Qualification Guide

Revision 2
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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 Exercises (STIX), Circuit Events, and Final Event. This document only covers the qualification requirements for the Circuits Stage of the competition. Details on how to participate in the Finals Stage will be provided at a later date.

DARPA encourages teams to submit their qualification materials as soon as possible. Failing a previous qualification attempt does not preclude a team from resubmitting a revised qualification submission, subject to qualification deadlines for any given event. DARPA may adjust the qualification rules for each event and may consider qualification waivers for teams that have successfully participated in a prior STIX or Circuit Event.

This document is subject to change and may be superseded by later versions.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

In the Circuits Stage, the Systems Competition includes three Circuit events (a.k.a. the Tunnel Circuit, Urban Circuit, and Cave Circuit) and at least one SubT Integration Exercise (STIX) event. The Virtual Competition will have concurrent and coordinated Circuit events but will not have a separate STIX event.

Qualification submissions will be accepted on a rolling basis but must be submitted no later than 100 days before each event to be eligible to participate in the event. DARPA will review and respond within 30 days of receiving materials for the Systems Track and within 15 days for the Virtual Track. DARPA may elect to request additional information, discuss a team's submitted materials via teleconference, or arrange a site visit.

Event	Tentative Date	Systems Track Qualification Deadline	Virtual Track Qualification Deadline
SubT Integration Exercise #1	April 2019	December 21, 2018	N/A
Tunnel Circuit	August 2019	April 22, 2019	June 10, 2019
Urban Circuit	February 2020	October, 2019	November, 2019
Cave Circuit	August 2020	April, 2020	May, 2019
SubT Integration Exercise #2	February 2021	October, 2020	N/A
Final Event	August 2021	April, 2021	May, 2019

3. Systems Track Submissions

Systems Track teams wishing to qualify will need to complete a set of Qualification Tasks 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
- Organization Location(s)
- Team Point-of-Contact (name, email, phone number)
- List of all team members and their affiliations

Part 2: Technical Approach (500 words max per sub-section)
- **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

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. 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.

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 STIX or Circuit Event.

All submissions should be sent as a Word document or PDF to the SubT Challenge email address (SubTChallenge@darpa.mil). 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 Track Qualification Tasks

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

4.1. Emergency stop

Teams must demonstrate emergency stop capability for all mobile assets. All mobile platforms must contain a remote emergency stop capability that can be activated through the operator console or other remote device. In addition, for all platforms over 10 kg, an easily accessible on-platform physical emergency stop switch must be present and demonstrated to work. The Emergency Stop must include clear visual feedback of the platform's safe power-off state. The platforms must enter a safe power-off state if either the onboard physical or remote wireless emergency stops are activated. 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, 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 will need to demonstrate both modes of operation. For any other mobility types or special-case considerations, teams may send inquiries to SubTChallenge@darpa.mil to ask for an appropriate mobility task.

4.3. Artifacts

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 at least three of the candidate artifacts listed in the SubT Competition Guidelines 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.

5. Virtual Track Submissions

Virtual Track teams wishing to qualify will need to complete the 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
- Organization Location(s)
- Team Point-of-Contact (name, email, phone number)
- List of all team members and their affiliations

Part 2: Technical Approach (1000 words max): Describe the overall technical approach to performing the mapping, navigation, and search functions described in the SubT Challenge Guidelines document. What is the high-level architecture of the software? What is the software development workflow? What laboratory and/or computing resources will be utilized?

Teams must also demonstrate that they can successfully complete the Qualification Scenario in order to qualify for a given Circuit event. Upon completing the Qualification Scenario, teams will submit a log file from the successful run. 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.

Submissions will be in the form of a zip file containing the team's narrative description and log files of their solution completing the corresponding Qualification Scenario. Submissions will be reviewed for validity within 15 days of being received. Log files may be produced using cloud resources, if desired and available, but will also be accepted from local instances of the SubT

Virtual Testbed environment. Submissions will be uploaded through the SubT Virtual Portal. Instructions on how to generate log files will be available by November 16, 2018 at https://bitbucket.org/osrf/subt/wiki/tutorials/qual.

6. Virtual Track Qualification Task

To qualify, teams must demonstrate their Team Configuration, chosen from the models available in the SubT Tech Repo, successfully completing the Qualification Scenario and achieving a minimum score. The Qualification Scenario will consist of a reduced-scale virtual environment with several artifacts distributed throughout the environment. In an effort to keep the Qualification Task manageable with limited computing resources, the Team Configurations will be limited to a maximum of five platforms.

DARPA is currently composing the Qualification Scenario and expects to make it available on the SubT Tech Repo by November 16, 2018. The SubT Virtual Portal will begin accepting Virtual qualification submissions on December 1, 2018.

The Qualification Scenario will require submitted solutions to demonstrate basic navigation and obstacle detection to complete the course. It will include both lighted and dark passages. DARPA expects to distribute approximately 10 artifacts throughout the environment. To achieve the minimum score threshold, teams will need to accurately locate at least half of the artifacts within 20 minutes of simulation time.

The submitted runs must be completely autonomous without any human inputs or teleoperation. Submissions will be analyzed for use of the networking model provided through the Virtual Tech Repo as their sole means of communication. The submitted log files will also be reviewed for transmission of an artifact report back to the virtual "ground control station" from beyond line-of-sight communications range.

A submission will consist of a single zip (.zip) file that contains three files: simulation.log, subt.log, and narrative.md. The simulation.log file is a Gazebo simulation state log of the entire qualification scenario. The subt.log file contains scoring information and data pertaining to the execution of the SubT Virtual Testbed. Both simulation.log and subt.log will be generated automatically by the virtual testbed. The final file, narrative.md, should contain the narrative description detailed above using the Markdown syntax. Extra files and files with incorrect names will be ignored.