



# **Tunnel Circuit Operations Guide**

**Revision 3  
July 12, 2019**



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## 1. Overview

This document serves as the Operations Guide for the DARPA Subterranean (SubT) Challenge Tunnel Circuit being held in August 2019 at the National Institute for Occupational Safety and Health (NIOSH) Mining Program's Safety Research Coal Mine and Experimental Mine in Pittsburgh, Pennsylvania, USA. [This document supersedes the \*Tunnel Circuit Operations Guide Revision 2\* document dated May 21, 2019.](#) Significant revisions in this document are indicated by blue text.

This Operations Guide is intended for Systems Track teams who qualified to participate in the August 2019 SubT Challenge Tunnel Circuit. **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. Experimenting on the Course

As detailed in the [Qualification Guide](#) document, teams were required to qualify prior to April 22, 2019, to be invited to participate in the SubT Challenge Tunnel Circuit event. Teams were notified directly of their qualification status.

[Teams will be scored on two different courses – Safety Research and Experimental – over their eight \(8\) days at NIOSH. Teams will be assigned one \(1\) 60-minute scored run time slot, preceded by 30 minutes for setup, per each of the four \(4\) competition days. Each team is expected to have up to four \(4\) scored runs throughout the Tunnel Circuit event, two \(2\) on each course. DARPA Competition Staff will be available to support teams during the approximately 30-minute setup window prior to their scored run. If a team is not prepared for their designated time slot, the team will not be given a make-up slot.](#)

The SubT Challenge Tunnel Circuit will be governed based on the rules as outlined in the [Competition Rules \(Tunnel Circuit\)](#) 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 (<https://community.subtchallenge.com/>).

## 3. Task Operations

DARPA Competition Staff will be responsible for providing transportation of the Team's systems between the Team Garages and the course Staging Areas (see Figure 1), which is a distance between approximately 1050 feet (320 m) and 1600 feet (488 m). DARPA will provide utility vehicles to support transport. The team members supporting field operations will walk to the Staging Area. Teams will not be allowed to use their own vehicles for transport of systems or team members. [DARPA will aim to support movement to the Staging Areas approximately thirty \(30\) minutes before their scored run.](#)

[Teams will be required to complete a Team System Checkout on Move-in Days. DARPA will bring the teams' hardware to the Staging Area to provide a system overview and verify what was demonstrated in the Qualification videos. During this System Checkout, teams will demonstrate the E-stop capability on each platform. In addition, teams will be required to bring their Base Station to the Staging Area to connect to the DARPA network and communicate status data and course data as described in the \*SubT Challenge Competition Rules \(Tunnel Circuit\)\* document. Teams will not be allowed on the competition courses until they successfully complete their Team System Checkout.](#)

Operational details can be found in Section 9, System Competition Rules, in the [Competition Rules \(Tunnel Circuit\)](#) document. Teams should note that no team members will be permitted to enter the competition course. 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.

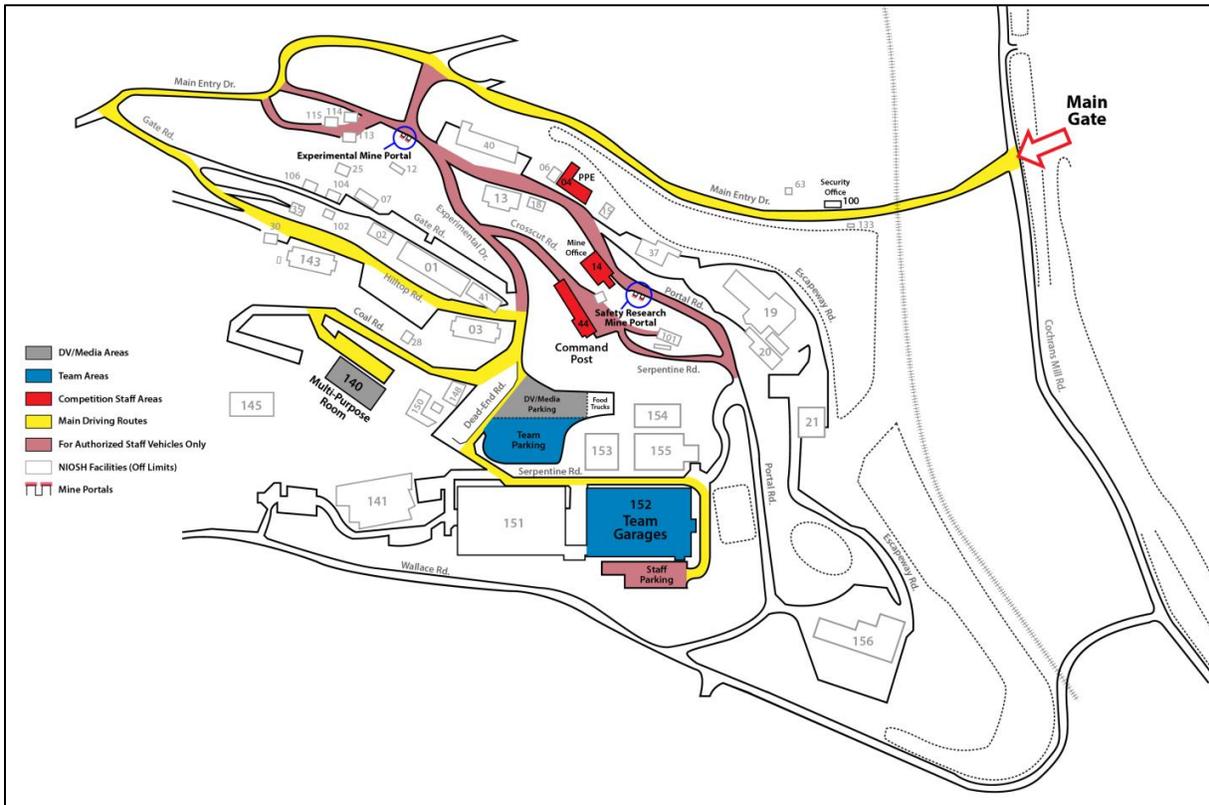


Figure 1: NIOSH Site Map

## 4. Schedule

All qualified teams will be on site during the August 15-22, 2019 timeframe. Teams should plan to be in the Pittsburgh area by 1600 on Thursday, August 15, and should plan to be on site for a full day on Thursday, August 22. [The daily schedule will vary based on numerous factors. DARPA will provide the next day's updated schedule by 1700 each day. An example daily schedule is provided below.](#)

Thursday August 15	Friday August 16	Saturday August 17	Sunday August 18	Monday August 19	Tuesday August 20	Wednesday August 21	Thursday August 22
Team Check-in & Orientation	Team Move-in	<b>Scored Runs Day 1</b>	<b>Scored Runs Day 2</b>	Working Day	<b>Scored Runs Day 3</b>	<b>Scored Runs Day 4 &amp; Move-out</b>	Awards Ceremony, Technical Interchange Meeting, & Course Walking Tours

Scored Runs Day 1 - Saturday, August 17						
Start	End	Safety Research Course	Experimental Course	Practice Area 1	Practice Area 2	
700	715	Staff Arrival & Course Setup	Staff Arrival & Course Setup			
715	730					
730	745					
745	800					
800	815	Team Setup				
815	830					
830	845	Run 1	Team Setup			
845	900		Run 2	Practice 1 Run 5 Team	Practice 2 Run 6 Team	
900	915					
915	930					
930	945		Course Reset			
945	1000	Team Setup				
1000	1015		Course Reset			
1015	1030	Run 3	Team Setup	Practice 3 Run 7 Team	Practice 4 Run 8 Team	
1030	1045		Run 4			
1045	1100					
1100	1115		Course Reset			
1115	1130	Team Setup	Course Reset	Practice 5 Run 9 Team	Practice 6 Run 10 Team	
1130	1145					
1145	1200					
1200	1215	Run 5	Team Setup			
1215	1230		Run 6	Practice 7 Run 11 Team	Practice 8 Run 1 Team	
1230	1245					
1245	1300					
1300	1315		Course Reset			
1315	1330	Team Setup				
1330	1345		Course Reset			
1345	1400	Run 7	Team Setup	Practice 9 Run 2 Team	Practice 10 Run 3 Team	
1400	1415		Run 8			
1415	1430					
1430	1445		Course Reset			
1445	1500	Team Setup	Course Reset	Practice 11 Run 4 Team	TBD	
1500	1515					
1515	1530	Run 9	Team Setup			
1530	1545		Run 10	TBD	TBD	
1545	1600					
1600	1615					
1615	1630		Course Reset			
1630	1645	Team Setup				
1645	1700	Run 11	Course Cleanup			
1700	1715					
1715	1730					
1730	1745					
1745	1800					
1800	1815	Course Cleanup				
1815	1830					
1830	1845					
1845	1900	Depart				

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## 5. Location

The SubT Challenge Tunnel Circuit will be held at the NIOSH Safety Research Coal Mine and Experimental Mine in Pittsburgh, Pennsylvania.

[NIOSH Safety Research Coal Mine and Experimental Mine](#)

626 Cochran Mill Road  
Pittsburgh, PA 15236

Teams are not allowed to use or visit the NIOSH site from the publication date of this document, until the completion of the Tunnel Circuit. Teams are also not permitted to contact NIOSH for information related to the SubT Challenge or the mines. All questions about NIOSH or Tunnel Circuit are to be sent to [SubTChallenge@darpa.mil](mailto:SubTChallenge@darpa.mil).

## 6. Enrollment

Teams are limited to 20 members in attendance at Tunnel Circuit. Each individual participant must enroll by 2359 EDT on Wednesday, June 19, 2019. Qualified Teams will be emailed a link to the enrollment website. Team leads must enroll their Systems as part of their individual enrollment. Systems enrollment will require details on the equipment a team is bringing to Tunnel Circuit and will require both technical details on the platforms as well as descriptions of the team for use in public communications.

## 7. Team Orientation

All enrolled team members are required to attend the Team Orientation from 1700–1900 on Thursday, August 15, 2019 at the Sheraton Pittsburgh at Station Square. Check-in for the orientation will begin at 1600.

[Sheraton Pittsburgh at Station Square](#)

300 W Station Square Drive  
Pittsburgh, PA 15219

The [Station Square Parking Garage](#) is located directly across the street from the Sheraton for a fee of \$6 for up to three (3) hours of parking.

During the Team Orientation, teams will receive:

1. Overview for the Tunnel Circuit
2. Information on move-in and move-out procedures
3. Challenge details
4. Safety brief

## 8. Team Garages

Teams will be provided a defined open work space in Building 152 as their Team Garage for their time at Tunnel Circuit. Each space will be approximately 40 feet (12.2 m) long x 12 feet (3.6 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 eight (8) tables and twenty (20) chairs. No computers, monitors, or power distribution equipment will be provided. Building 152 is equipped with fans; however, the August weather plus extra bodies and equipment in the space is expected to make the building warm. It is suggested that teams bring their own

fans with them to make their space more comfortable for working. Portable air conditioning units are not permitted.

Team Garages may be used for ground robot operations as long as operations are deemed safe as determined by Competition Staff and such operations do not interfere with adjacent teams. Teams operating drones or other aircraft should note that such aerial vehicles are not permitted to launch or fly in the Team Garage areas. DARPA will not be controlling wireless interference in the Team Garages.

DARPA will provide power to the teams in two (2) locations: in the Team Garages and in the course Staging Areas. In the Team Garages, there will be one (1) 120V, single-phase, 20A circuit, and in the Staging Areas, there will be a generator providing 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 1st.

Teams are only permitted in the Staging Areas 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 152 to answer questions or assist with on-site issues. Teams are not required to be in their Team Garages for any set times and may consider utilizing off-site locations for practice or development purposes.

## 9. Practice Area

Each team will have an optional scheduled slot every day in a practice area, also within Building 152. The room is approximately 30 feet (9.1 m) long x 30 feet (9.1 m) wide and 16 feet (4.9 m) in height. In the practice area, 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 that is responsible for preserving the safety of personnel and property during all practice runs. No personnel are permitted to be inside the practice area while robots are active. A netted area is provided for team personnel to operate and monitor their active systems. Details of the practice area schedule will be distributed at Team Orientation and then updated and distributed in real-time to reflect any schedule changes.

## 10. E-Stops

DARPA has established a set of emergency stop (E-Stop) requirements to ensure the safety of personnel, equipment, and the Circuit 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 Tunnel Circuit 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 \(Tunnel Circuit\)](#) document.

During the Team System Checkout, 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 may be required to use their first scheduled scored run to complete this task.

## 11. Course Walking Tour

At the end of the event, team members will be given a short walking tour of the mine to see the competition course firsthand. Up to four (4) members from each team will be permitted to participate in the course tour which is expected to be less than sixty (60) minutes including the safety briefing. Walking tour participants are prohibited from bringing any cameras or sensors of any kind (e.g., cell phones). [Team members planning on going on the course walking tour will need to provide their own steel-toed boots.](#)

## 12. Travel

[The Pittsburgh International Airport \(PIT\)](#) is the closest major airport and is about a 40-minute drive to NIOSH. PIT has non-stop service on 16 airlines to various destinations throughout the United States and abroad.

## 13. Area Maps

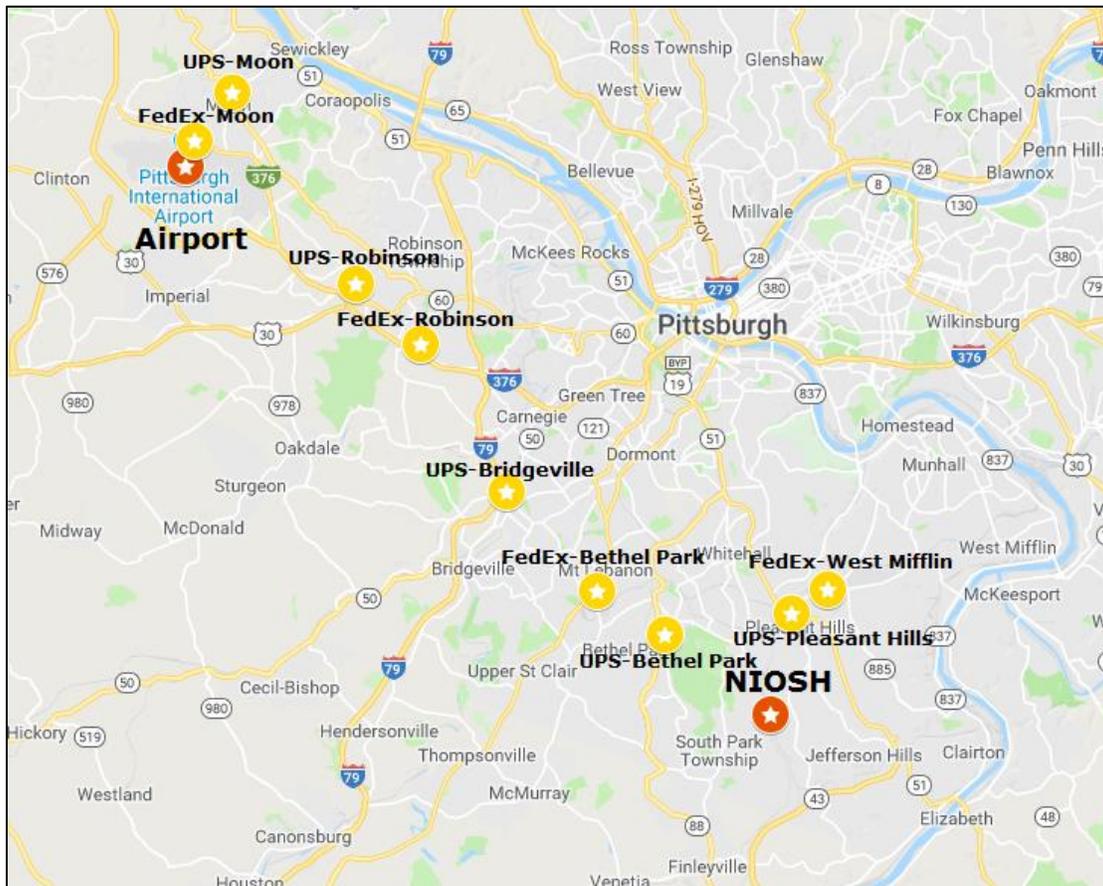


Figure 2: Pittsburgh Area Map with Key Locations

## 14. Lodging

Teams are responsible for making their own hotel reservations. Local hotels and distances to NIOSH 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 NIOSH
<a href="#">Comfort Inn West Mifflin</a>	1340 Lebanon Church Rd, West Mifflin, PA 15122	412-653-6600	4.0 miles
<a href="#">Extended Stay West Mifflin</a>	1303 Lebanon Church Rd, West Mifflin, PA 15241	412-650-9096	4.2 miles
<a href="#">Holiday Inn Express &amp; Suites West Mifflin</a>	3122 Lebanon Church Rd, West Mifflin, PA 15122	412-469-1900	5.7 miles
<a href="#">Crowne Plaza Pittsburgh South</a>	164 Fort Couch Rd, Pittsburgh, PA 15241	412-833-5300	6.6 miles
<a href="#">Hampton Inn West Homestead</a>	301 West Waterfront Dr, West Homestead, PA 15120	412-462-4226	10.7 miles
<a href="#">Holiday Inn Express &amp; Suites Pittsburgh East</a>	658 East Waterfront Dr, Munhall, PA 15120	412-205-3904	10.7 miles
<a href="#">Courtyard Pittsburgh West Homestead</a>	401 West Waterfront Dr, West Homestead, PA 15120	412-462-7301	10.7 miles

## 15. Move-in/Move-out

Due to NIOSH security requirements, teams will move into NIOSH areas on a staggered schedule starting at 0800 EDT on Friday, August 16, 2019. [A detailed move-in schedule is provided below.](#) Move-in times will also align with a safety and network check schedule so teams are requested to arrive on time but not more than five (5) minutes before their assigned time slot. All team members must have government-issued photo identification with them as well as their SubT Challenge badge distributed at the Team Orientation.

0800 – 0830	Robotika/Coordinated Robotics
0830 – 0900	CTU-CRAS
0900 – 0930	CRETISE
0930 – 1000	NCTU
1000 – 1030	MARBLE
1030 – 1100	CoSTAR
1100 – 1130	CSIRO Data61
1130 – 1200	CERBERUS
1200 – 1230	PLUTO
1230 – 1300	Explorer

Team operations on site must conclude no later than 1900 each day. After completion of the Tunnel Circuit each team must return their workspace to its original condition and check out with DARPA staff before departure.

## 16. On-site Parking

Each team is permitted to bring up to six (6) total vehicles to NIOSH to include a combination of both passenger vehicles to get team members on and off site and a utility vehicle for equipment move-in and move-out. Parking passes will be distributed to the identified team leader at Team Orientation.

## 17. Transporting Equipment

All team equipment should be transported to their Team Garage at NIOSH via one (1) team rented or owned vehicle. Upon arrival to the NIOSH main gate, all equipment will be inspected by NIOSH security. After completion of the inspection, the team utility vehicle should be brought to the Team Garage (Building 152) to unload equipment. Once all equipment has been off-loaded, the vehicle must be moved to the Team Parking Lot. Teams will not be allowed to use their own vehicles for transport of systems or team members between the Team Garages and the Staging Areas. Teams will be provided a detailed site map at Orientation and staff members will be present to help direct teams.

## 18. 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 NIOSH facility. Due to liability reasons, NIOSH 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 Airport	Distance to NIOSH
FedEx Ship Center – Moon	2000 Halverson Rd, Building 2, Moon, PA 15108	800-463-3339	5.7 miles	26.5 miles
FedEx Ship Center – Robinson	600 Vista Drive, Pittsburgh, PA 15205	800-463-3339	10.8 miles	17.1 miles
FedEx Print & Ship Center – Bethel Park	1720 Washington Rd, Pittsburgh, PA 15241	412-835-4005	21.2 miles	6.0 miles
FedEx Print & Ship Center – West Mifflin	2033 Lebanon Church Rd Suite A, West Mifflin, PA 15122	412-650-9800	25.9 miles	4.8 miles
The UPS Store – Moon	5990 University Blvd, Moon, PA 15108	412-264-9333	7.4 miles	25.5 miles
The UPS Store – Robinson	1525 Park Manor Blvd, Pittsburgh, PA 15205	412-787-5912	8.8 miles	19.9 miles
The UPS Store – Bridgeville	1597 Washington Pike A38, Bridgeville, PA 15017	412-446-2777	17.3 miles	10.8 miles
The UPS Store – Bethel Park	5225 Library Road South Park Shops Bethel Park, PA 15102	412-854-5955	23.8 miles	4.0 miles
The UPS Store – Pleasant Hills	10 Old Clairton Rd #12A, Pittsburgh, PA 15236	412-653-8020	25.1 miles	3.6 miles

## 19. Operational Considerations

The NIOSH Safety Research Coal Mine and Experimental Mine is purposefully designed and used for experimentation with existing and emerging technologies. However, 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 Tunnel Circuit.

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 mine 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 mine. Some useful resources can be found at <https://arlweb.msha.gov/techsupp/commoandtracking.asp>.

Teams may only conduct flight operations at two locations at NIOSH: the practice area within Building 152 and the competition course including the Staging Area.

For teams looking to power their systems with fuel-based solutions, please note that diesel and liquid propane may be approved in small quantities for operations inside the mine, but are not permitted for operations at the Team Garages or practice area. Note, fuels such as JP-8, avgas, and standard unleaded are not permitted in the mine.

## **20. Safety**

A safety brief will be provided by DARPA at the Team Orientation. No manual physical intervention or entry by any (human) team members on the course will be permitted, except for the course walking tour at the end of the event. Only trained and authorized Competition Staff personnel will be allowed to enter the course preceding, during, and following any course runs.

Teams will be required to provide an overview of their systems to the DARPA Competition Staff during their Team System Checkout on Move-in day. Teams will be required to bring at least one of each platform to the Staging Area and describe the operation, safety, and recovery methods of their platforms.

Closed-toed shoes, reflective safety vests, hard hats, and protective eyewear will be required to be worn in the Staging Areas and practice area at all times. All personal protective equipment (PPE) will be provided by DARPA but teams are responsible for bringing their own closed-toed shoes. Any additional PPE required for the course walking tour will be provided by DARPA, with the exception of steel-toed boots. Team members planning on going on the course walking tour will need to provide their own steel-toed boots.

## **21. Security**

The NIOSH facilities will be gated after event hours. Teams are still encouraged to secure their equipment at the end of the day in their Team Garage or return their equipment to their hotel for overnight storage.

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.

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

DARPA intends to capture photographs and video during Tunnel Circuit for use in future 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. Teams may collect video and photographs of their systems operating within the Staging Areas 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 Tunnel Circuit. DARPA Public Affairs will assist in coordinating team interviews with media outlets and will provide additional details in the coming months.

## **23. Food**

Food trucks may be made available on site for purchase of food and beverage. Teams are encouraged to bring food with them each day or plan to utilize the on-site vendors to minimize the number of trips through the NIOSH security gate.

## **24. Weather**

The weather in Pittsburgh during mid-August has an average high of 82°F (28°C), low of 64°F (18°C), and averages approximately 2.8 inches of precipitation during the month. While the courses are underground, the movement between Team Garages and Staging Areas is outdoors and periods of rain are possible. The DARPA team will be monitoring weather and may temporarily halt operations due to rain or inclement weather. Participants should be prepared for all types of weather by bringing sun screen, hats, umbrellas, and rain jackets.