



**Final Event**  
**Operations Guide**  
Revision 1  
June 18, 2021



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# 1. Overview

This document serves as the Operations Guide for the DARPA Subterranean (SubT) Challenge Final Event being held September 21-24, 2021 at Louisville Mega Cavern in Louisville, Kentucky, USA.

This Operations Guide is intended for teams who qualified to participate in the SubT Challenge Final Event. **The purpose of this document is to provide details regarding (1) competition activities, (2) event logistics and operations, and (3) supporting information to ensure a safe and successful event.**

## 2. Systems & Virtual Team Participation

As detailed in the [Qualification Guide](#) document, Systems Teams were required to qualify prior to April 21, 2021, and Virtual Teams were required to qualify prior to June 29, 2021, to be invited to participate in the SubT Challenge Final Event. Teams were notified directly of their qualification status.

Systems Teams will be scored on multiple runs over their seven (7) days at Louisville Mega Cavern. The Final Event includes two (2) competition days as the Preliminary Round and a third (3<sup>rd</sup>) competition day as the Prize Round. Qualified teams will be eligible to participate in the Preliminary Round which will consist of two (2) scored runs, each thirty (30) minutes in duration. All qualified teams will advance to the Prize Round which will consist of one (1) scored run, sixty (60) minutes in duration. The final ranking will be determined based solely on the Prize Round run score. DARPA Competition Staff will be available to support teams during the 30-minute integration window prior to each scored run.

Virtual Teams will submit their solutions to the SubT Virtual Portal, where cloud-based simulations will be run against the unreleased Final Event competition scenarios. The solution submission window for the Virtual Competition Preliminary Round opens July 22, 2021 and closes July 29, 2021. The Preliminary Round submissions will be evaluated and the results will be announced August 9-13, 2021. The solution submission window for the Virtual Competition Prize Round opens August 19, 2021 and closes August 26, 2021. The submissions will be evaluated and the final results will be announced alongside the Systems Competition results. [The top 10 Virtual Teams that advance to the Prize Round are invited to attend the Final Event activities in person on September 23-24, 2021, to include the Awards Ceremony and SubT Summit. Virtual Teams may also participate remotely, as the event will be live streamed.](#)

The SubT Challenge Final Event will be governed based on the rules as outlined in the SubT Challenge [Competition Rules \(Final Event\)](#) document, so teams should reference that document for additional technical rules and restrictions. Questions related to the rules and any information provided in this Operations Guide may be posted to the [SubT Community Forum](#).

## 3. Systems Competition Task Operations

Competition Staff will be responsible for providing transportation of the teams' systems between the Team Garages and the course Staging Area (see Figure 1). DARPA will provide utility vehicles to support transport of both the systems and team members. Teams will not be allowed to use their own vehicles for transport of systems or team members to the course Staging Area.

Operational details can be found in Section 8, System Competition Rules, in the [Competition Rules \(Final Event\)](#) document. Teams should note that no team members will be permitted to

enter the courses until the completion of the competition. Competition Staff will assist with platform recovery at the end of each run. Safety is one of the most important facets of the event and the Chief Official will have the final authority to determine if any team is operating in an unsafe manner or is not operating in the spirit of the SubT Challenge.

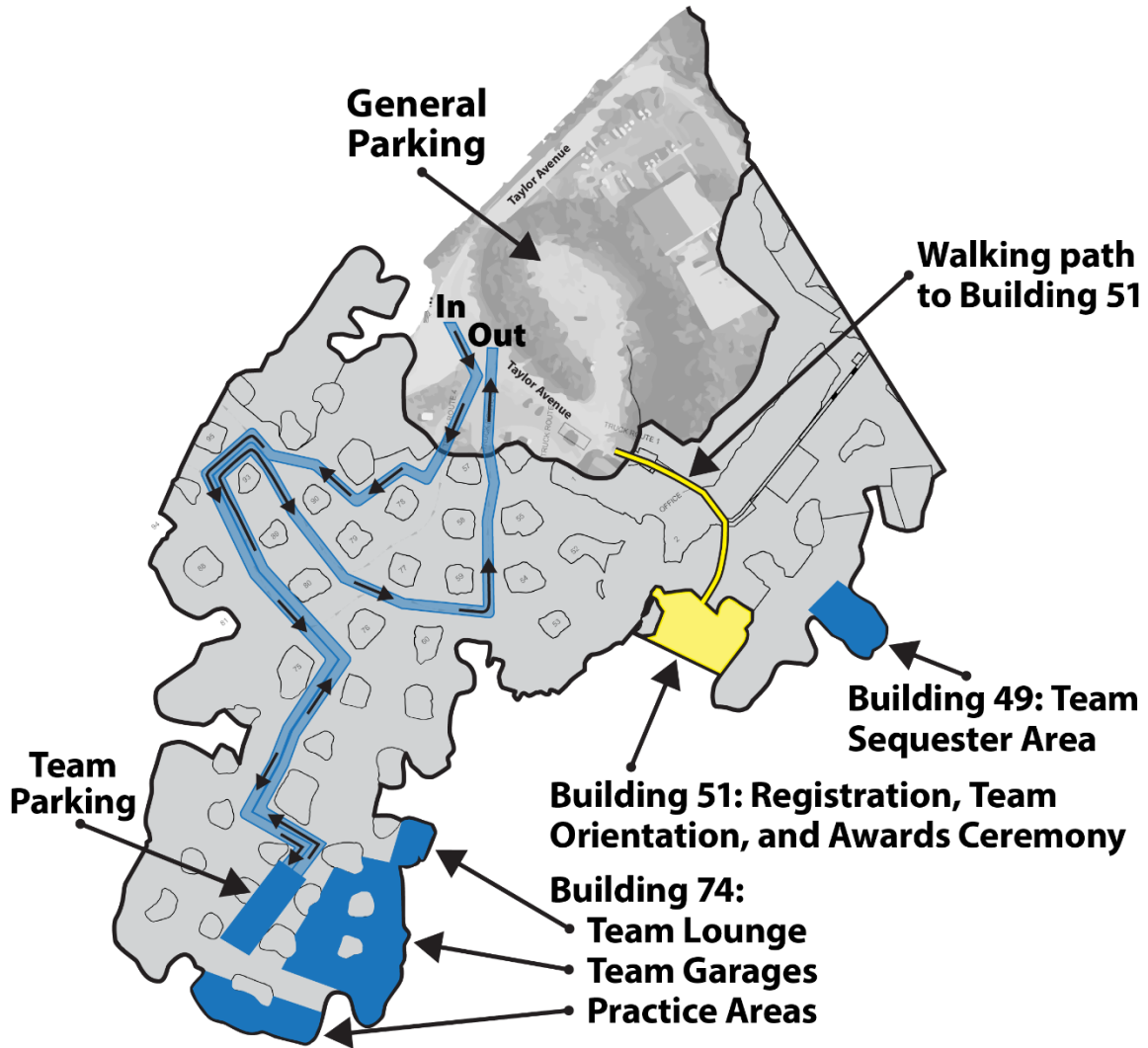


Figure 1: Louisville Mega Cavern Site Map

## 4. Schedule

All qualified Systems Teams will be on site September 18-24, 2021. Systems Teams should plan to be at the Louisville Mega Cavern in Louisville, Kentucky by 4:00 p.m. EDT Saturday, September 18. [Virtual Teams should plan to be at the venue by 9:00 a.m. EDT Thursday, September 23.](#) Systems and Virtual Teams should plan to be on site until 5:00 p.m. EDT Friday, September 24, for the Awards Ceremony and SubT Summit.

**Course Open House:** On Friday, September 24, Systems and Virtual Teams will be given the opportunity to see the competition course firsthand. The course will be opened for 30-minute blocks during the 9:00 a.m. to 11:30 a.m. timeframe.

**Post-event Team Testing:** Systems Teams will be given the opportunity to continue testing on the course for the dates of Saturday, September 25 through Friday, October 1. Testing date requests will be collected from Systems Team Leads in the enrollment form.

| Saturday, September 18   | Sunday, September 19                      | Monday, September 20                                  | Tuesday, September 21   | Wednesday, September 22 | Thursday, September 23                                     | Friday, September 24   |
|--------------------------|---|---|-------------------------|-------------------------|--|--|
| Systems Team Orientation | Systems Team Move-in and Systems Checkout | Systems Team Move-in and Systems Checkout (continued) | Preliminary Round Day 1 | Preliminary Round Day 2 | Prize Round, Virtual Team Arrival, & Systems Team move-out | Course Open House, Awards Ceremony & SubT Summit & Systems Team move-out (continued) |
| Saturday, September 25   | Sunday, September 26                      | Monday, September 27                                  | Tuesday, September 28   | Wednesday, September 29 | Thursday, September 30                                     | Friday, October 1  |
| Systems Team Test Day    | Systems Team Test Day                     | Systems Team Test Day                                 | Systems Team Test Day   | Systems Team Test Day   | Systems Team Test Day                                      | Systems Team Test Day  |

## 5. Location

The SubT Challenge Final Event will be held at the Louisville Mega Cavern in Louisville, Kentucky.

### [Louisville Mega Cavern](#)

1841 Taylor Avenue  
Louisville, KY 40213

Teams are not allowed to use or visit Louisville Mega Cavern until the completion of the Final Event. Teams are also not permitted to contact Louisville Mega Cavern for information related to the SubT Challenge or the facilities. All questions about Louisville Mega Cavern or the Final Event should be posted on the [SubT Community Forum](#).

## 6. Enrollment

Systems Teams are limited to twenty (20) members in attendance at the Final Event. [If a Systems Team is also competing in the Virtual Competition, they are limited to a total of twenty \(20\) members at the Final Event across both competitions.](#) Each individual participant must enroll on the Team Enrollment Website (below) by 11:59 p.m. EDT Wednesday, July 21, 2021.

**Team Enrollment Website:** <https://events.sa-meetings.com/DARPAsubTChallengeFinals>

**Username:** SubTFinals

**Password:** Kentucky2021

Systems Team Leads must enroll their robotic systems separately to their individual enrollment. All platforms intended to be used in the Systems Competition must be submitted via the [SubT Challenge Team Portal](#) by 11:59 p.m. EDT Monday, June 21, 2021 to meet the Platform Qualification requirements. Team Leads should include an updated narrative description and demonstration videos of the platforms successfully completing the qualification tasks listed in Section 4 of the [Qualification Guide](#) document.

[Virtual Teams planning to attend the Final Event activities on September 23-24, 2021 in person must enroll each individual participant on the Team Enrollment Website \(above\) by 11:59 p.m. EDT Friday, September 3, 2021. Virtual Teams are limited to six \(6\) members in attendance at the Final Event.](#)

Individuals planning to participate in the Final Event via live stream do *not* need to enroll. The live stream will be found on the [SubT Challenge website](#).

## 7. Systems Team Orientation

All enrolled Systems Team members are required to attend the Systems Team Orientation from 5:00 p.m.–6:00 p.m. EDT Sunday, September 18, 2021. Check-in will begin at 4:00 p.m. The orientation will be held at the Louisville Mega Cavern in Building 51 (see Figure 1).

### [Louisville Mega Cavern](#)

1841 Taylor Avenue, Building 51  
Louisville, KY 40213

During the Systems Team Orientation, teams will receive:

1. Overview of the Final Event
2. Information on move-in and move-out procedures
3. SubT Challenge details
4. Safety brief

## 8. Systems Team Garages

Systems Teams will be provided a defined open workspace in Building 74 as their Team Garage for their time at the Final Event. Teams will be given 24-hour access to their Team Garage and shared Practice Areas from team move-in on September 19 through move-out on September 24. Each space will notionally be 30 feet (9.1 m) long x 53 feet (16.2 m) wide on cement flooring. These spaces will be clearly identified but teams should note these open spaces will be adjacent to each other. Each Team Garage will be outfitted with twenty-four (24) banquet tables and twenty (20) chairs. No computers, monitors, or power distribution equipment will be provided. Building

74 is not equipped with heating or air conditioning but the entire cavern maintains an average temperature of 58°F (14.4°C) year-round. Teams may bring and utilize their own electric heaters or air conditioners; however, teams will receive limited power and will be responsible for prioritizing their power needs.

Teams may operate ground robots within their assigned Team Garage as long as operations are deemed safe as determined by Competition Staff and such operations do not interfere with adjacent teams. Teams operating multirotors or other aircraft should note that such aerial vehicles are not permitted to launch or fly in the Team Garage areas. DARPA will not control wireless interference in the Team Garages. A single wired internet connection will be provided to each garage. Teams are permitted to bring their own unmanaged switches to expand ports available. Cellular service is not available within the cavern.

DARPA will provide power to the teams in two (2) locations: in the Team Garages and in the course Staging Area. In the Team Garages there will be two (2) 120V, single-phase, 20A circuits, and in the Staging Area there will be one (1) 120V, single-phase, 20A circuit. Both of these locations will have NEMA 5-20R T-slot receptacles. Teams should plan accordingly to have the correct adapters, chargers, and power strips to match their individual team needs. International teams should pay special attention to voltages common in the United States and bring any necessary equipment. If teams have additional power needs, they should identify them in the team enrollment form and/or inform DARPA via [SubTChallenge@darpa.mil](mailto:SubTChallenge@darpa.mil) before July 1, 2021.

Teams are only permitted in the Staging Area during their scheduled runs and must otherwise remain in their Team Garage areas while on site. A DARPA representative will be available at all times in Building 74 to answer questions or assist with on-site issues.

## 9. Virtual Team Garages

Virtual Teams will be provided a defined workspace in Building 74 as a shared Virtual Competition Team Garage for their time at the Final Event. The size of this space will be dependent on Virtual Team participation (enrollment). DARPA will provide a large screen monitor with HDMI connection for large displays/demos. This monitor will be shared across all Virtual Teams. DARPA will also provide power and wired internet to support one (1) team-supplied laptop and one (1) monitor per team member. Each team will be given one (1) round table and enough chairs for each enrolled team member. Building 74 is not equipped with heating or air conditioning but the entire cavern maintains an average temperature of 58°F (14.4°C) year-round.

Virtual Teams must remain in the Virtual Team Garage area while on site. A DARPA representative will be available at all times in Building 74 to answer team questions or assist with on-site issues.

## 10. Practice Areas

Systems Teams will have daily access to two (2) Practice Areas, also within Building 74. The spaces are approximately 100 feet (30.5 m) long x 40 feet (12.2 m) wide and 25 feet (7.6 m) in height. In the practice areas, teams may operate all of their systems, both air and ground. Platforms will be able to take off and fly within the Practice Area for practice flights. Teams are required to have a Safety Officer who is responsible for preserving the safety of personnel and property during all practice runs. No personnel are permitted to be inside the Practice Areas while robots are active. Personnel will operate and monitor their active systems outside of the netted areas.

## 11. E-Stops

DARPA has established a set of emergency stop (E-Stop) requirements to ensure the safety of personnel, equipment, and the course environment. These requirements are designed to address common and/or anticipated modes of failure and provide a consistent, predictable method to disable equipment without creating additional hazards. All systems participating in the Final Event will be required to demonstrate and utilize a Tier 1 wireless emergency stop, Tier 2 recovery wireless emergency stop, and Tier 3 on-platform emergency stop (if applicable) as described in the [Competition Rules \(Final Event\)](#) document.

Prior to operating their systems on the designated competition courses, Systems Teams will be required to successfully demonstrate connectivity to their systems and the operation of the Tier 1, Tier 2, and Tier 3 (if applicable) emergency stops. If a team fails to successfully pass their safety and network check, they will be required to use their first scheduled scored run to complete this task.

## 12. Systems Team Sequestration

For the Prize Round, the Human Supervisor and Pit Crew personnel will be sequestered in Building 49 to prevent teams that have not completed their runs from gaining knowledge about the courses. Sequestered personnel will not be permitted to communicate with any other team personnel during the sequester period.

The sequester schedule will vary by time slot. A detailed sequester schedule will be provided closer to the event date.

Teams with early time slots will be sequestered after their run is complete and may need to be sequestered for up to 6.5 hours after their run. Teams with later time slots will be sequestered before their run begins and may need to be sequestered for up to 3.5 hours before their run. Sequestered teams are expected to have access to their Base Station and systems, subject to DARPA's ability to isolate them.

No cell phones, personal electronic devices, or wireless communications of any kind are permitted during the sequestration period. Teams are only permitted to use wired connections to interface with their systems. The wireless spectrum will be actively monitored, and teams found in violation may be disqualified from the competition.

Sequestered personnel are encouraged to bring materials to pass the time (e.g., reading material, non-electronic games).

## 13. Travel

The [Louisville Muhammad Ali International Airport \(SDF\)](#) is the closest major airport. It is a ten (10) minute drive to Louisville Mega Cavern and to downtown Louisville. Seven (7) airlines serve thirty-five (35) non-stop domestic locations.



## 14. Area Map

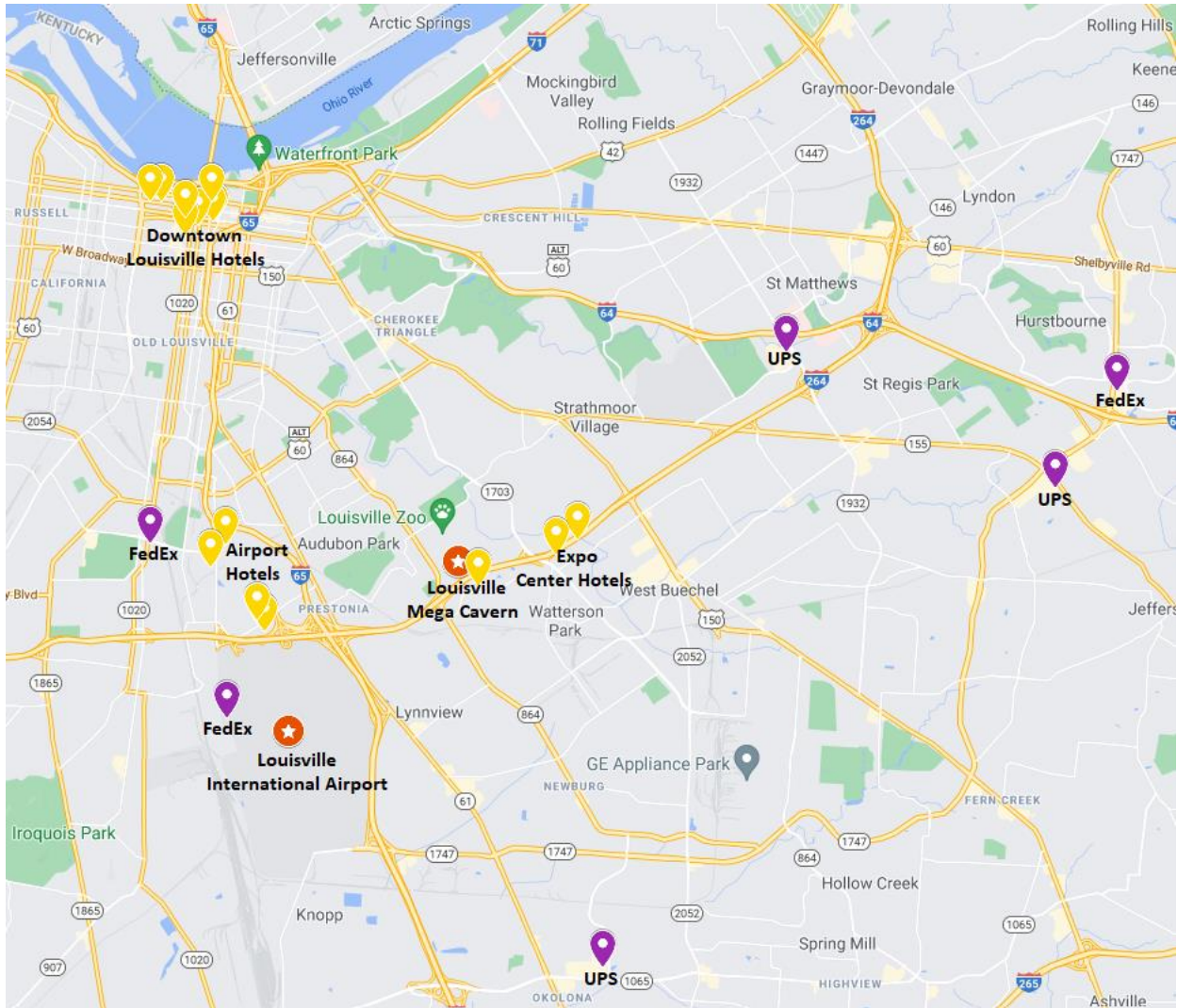


Figure 2: Louisville Area Map with Key Locations

## 15. Lodging

Teams are responsible for making their own hotel reservations or sleeping arrangements. Local hotels and distances to Louisville Mega Cavern are listed below. The hotel list is provided solely for informational purposes for the convenience of the teams. DARPA does not promote or prefer any of the hotels listed below.

| Name   | Address                                    | Phone          | Distance to Venue |
|--|--|----------------|-------------------|
| <a href="#">Candlewood Suites Louisville Airport, an IHG Hotel</a>               | 1367 Gardiner Lane<br>Louisville, KY 40214 | (502) 357-3577 | 0.4 miles         |
| <a href="#">Holiday Inn Express Louisville Airport Expo Center, an IHG Hotel</a> | 1921 Bishop Lane<br>Louisville, KY 40218   | (502) 456-4411 | 1.0 miles         |
| <a href="#">Wingate by Wyndham Louisville Fair and Expo</a>                      | 3200 Kemmons Drive<br>Louisville, KY 40218 | (502) 694-4726 | 1.3 miles         |
| <a href="#">Tru by Hilton Louisville Airport</a>                                 | 810 Phillips Lane<br>Louisville, KY 40209  | (502) 792-8800 | 2.2 miles         |

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|--|---|----------------|-----------|
| <a href="#">Springhill Suites by Marriott Louisville Airport</a>                   | 820 Phillips Lane<br>Louisville, KY 40209         | (502) 361-9009 | 2.2 miles |
| <a href="#">Courtyard by Marriott Louisville Airport</a>                           | 819 Phillips Lane<br>Louisville, KY 40209         | (502) 368-5678 | 2.2 miles |
| <a href="#">Hilton Garden Inn Louisville Airport</a>                               | 2735 Crittenden Drive<br>Louisville, KY 40209     | (502) 637-2424 | 2.5 miles |
| <a href="#">Home2 Suites by Hilton Louisville Airport/Expo Center, KY</a>          | 3000 Crittenden Drive<br>Louisville, KY 40209     | (502) 916-3800 | 2.6 miles |
| <a href="#">Springhill Suites by Marriott Louisville Downtown</a>                  | 132 East Jefferson Street<br>Louisville, KY 40202 | (502) 569-7373 | 7.1 miles |
| <a href="#">Fairfield Inn &amp; Suites by Marriott Louisville Downtown</a>         | 100 East Jefferson Street<br>Louisville, KY 40202 | (502) 569-3553 | 7.1 miles |
| <a href="#">Omni Louisville Hotel</a>  | 400 South 2nd Street<br>Louisville, KY 40202      | (502) 313-6664 | 7.1 miles |
| <a href="#">Embassy Suites by Hilton Louisville Downtown</a>                       | 501 South Fourth Street<br>Louisville, KY 40202   | (502) 813-3800 | 7.2 miles |
| <a href="#">Aloft Louisville Downtown</a>  | 102 West Main Street<br>Louisville, KY 40202      | (502) 583-1888 | 7.3 miles |
| <a href="#">Hyatt Regency Louisville</a>   | 320 West Jefferson Street<br>Louisville, KY 40202 | (502) 581-1234 | 7.4 miles |
| <a href="#">Homewood Suites by Hilton Louisville Downtown, KY</a>                  | 635 West Market Street<br>Louisville, KY 40202    | (502) 589-2000 | 7.8 miles |
| <a href="#">Holiday Inn Express &amp; Suites Louisville Downtown, an IHG Hotel</a> | 800 West Market Street<br>Louisville, KY 40202    | (502) 583-2552 | 9.6 miles |

## 16. Systems Team Move-in/Move-out

Systems Teams will move into Louisville Mega Cavern areas on a staggered schedule starting at 8:00 a.m. EDT Sunday, September 19. A detailed move-in schedule will be provided closer to the event date. Move-in times will also align with a safety and network check schedule so teams are asked to not arrive before their assigned time slot.

Teams must return their workspace to its original condition and check out with DARPA staff on or before 5:00 p.m. EDT Friday, September 24.

## 17. On-site Parking

Each Systems Team is permitted to bring up to six (6) total vehicles to park at Louisville Mega Cavern. Teams are permitted to park all six (6) vehicles in the designated team parking area inside Louisville Mega Cavern near the Team Garages. All team vehicles parked on site should fit in a standard parking spot. All remaining vehicles, to include large utility vehicles used for equipment move-in and move-out, should be parked at the teams' hotel/accommodations. Parking passes will be distributed to the identified Team Lead at Systems Team Orientation.

Virtual Teams are permitted to bring up to two (2) total vehicles to Louisville Mega Cavern and should park in the designated team parking area inside Louisville Mega Cavern near the Team Garages. Parking passes will be distributed to the identified Team Lead at on-site check-in.

## 18. Transporting Equipment

All team equipment should be transported to the Team Garages at Louisville Mega Cavern via one (1) team rented or owned vehicle. The team utility vehicle should be brought to the Team Garages (Building 74) to unload equipment. Once all equipment has been off-loaded, the vehicle must be moved to the general parking area outside of the cavern entrance.

Systems Teams will not be allowed to use their own vehicles for transport of systems or team members between the Team Garages and the Staging Area. Teams will be provided a detailed site map at orientation and staff members will be present to help direct teams.

## 19. Shipping

Teams are responsible for shipping their equipment to an outside provider as well as pickup and transfer of the equipment to and from the Louisville Mega Cavern. Due to liability reasons, Louisville Mega Cavern staff will be unable to receive or sign for any team shipments. Local shipping centers are listed below and illustrated in Figure 2. DARPA does not promote or prefer any shipping provider below.

| Name   | Address  | Phone          | Distance to Venue |
|--|--|----------------|-------------------|
| <a href="#">FedEx Ship Center</a>                    | 4901 Crittenden Drive<br>Louisville, KY 40209          | (800) 463-3339 | 4.8 miles         |
| <a href="#">FedEx Office Print &amp; Ship Center</a> | 3107 South 3rd Street<br>Louisville, KY 40214          | (502) 368-9980 | 5.0 miles         |
| <a href="#">The UPS Store</a>                        | 4621 Outer Loop<br>Louisville, KY 40219                | (502) 966-0095 | 5.9 miles         |
| <a href="#">The UPS Store</a>                        | 974 Breckenridge Lane<br>Louisville, KY                | (502) 894-0771 | 6.1 miles         |
| <a href="#">FedEx Office Print &amp; Ship Center</a> | 1235 South Hurstbourne Parkway<br>Louisville, KY 40222 | (502) 429-8421 | 9.4 miles         |
| <a href="#">The UPS Store</a>                        | 9152 Taylorsville Road<br>Louisville, KY 40299         | (502) 654-7800 | 9.8 miles         |

## 20. Operational Considerations

Systems Teams are responsible for assessing the potential dangers and/or real-world limitations of their technical solutions to be tested, in the context of safety to both personnel and equipment. If a team is unsure if a specific piece of equipment is allowable, the team should check with DARPA prior to arrival at the Final Event.

Standard radio frequencies (i.e., ISM bands) are permitted for use in and around the site. Teams should note that technologies that either require amplification or non-standard frequencies may be limited to within the course and possibly not be allowed for use within the Team Garages. If communication interference is discovered between systems, priority will be given to the team(s) experimenting in the course.

Systems Teams may only conduct flight operations at two locations at Louisville Mega Cavern: the Practice Areas within Building 74 and the competition course including the Staging Area.

Platforms that rely on fuel-based power sources are not permitted at the Final Event.

## 21. Safety

DARPA will provide a safety brief at the Systems Team Orientation. No manual physical intervention or entry by any (human) team members on the courses will be permitted, except for the course open house at the end of the event. Only trained and authorized Competition Staff will

be allowed to enter the courses preceding, during, and following any course runs until the completion of the competition.

We are in the midst of a global pandemic that has required that we change the way we interact with one another. The SubT Challenge Planning Team has put in place safety rules and precautions in order to mitigate the spread of COVID-19, which may be updated at any time. These rules and precautions are outlined in detail in the [DARPA SubT Challenge Final Event COVID-19 Travel Guidance and Safety Plan](#). A participant's failure to comply with these rules and precautions will be taken seriously and may result in exclusion from the SubT Challenge.

Closed-toed shoes, long pants, reflective safety vests, hard hats, COVID-19 face masks and protective eyewear will be required to be worn in the Staging Area and Practice Areas at all times. All PPE except COVID-19 face masks, closed-toed shoes, and long pants will be provided by DARPA and can be found in the Field Operations tent near the Challenge Course and near the Team Garages (Building 74). Team members participating in the Course Open House will be required to wear closed-toed shoes. Steel-toed shoes and ear protection are encouraged but not required.

DARPA encourages teams to devise their own battery safety protocol to follow on site. When not in use, teams should store LiPo batteries in fire retardant battery bags, no more than five (5) batteries per bag. Batteries should be stored at room temperature between 40°F (4°C) and 70°F (21°C).

## **22. Security**

The Louisville Mega Cavern facilities will be monitored by security after event hours. Teams are still encouraged to secure their equipment when they are not in their Team Garage or bring their equipment with them if leaving the venue.

Team Garages are open spaces. Teams must respect each other's privacy and property. If teams do not want their systems viewed, they are encouraged to bring covering material for when they are being transported or stored in their garage.

DARPA is not responsible for any lost or stolen equipment. Nevertheless, acts of theft or sabotage will not be tolerated and will result in immediate disqualification.

## **23. Photo/Video Collection & Media**

DARPA intends to capture photographs and video during Final Event for use in production materials and to provide situational awareness of progress throughout the course. Team members may be asked to be interviewed on camera by DARPA Public Affairs and/or a DARPA-hired production crew. Participation is optional, but encouraged, to provide a range of perspectives on the work being done in the competition. Systems Teams may collect video and photographs of their systems operating within the Staging Area and their Team Garage. Teams are not permitted to take photographs or video of other teams' equipment or operations without explicit permission.

Select national, international, and local media will be present at the Final Event. DARPA Public Affairs will assist in coordinating team interviews with media outlets and will provide additional details closer to the event date.

## **24. Food**

Food trucks/outlets may be made available on site for purchase of food and beverage. Teams are encouraged to bring food with them each day, plan to utilize the on-site vendors, or travel off site to purchase food and beverage. There are many food outlets within short driving distance of the venue. Water coolers will be provided by DARPA so teams are encouraged to bring their own reusable water bottles.

## **25. Weather**

The weather in September in Louisville is moderately hot, with average temperatures fluctuating between lows of 60°F (16°C) and 80°F (26°C). In September, the average relative humidity in Louisville is 74 and Louisville accumulates ~1.06" (27mm) of rain. Team parking and food stalls will be located outside but all other event activities will be indoors. The SubT Challenge event spaces within Louisville Mega Cavern are not equipped with heating or air conditioning but the entire cavern maintains an average temperature of 58°F (14°C) year-round. Participants should be prepared for all types of weather by bringing layered clothing, umbrellas and rain jackets.