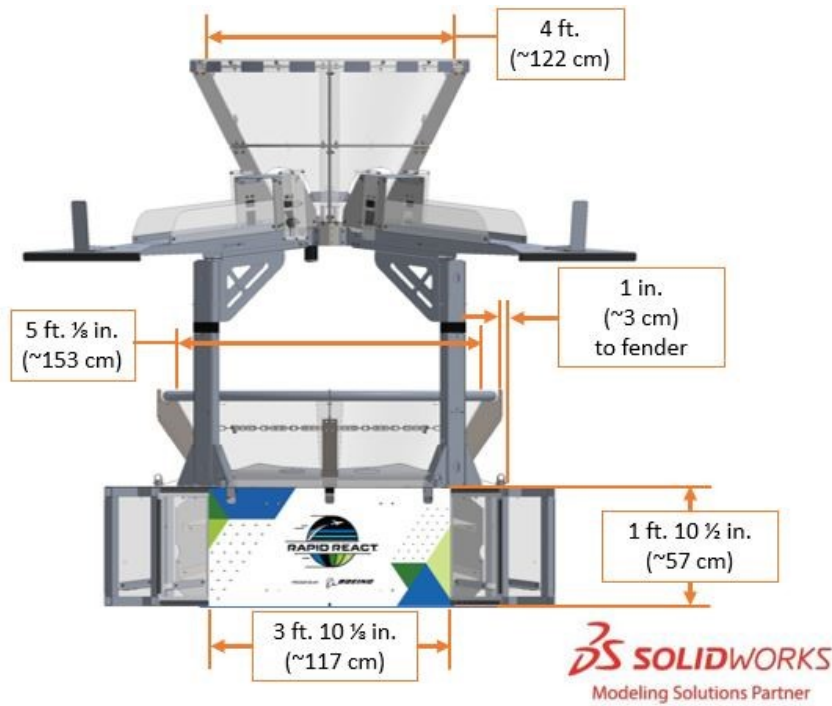
5.3.1 UPPER HUB and LOWER HUB

Figure 5-11 HUB with nominal dimensions



The opening of the LOWER HUB is 3 ft. 5 in. (~104 cm) above FIELD carpet, and the opening of the UPPER HUB is 8 ft. 8 in. (~264 cm) above the FIELD carpet. A web of #2 black plastic chain is hung 7 1/2 in. (~19 cm) below the rim of the LOWER HUB opening.

Figure 5-12 HUB with nominal dimensions

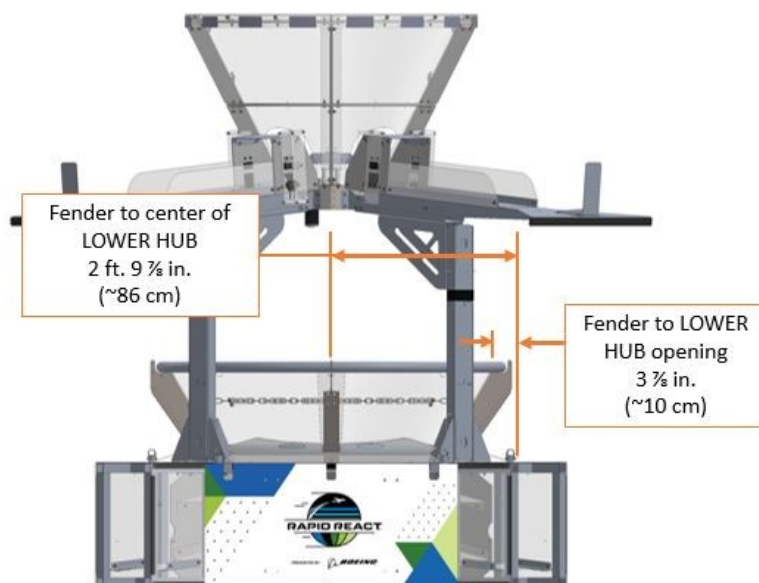


The UPPER HUB opening has a 4-ft. (~122-cm) diameter, and the LOWER HUB opening has a 5-ft. 1/2 in. (~153 cm) diameter.

5.3.2 Fenders

Fenders are 3 ft. 10 $\frac{1}{8}$ in. (~117 cm) wide by 1 ft. 10 $\frac{1}{2}$ in. (~57 cm) tall, are positioned between each LOWER EXIT, and are perpendicular to the carpet. Fenders extend past the footprint of the LOWER HUB by 1 in. (~3 cm). The shortest horizontal distance between the outward face of a fender and the opening of the LOWER HUB is 3 $\frac{7}{8}$ in. (~10 cm). The shortest horizontal distance between the outward face of a fender and center of the LOWER HUB is 2 ft. 9 $\frac{7}{8}$ in. (~86 cm).

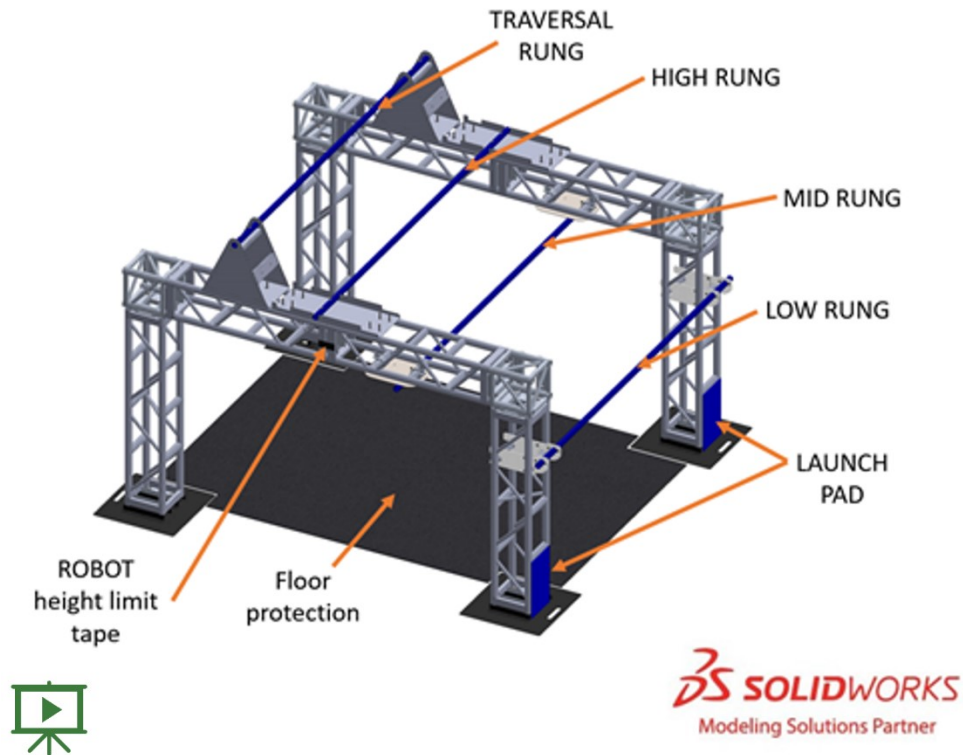
Figure 5-13 Fender geometry



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5.4 HANGARS

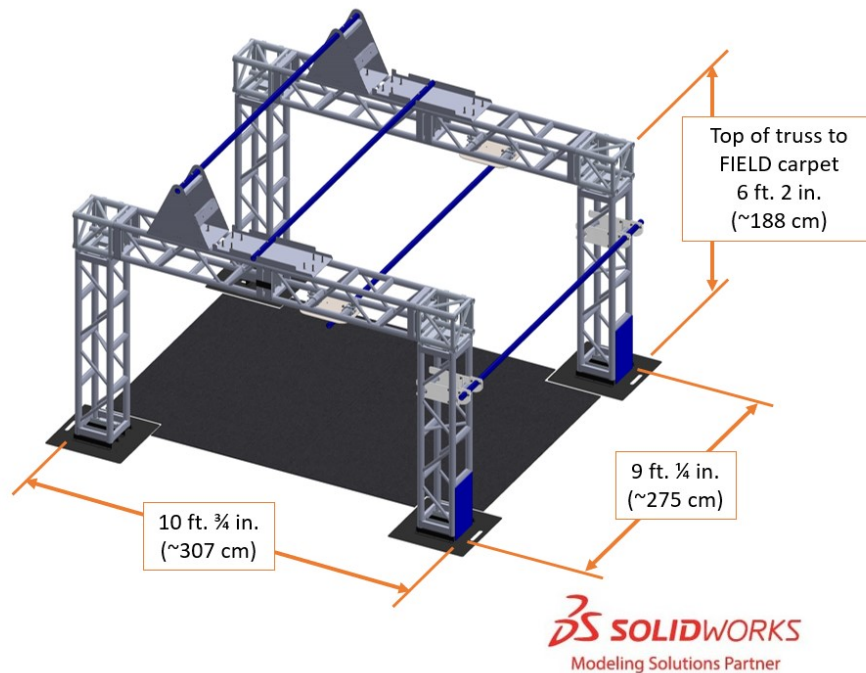
Figure 5-14 Blue HANGAR (click image to see field tour video)



A HANGAR is located in front of each HANGAR WALL and DRIVER STATION 1. A HANGAR assembly consists of truss structure, bases, 4 RUNGS, RUNG mounting brackets, floor protection, and 2 LAUNCH PADS. The maximum ROBOT height limit described in G106 is marked on the center of each horizontal truss assembly in black tape (i.e. the bottom edge of the tape is 5 ft. 6 in. (~168 cm) above floor protection carpet).

5.4.1 Truss Structure

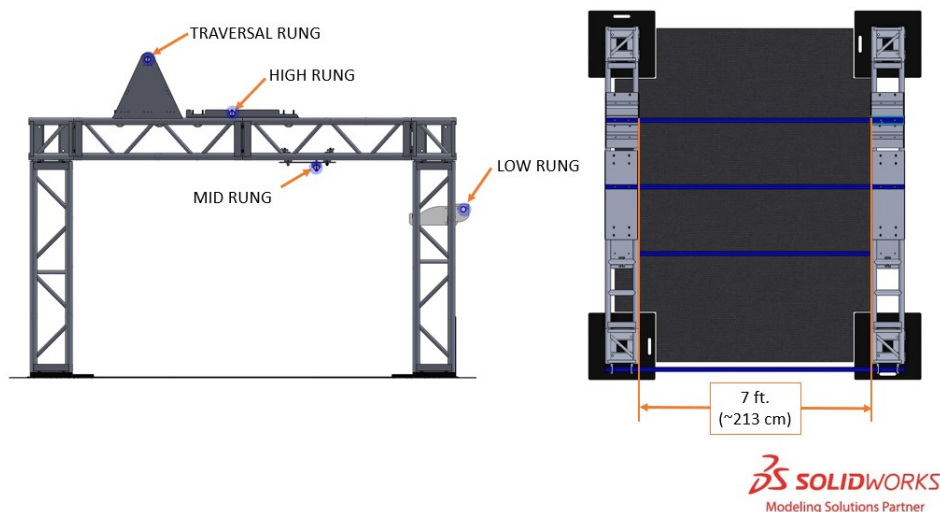
Figure 5-15 HANGAR nominal dimension



HANGAR truss is 1 ft. x 1 ft. (~30 cm x ~30 cm) square truss. The truss structure is 9 ft. 1/4 in. (~275 cm) wide, 10 ft. 3/4 in. (~307 cm) deep, and 6 ft. 2 in. (~188 cm) tall when measured from the FIELD carpet. Each of the 4 legs is attached to a baseplate (baseplates are not part of the truss structure). Each baseplate extends 6 in. (~15 cm) out from each leg face and is 1/8 in. (~3 mm) thick.

5.4.2 Rungs

Figure 5-16 Blue HANGAR

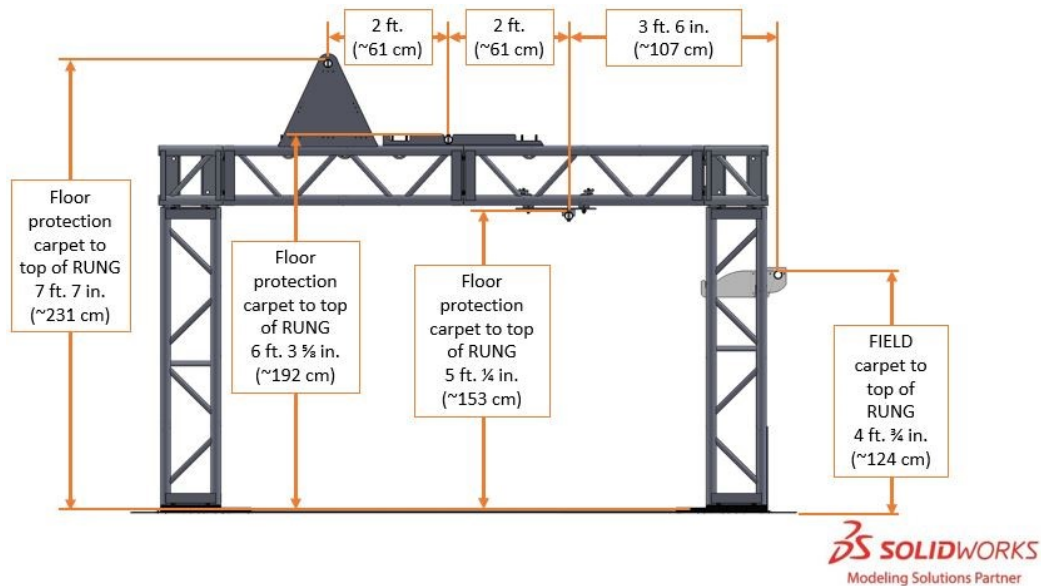


Each HANGAR has 4 RUNGS highlighted in Figure 5-16: LOW, MID, HIGH, and TRAVERSAL. RUNGS are 1 1/4 in. Schedule 40 steel pipes, with a 1.66 in. (~4 cm) outer diameter, and are powder coated to reflect the

ALLIANCE color. RUNGS are 7 ft. (~213 cm) wide and bound by the truss and brackets (note that pipe that overlaps the truss structure and brackets is not considered part of the RUNG).

Figure 5-17 illustrates spacing between RUNGS. The top of the LOW RUNG is 4 ft. $\frac{3}{4}$ in. (~124 cm) above FIELD carpet. The top of the MID RUNG is 5 ft. $\frac{1}{4}$ in. (~153 cm) above floor protection carpet, and its center is 3 ft. 6 in. (~107 cm) from the center of the LOW RUNG. The top of the HIGH RUNG is 6 ft. $3\frac{5}{8}$ in. (~192 cm) above floor protection carpet, and the top of the TRAVERSAL RUNG is 7 ft. 7 in. (~231 cm) above floor protection carpet. MID, HIGH, and TRAVERSAL RUNGS are spaced such that their centers are 2 ft. (~61 cm) apart. The horizontal distance between the center of the TRAVERSAL RUNG and the ALLIANCE WALL is 3 ft. 3 in. (~99 cm).

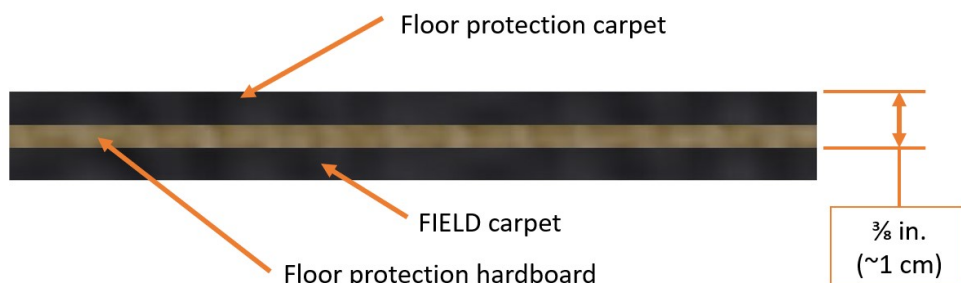
Figure 5-17 RUNG spacing



5.4.3 Floor Protection

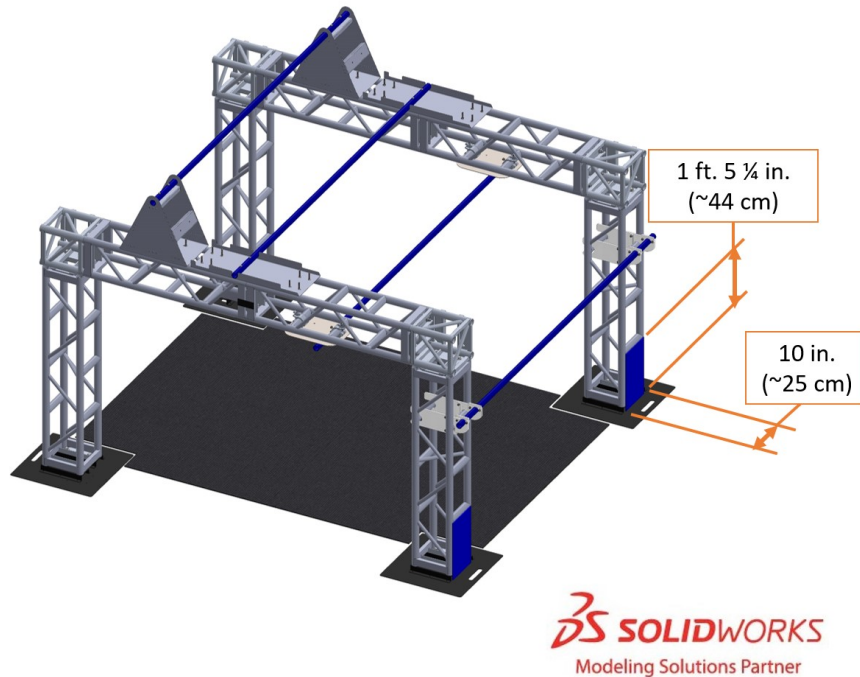
A layer of $\frac{3}{8}$ in. (~3 mm) thick hardboard is installed on top of the FIELD carpet in the space bounded by the truss bases to protect venue flooring. The hardboard is covered with a layer of carpet and adds approximately $\frac{3}{8}$ in. (~1 cm) of height to the area.

Figure 5-18 Floor protection cross section



5.4.4 LAUNCH PADS

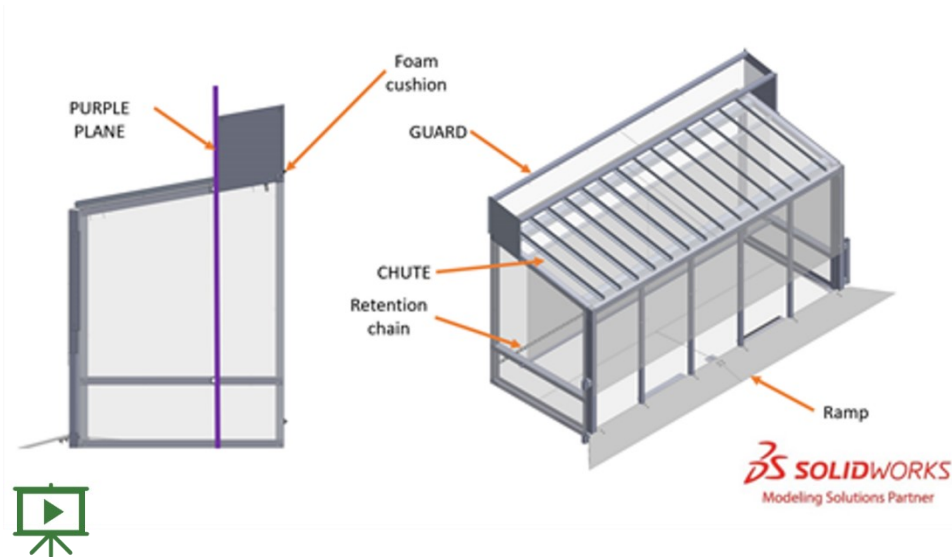
Figure 5-19 LAUNCH PAD locations



LAUNCH PADS are mounted to the 2 truss legs closest to the HUB such that they are flush to the top of the truss base. Each LAUNCH PAD is a piece of 1/4 in. (~6 mm) thick, 1 ft. 5 1/4 in. (~44 cm) tall, and 10 in. (~25 cm) wide HDPE of the corresponding ALLIANCE color.

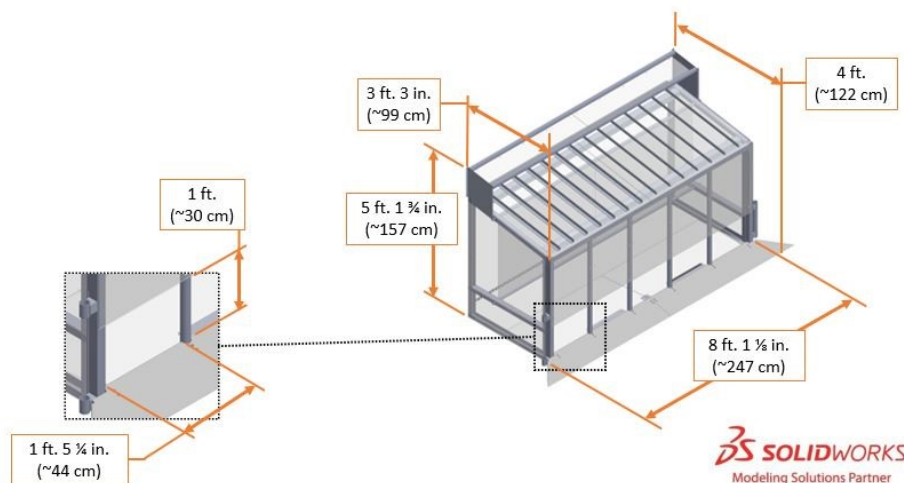
5.5 TERMINALS

Figure 5-20 TERMINAL (click image to see field tour video)



One TERMINAL is in each of the 2 FIELD corners opposite the HANGARS. Each TERMINAL is shared between ALLIANCES. A TERMINAL consists of 1 ramp, 1 GUARD, 1 PURPLE PLANE, 1 CHUTE, and other structure elements shown in Figure 5-20. Each TERMINAL has 5 CARGO delivery openings through which ROBOTS may transfer CARGO to HUMAN PLAYERS. The space between the PURPLE PLANE and the retention chain can hold approximately 10 CARGO.

Figure 5-21 TERMINAL details



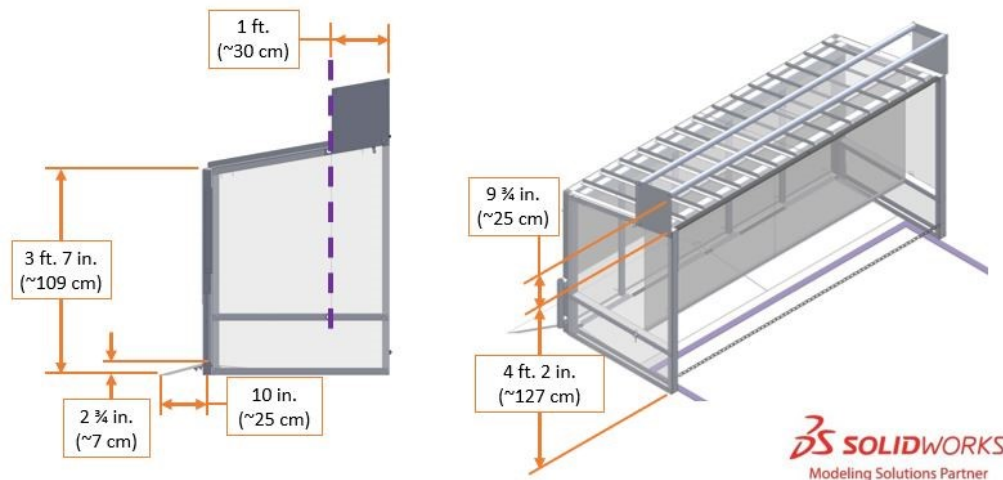
Each TERMINAL is 4 ft. (~122 cm) deep, 8 ft. 1 1/8 in. (~247 cm) wide (excluding the ends of the ramp) and is a maximum of 5 ft. 1 3/4 in. (~157 cm) tall.

A 2 3/4 in. (~7 cm) tall ramp leads to the 1 ft. 5 1/4 in. (~44 cm) wide, 1 ft. (~30 cm) tall openings.

The CHUTE is a plastic sheet with 1 1/8 in. (~3 cm) tall aluminum angles spaced 6 1/2 in. (~17 cm) from each other to form channels. The CHUTE is angled such that the top of the plastic is 3 ft. 7 in. (~109 cm) above

carpet on the FIELD side and 4 ft. 2 in. (~127 cm) on the HUMAN PLAYER side. The high edge of the CHUTE is padded with black foam cushion.

Figure 5-22 PURPLE PLANE



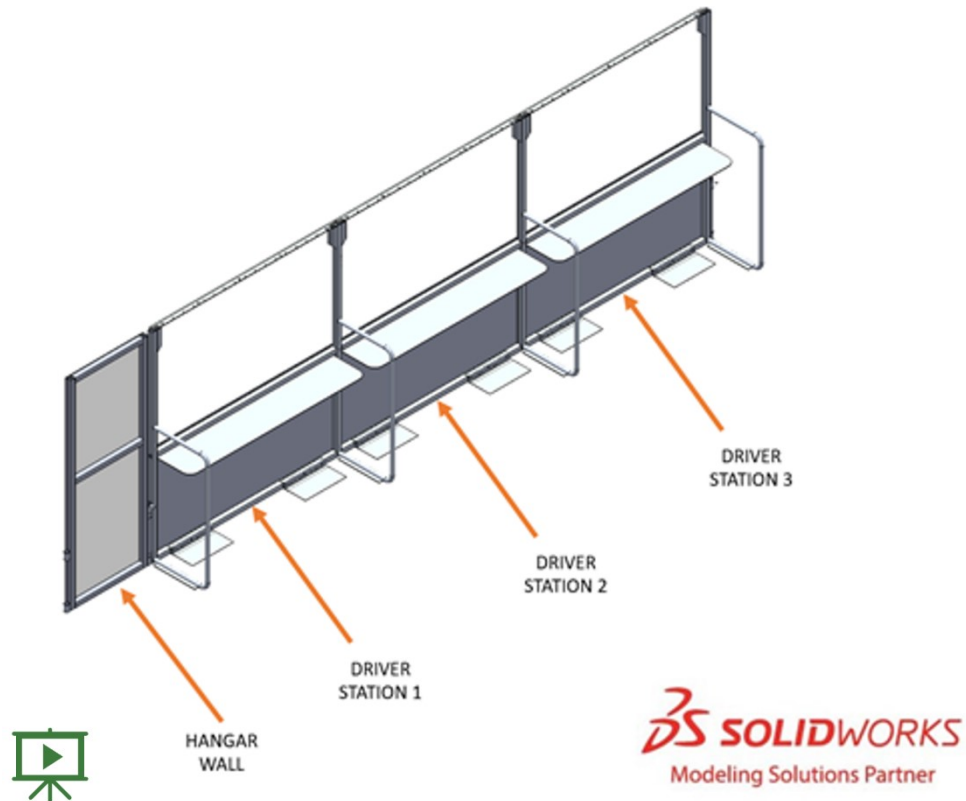
The TERMINAL has exterior HPDE and interior polycarbonate ramps which each run the width of the TERMINAL and meet at a height of 2 $\frac{3}{4}$ in. (~7 cm). The exterior ramp is 10 in. (~25 cm) deep. Once pushed through any opening, a CARGO rolls down the interior ramp into the TERMINAL AREA.

A PURPLE PLANE is a virtual boundary which extends the width of the TERMINAL and is defined by the FIELD side edge of the GUARD and the purple tape which runs parallel to the interior ramp. It is 1 ft. (~30 cm) from the HUMAN PLAYER side of the TERMINAL.

The GUARD is the framing formed by all TERMINAL structure above the CHUTE, and it is used by HUMAN PLAYERS to feed CARGO to the FIELD. The top of the GUARD is above and parallel to the CHUTE. The GUARD creates a 9 $\frac{3}{4}$ in. tall opening (~25 cm) which is 4 ft. 2 in. (~127 cm) above the carpet.

5.6 ALLIANCE WALLS

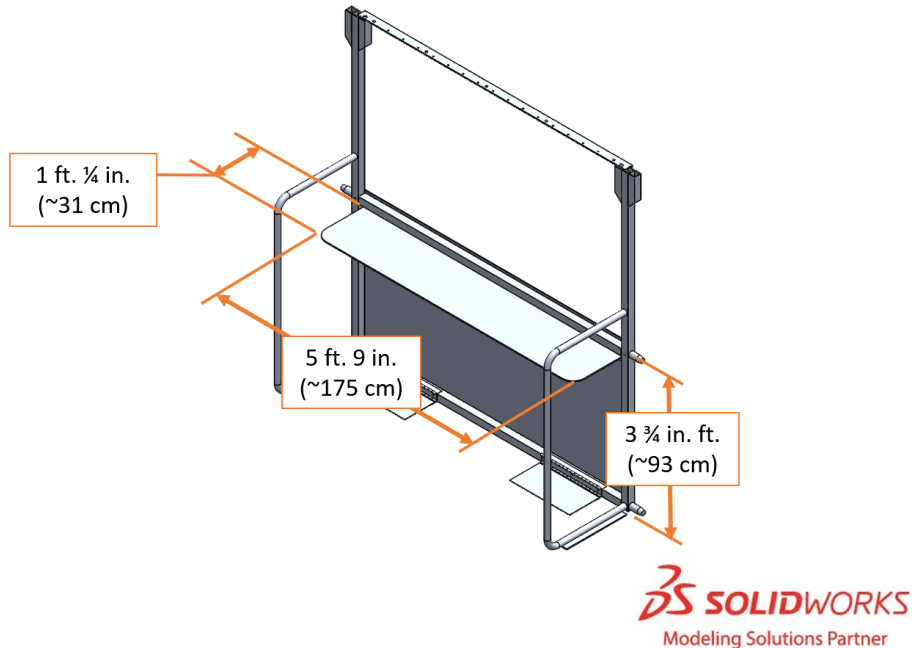
Figure 5-23 ALLIANCE WALL (click image to see field tour video)



An ALLIANCE WALL consists of 3 DRIVER STATIONS and a HANGAR WALL.

5.6.1 DRIVER STATIONS

Figure 5-24 DRIVER STATION dimensions



A DRIVER STATION is 1 of 3 assigned positions in an ALLIANCE WALL from where 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.

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 [Section 5.6.1.1 DRIVER STATION LED Strings](#).
- 1 timer (in DRIVER STATION 2 only): displays the official time remaining in the MATCH and TIMEOUTS. It is marked with white tape along the bottom edge.
- FMS hardware and wiring: mostly located below the DRIVER STATION 2 shelf

5.6.1.1 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 CARGO BONUS progress.

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

Figure 5-25 FIELD is safe for humans



During a MATCH, nodes 1 through 4 and 15-17 are yellow if the MATCH is in AUTO (as shown in Figure 5-26) and white if in TELEOP (as shown in Figure 5-27 and Figure 5-28). Additionally, the center 10 nodes of each string, 5 through 14, indicate the ALLIANCE'S CARGO BONUS progress in the ALLIANCE'S color. The first scored CARGO causes node 5 to turn on. The second CARGO causes node 5 to dim. The third CARGO causes the node 6 to turn on; the fourth CARGO causes node 6 to dim, and so on (see Figure 5-26, Figure 5-27, and Figure 5-28).

If an ALLIANCE achieves a QUINTET (as described in Table 6-1), node 14 turns on (see Figure 5-27) indicating the lowered threshold to achieve the CARGO BONUS.

Figure 5-26 MATCH is in AUTO, red ALLIANCE has scored 3 CARGO



Figure 5-27 MATCH is in TELEOP, red ALLIANCE achieved a QUINTET



Figure 5-28 MATCH is in TELEOP, red ALLIANCE has scored 7 CARGO, but without a QUINTET



If the CARGO BONUS is achieved, all 3 DRIVER STATION strings display an animated light sequence, blink twice, and then all nodes remain dim in the ALLIANCE color for the remainder of the MATCH.

Figure 5-29 Red ALLIANCE has earned the CARGO BONUS

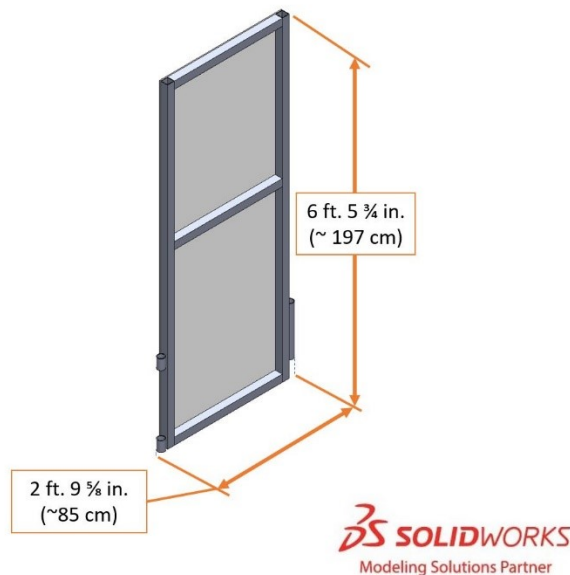


DRIVER STATION light strings remain active after TELEOP ends for 5 seconds. The lights then pulse for an additional 5 seconds (to indicate that the time frame described in [Section 6.4, item C](#) is complete).

5.6.2 HANGAR WALLS

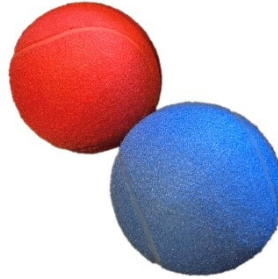
A HANGAR WALL is a 2 ft. 9 $\frac{5}{8}$ in. (~85 cm) wide by 6 ft. 5 $\frac{1}{4}$ in. (~197 cm) tall structure located between DRIVER STATION 1 and the guardrail. The aluminum frame is covered with clear polycarbonate on the FIELD side.

Figure 5-30 HANGAR WALL frame



5.7 CARGO

Figure 5-31: CARGO

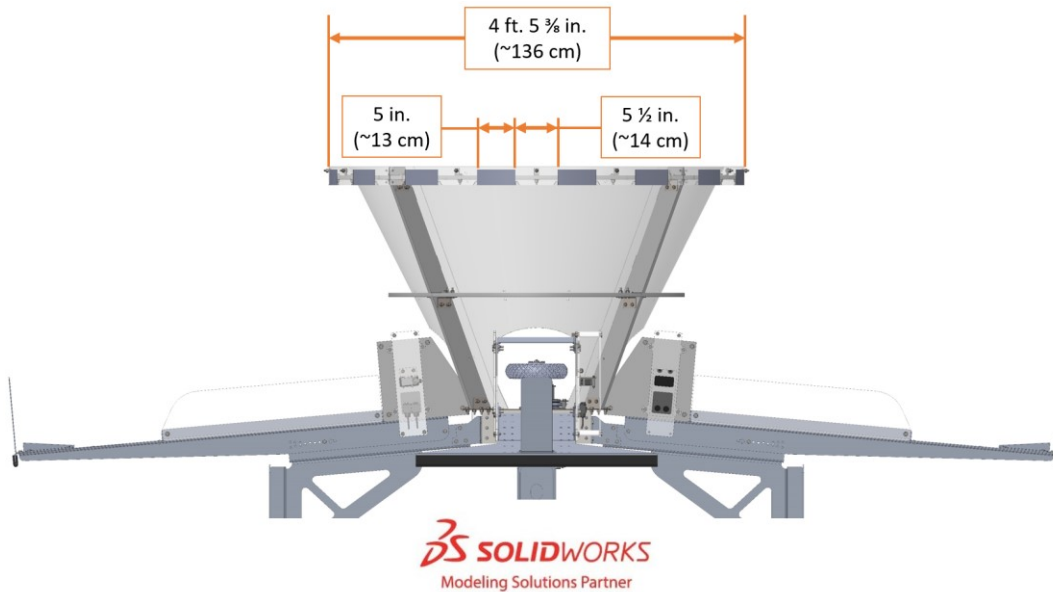


RAPID REACT is played with oversized tennis balls called CARGO, custom modified for *FIRST* by Flaghouse. CARGO is 9½ in. (~24 cm) in diameter, weighs 9½ oz. (~270 g), and has a fuzz surface. CARGO is inflated to 3½ psi. ±½ psi. (checked every morning and lunch break and as outliers are suspected using [this gauge](#) at official events). Typically, if a CARGO is dropped on FIELD carpet from a height of 3 ft., it bounces back to a height between 2 ft. 1 in. (~64 cm) and 2 ft. 6 in. (~76 cm) (as measured from the bottom of the ball). CARGO is available for purchase at [AndyMark](#), part numbers am-4600_blue and am-4600_red. The oversized tennis balls used as CARGO are not manufactured with any tight tolerance. Wall thickness, surface pilling, and shedding may vary. An off-the-shelf ball may perform differently from the official CARGO.

5.8 Vision Targets

The UPPER HUB is marked with a single 360° vision target consisting of 5 in. (~13 cm) long strips of 2 in. (~5 cm) wide [3M 8830 Scotchlite™ Reflective Material](#). A sample of the material is included in each Rookie Kickoff Kit and *FIRST* Choice. The target is a 4 ft. 5⅜ in. (~136 cm) diameter ring of plastic with 16 strips adhered to it with 5½ in. (~14 cm) gaps between them. The ring is aligned such that 1 of the gaps is centered over each UPPER EXIT. The distance from FIELD carpet to the top of the target assembly is 8 ft. 8 in. (~264 cm); the distance from FIELD carpet to the bottom of the vision tape is 8 ft. 5⅝ in. (~258 cm).

Figure 5-32: Vision target



5.9 The FIELD Management System

The FIELD Management System (FMS) is the electronics core 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 5-1. 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 5-1 Audio cues

Event	Timer Value	Audio Cue
MATCH start	0:15 (for AUTO)	"Cavalry Charge"
AUTO ends	0:00 (for AUTO)	"Buzzer"
TELEOP begins	2:15	"3 Bells"
HANGAR ZONE protection engaged	0:30	"Train Whistle"
MATCH end	0:00	"Buzzer"

Event	Timer Value	Audio Cue
MATCH stopped	n/a	"Foghorn"
TIMEOUT warning	1:00	"Trumpet Fanfare"
TIMEOUT end	0:00	"Buzzer"

