
# Qualification Guide

**Revision 6**

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**Defense Advanced Research Projects Agency**
Tactical Technology Office
675 North Randolph Street
Arlington, VA 22203-2114

# 1. Introduction

This document describes the qualification guidelines and submission instructions for the DARPA Subterranean (SubT) Challenge. Prospective teams are required to demonstrate appropriate safety measures and baseline performance capabilities to be eligible to participate in events. All teams in both competitions (Systems and Virtual) must qualify for each event including the SubT Integration Exercise (STIX), Circuit Events, and Final Event. This document covers the qualification requirements for the Final Event of the competition.

DARPA encourages teams to submit their qualification materials as soon as possible. Failing a previous qualification attempt from the Circuits Stage does not preclude a team from resubmitting a qualification submission for the Final Event. DARPA may adjust the qualification rules for each event.

This document supersedes the *SubT Challenge Qualification Guide Revision 5* document dated July 30, 2020. Significant revisions in this document are indicated by blue text. This document is subject to change and may be superseded by later versions. The latest official versions of all documents will be posted to the SubT Challenge website and the SubT Community Forum.

# 2. Qualification Schedule

The Systems Competition and Virtual Competition have concurrent and coordinated Circuit and Final events. The Circuits Stage included three Circuit events (a.k.a. the Tunnel Circuit, Urban Circuit, and Cave Circuit).

## 2.1. Team Qualification

Teams wishing to qualify must submit a narrative description of their approach and complete a set of qualification tasks. The Team Qualification deadline for Systems Competition teams is April 21, 2021, five months before the Final Event. The Team Qualification deadline for Virtual Competition teams is June 29, 2021, one month before the submission deadline for Final Event. The purpose of the Team Qualification is to demonstrate that a team has baseline performance capabilities necessary to be successful in the SubT Challenge competition events.

For Systems Competition teams, at least one robotic platform must successfully complete the qualification tasks listed in Section 4. If a team successfully qualifies for the Final Event, additional robotic platforms may then be qualified up until the Platform Qualification deadline as described in Section 2.2. To be eligible for the later Platform Qualification deadline, all possible platform types that are expected to participate in the competition event must be disclosed in the narrative description as part of the Team Qualification submission. Teams are encouraged to qualify as many of their robotic platforms as possible in their initial Team Qualification submission to improve the competitiveness of their submission.

All qualification materials should be submitted via the SubT Challenge Team Portal.

### 2.2. Platform Qualification

For teams that successfully qualified for the Systems Competition, robotic platforms that were not qualified during Team Qualification may be resubmitted for qualification by the platform qualification deadline which is 3 months before the Final Event. Platform qualification submissions should include an updated narrative description and demonstration videos of the platforms successfully completing the qualification tasks listed in Section 4. All qualification materials must be submitted via the SubT Challenge Team Portal.

### 2.3. Qualification Deadlines

Qualification submissions must be submitted no later than the listed deadlines to be eligible to participate in the Final Event. DARPA will review the submissions and notify teams of qualification status within 10 business days after the qualification deadline. Teams are encouraged to submit their materials well in advance of the qualification deadlines. DARPA may elect to request additional information, discuss a team's submitted materials via teleconference, or arrange a site visit.

| Systems Event | Team Qualification | Platform Qualification | Event Date |
|---|---|---|---|
| **STIX** | December 21, 2018 | December 21, 2018 | April 5-11, 2019 |
| **Tunnel Circuit** | April 22, 2019 | July 1, 2019 | August 15-22, 2019 |
| **Urban Circuit** | December 3, 2019 | January 17, 2020 | February 18-27, 2019 |
| **Cave Circuit** | – | – | – |
| **Final Event** | April 21, 2021 | June 21, 2021 | September 21-23, 2021 |

*Table 1: Systems Competition qualification deadlines*

| Virtual Event | Team Qualification | Event Submission Deadline |
|---|---|---|
| **STIX** | N/A | June 10, 2019 |
| **Tunnel Circuit** | June 10, 2019 | October 9, 2019 |
| **Urban Circuit** | January 3, 2020 | January 30, 2020 |
| **Cave Circuit** | September 15, 2020 | October 15, 2020 |
| **Final Event** | June 29, 2021 | July 29, 2021 |

*Table 2: Virtual Competition qualification deadlines*

## 3. Systems Team Qualification

To qualify for the Systems Competition, teams must complete a set of qualification tasks and submit a narrative description of their approach. Submissions will be reviewed for validity and qualifying competitors will be notified within 10 business days after the qualification deadline.

It is anticipated that **up to** 15 teams may successfully qualify for the Final Event. DARPA will review all of the materials submitted by the Team Qualification deadline before finalizing the number of qualified teams for the Final Event.

DARPA will use the narrative description to evaluate the team's overall approach and potentially inform additional follow-up questions and/or tasks. The narrative description must include the following sections:

**Part 1: Team Information**

- Team Name
- Team Organization(s)
- Team Point-of-Contact (name, email, phone number)
- Team Roster, i.e., list of all team members and their affiliations
- Team Email Distribution List

**Part 2: Technical Approach** (500 words max per subsection)

- **Autonomy:** high-level software architecture, human interfaces
- **Perception:** sensors, software, degraded sensing approach
- **Networking:** hardware, software, radio frequency spectrum
- **Mobility:**
    - Number of platforms, types of platforms
    - Fuel sources, safety considerations
    - Platform types being qualified in this submission
    - Platform types expected to be qualified before the platform qualification deadline

**Part 3: Demonstration Videos**

- Links to unlisted YouTube videos
- Short descriptions of each video (100 words max per video)

The demonstration videos must include at least the qualification tasks listed in Section 4 but may also include additional videos that the teams feel will support their submission. Videos from SubT Challenge competition events may be included if they demonstrate the requested qualification tasks. Demonstration videos are required for each different type of mobile platform. For platforms with multiple configurations (e.g., different payloads), teams may select a representative platform to use in all of the demonstration videos. Other variants of that platform type should be listed in the "Mobility" section of the narrative description.

Based on the original submission, DARPA may choose to request additional demonstration videos, a follow-up teleconference, or in-person visit to a team's site. Teams should be prepared for possible visits, if needed. Only materials received by the qualification deadline will be considered.

Any significant changes in technical approach after initial qualification must be disclosed to DARPA and approved in advance of each event. Examples of significant changes could include

different communications hardware, frequency bands, and/or platform type. DARPA may require additional demonstrations and/or safety inspections before a new platform type may be used in a competition event.

All qualification materials must be submitted via the SubT Challenge Team Portal. The narrative description should include links to any videos that are intended to be included as part of the submission. All videos should be posted to YouTube with the privacy setting set to "Unlisted." Narration of the videos is allowed.

# 4. Systems Qualification Tasks

To qualify, teams must demonstrate their robot systems performing the following tasks.

## 4.1. Emergency stop

Teams must demonstrate emergency stop capability for all mobile assets. All systems participating in the SubT Challenge Systems Competition must utilize a complementary three-tiered emergency stop system as described in the *SubT Challenge Competition Rules* document.

**Tier 1 – Team Wireless E-Stop:** All mobile platforms must have a remote emergency stop capability that can be activated through the team's base station and/or portable wireless transmitter.

**Tier 2 – Recovery Wireless E-Stop:** Teams must integrate a DARPA-defined emergency stop receiver on all mobile platforms weighing more than 0.5 kg. Qualifying teams are responsible for purchasing and configuring their own Tier 2 E-Stop receiver for qualification purposes. The module specifications and configuration guidelines for the Tier 2 E-Stop are detailed in the *Transponder and Emergency Stop Integration Guide*.

**Tier 3 – On-Platform E-Stop:** Teams must integrate at least one physical emergency stop button on each platform that weighs more than 10 kg.

Additional details and requirements for the three-tiered emergency stop system are provided in the *SubT Challenge Competition Rules* document.

The demonstration videos should show the successful integration of all three tiers of the emergency stop system for each platform type. The wireless emergency stop videos must show a simultaneous view of both the platform and the emergency stop interface.

## 4.2. Mobility

Each type of mobile platform must demonstrate **autonomously** traversing a course with a distance of at least 25 meters. Only sensors that are operational in subterranean environments may be used (e.g., no GPS). The demonstration video should show the platform traversing the course. The video can be from the platform's point-of-view, a third-person point-of-view, or both.

If relevant, teams are encouraged to include a second video that shows a simultaneous view of the supervisor interface. Teams are not required to show operation of multiple instances of the same platform type.

For ground systems, the movement must be over uneven terrain to include dirt, gravel, and grass. The course should include at least two 90-degree turns, and at least one constrained passage. The constrained passages should be no more than 1.2 m wide and at least 3 m long. Alternatively, teams with larger systems may demonstrate a constrained passage that is no more than twice as wide as the platform width and at least five times as long as the platform length.

For aerial systems, the video must show takeoff, **autonomous** traversal, and landing. The course should include at least two ninety-degree turns. The video should also include traversal of a constrained passage, either as part of the 25 m course or as a separate demonstration. The constrained passage should be no more than 1.5 m wide, no more than 1.5 m high, and at least 3 m long. Alternatively, teams with larger systems may demonstrate a constrained passage that is no more than twice as wide and twice as high as the maximum platform width. The maximum platform width is defined as the wingspan for fixed-wing platforms and the minimum diameter that encompasses all propellers for multirotor platforms.

Hybrid air-ground systems are required to demonstrate both modes of operation.

Marsupial systems are required to separately qualify each platform. Additionally, teams are encouraged to include demonstration videos showing safe deployment.

**Supplemental Tasks:** DARPA encourages submissions that also include video demonstrations of the following capabilities. It is anticipated that these capabilities may be necessary to be competitive in the Final Event.

- UGVs: Autonomous traversal of stairs
- UAVs: Autonomous traversal of stairs and/or vertical shafts

For any special-case considerations (e.g., other mobility types, teleoperation-based deployment), teams may send inquiries to SubTChallenge@darpa.mil to ask for an appropriate mobility task.

## 4.3. Perception

At least one platform must demonstrate the ability to **autonomously** identify artifacts while navigating no-light environments (only onboard illumination allowed). Only sensors that are operational in subterranean environments may be used (e.g., no GPS). Teams must provide videos of their system navigating between at least two rooms and identifying **all** of the artifacts from the Circuits Stage: the three common artifacts and all six event-specific artifacts as described in the *Artifacts Specification* document. The rooms should be connected by a hallway that is at least 10 m long and includes at least one constrained passage (e.g., doorway) with a minimum cross section of no larger than 2.25 $m^2$. Teams with larger systems may use the constrained passage dimensions described in the previous section.

The demonstration video should show the platform traversing the course (even if it is difficult to see due to lack of lighting). The video can be from the platform's point-of-view, a third-person point-of-view, or both. If relevant, teams are encouraged to include a second video demonstrating the mapping capabilities of the platform.

**Supplemental Tasks:** DARPA encourages submissions that also include video demonstrations of the following capabilities. It is anticipated that these capabilities may be necessary to be competitive in the Final Event.

- Multimodal sensing of artifacts
- Demonstration of 3D mapping capabilities
- Demonstration of the Human Supervisor interface

For any special-case considerations, teams may send inquiries to SubTChallenge@darpa.mil to ask for an appropriate artifact task.

# 5. Virtual Team Qualification

To qualify for the Virtual Competition, teams must complete the relevant qualification scenario and submit a narrative description of their approach. DARPA will use the narrative description to evaluate the team's overall approach and potentially inform additional follow-up questions and/or tasks. The narrative description must include the following sections:

**Part 1: Team Information**

- Team Name
- Team Organization(s)
- Team Point-of-Contact (name, email, phone number)
- Team Roster, i.e., list of all team members and their affiliations
- Team Email Distribution List

**Part 2: Technical Approach** (500 words max per subsection)

- **Autonomy:** high-level software architecture, navigation and search functions
- **Perception:** sensors, mapping, artifact detection
- **Networking:** communication approach, multi-robot coordination
- **Workflow:** software development workflow, laboratory/computing resources
- **Robots:**
  - Number of platforms, types of platforms
  - Platform types used in the qualification submission
  - Platform types expected to be used in the competition submission

The narrative description should be submitted via the SubT Challenge Team Portal. You are welcome to attach a document with any diagrams, video clips, or images to support your narrative. Responses are expected to provide sufficient detail to differentiate your approach from other similar approaches.

At its discretion, DARPA may choose to arrange a follow-up teleconference to discuss a team's submission and/or request additional details about the submission to aid in the review. Only materials received by the qualification deadline will be considered. DARPA retains the right to approve or deny qualification to teams upon review of any submitted materials.

# 6. Virtual Qualification Scenario

To qualify, teams must demonstrate their Team Configuration – chosen from the models available in the SubT Tech Repo – successfully completing the relevant qualification scenario. The qualification scenario will consist of a reduced-scale virtual environment with artifacts distributed throughout the environment. As described in the *SubT Challenge Competition Rules* document, team configurations are limited by a maximum allowable budget of 1,000 "SubT Credits."

For each Circuit and the Final Event, qualifying teams must successfully complete the corresponding qualification scenario. Teams must submit their solutions through the SubT Virtual Portal in the form of a Docker image or series of Docker images against the qualification scenario. Instructions and resources for how to build Docker image(s) and submit solutions are available on the How to Compete page of the SubT Virtual Portal.

Submissions will be reviewed for validity and qualifying competitors will be notified within 10 business days after the qualification deadline. Submissions will be evaluated on AWS resources in the Cloudsim environment; simulation log files are provided to competitors through the SubT Virtual Portal. The Qualification Scenario will be released in advance so that competitors can also practice locally. Competitors will be able to submit their Docker solutions against the Qualification Scenario as many times as required to qualify before the deadline.

The qualification scenario will require submitted solutions to demonstrate basic navigation and obstacle detection to maneuver through the course. It may include both lighted and dark passages. DARPA expects to distribute 20 artifacts throughout the environment. To achieve the minimum score threshold, teams will need to accurately locate and successfully report **at least one artifact** within one hour of simulation time. The submitted runs must be completely autonomous without any human inputs or teleoperation. Vehicles in the submitted scenario will only be able to utilize the networking model provided through the SubT Simulator to communicate.

# 7. Prospective Competitor's Qualification Checklist

- ❑ STEP 1: Register your team by submitting the official online Team Registration Form
- ❑ STEP 2: Submit your online Team Qualification materials
- ❑ STEP 3: Respond to any feedback/inquiries from the DARPA SubT Challenge team
- ❑ STEP 4: Wait to receive final notification from DARPA on your qualification status

Then what?

- ❑ Join the SubT Community Forum and share with the SubT community!
- ❑ Prepare your team and technologies for an exciting SubT Challenge event!