



*The Mobile
Manipulation
Challenge*

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ICRA 2019

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1 Competition Overview

Fetch Robotics is organising FetchIt!, a mobile manipulation challenge at ICRA 2019, in Montreal, QC, Canada. The goal of the competition is to have a Fetch Mobile Manipulator autonomously assemble “kits” by navigating to stations in a work cell, picking up items, operating basic machinery, placing items into kits, and transporting the finished kits to a drop-off location. The team that assembles the most kits within forty five (45) minutes wins a Fetch Manipulator Research Robot.

Competition Robot

The robot used for the competition is a Fetch Mobile Manipulator. The robot has Ubuntu™ 18.04 and ROS™ Melodic installed. Official competition robots will be provided for teams to use at the competition. Teams who have access to their own Fetch Research Platform can bring their own robot, as long as no hardware modifications have been made.

Competition Tasks

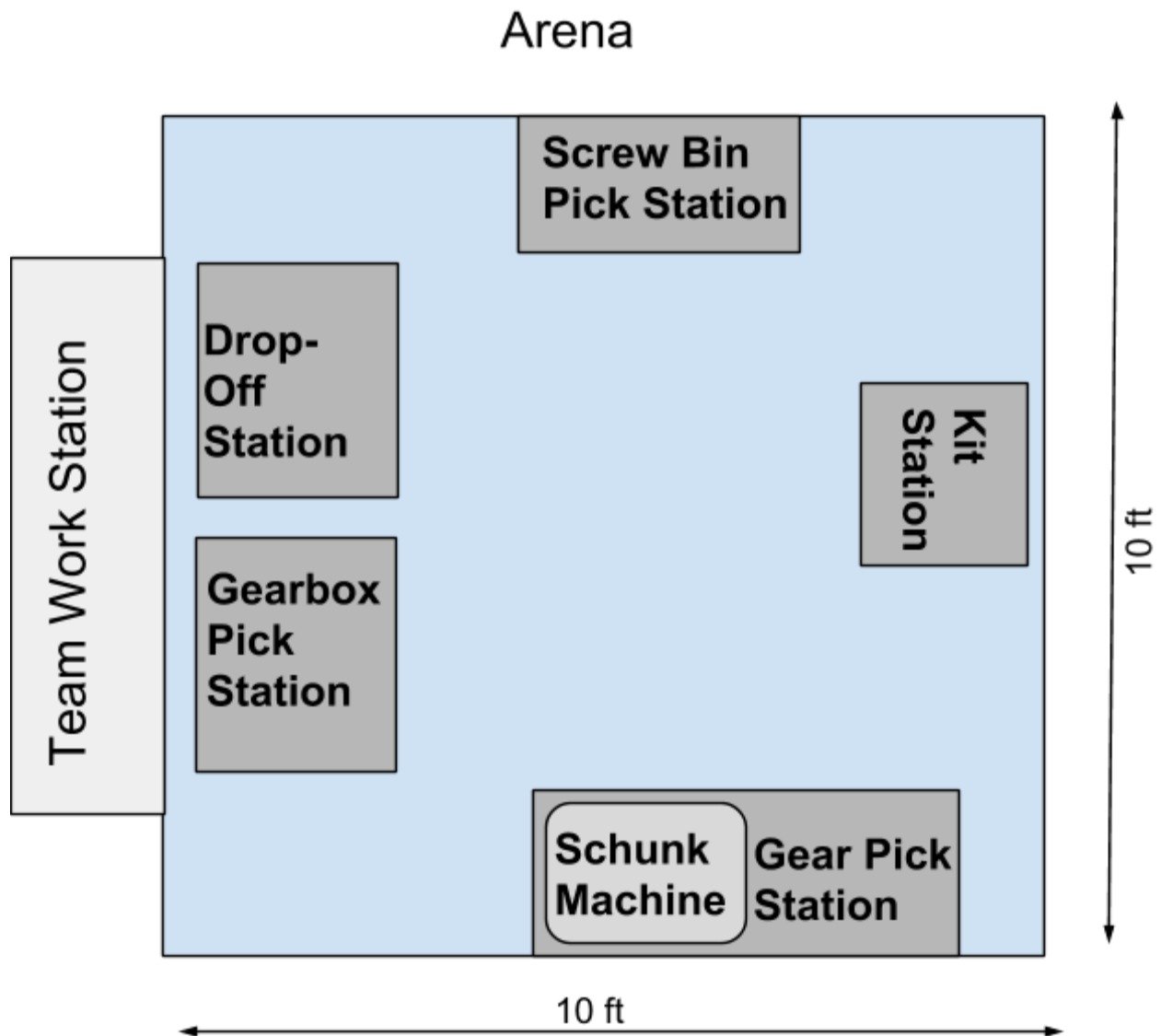
The competition focuses on autonomously completing combined manipulation, perception, and navigation tasks. The task is to assemble a kit from four objects obtained from stations around the arena. The objects may be picked from bins and require additional processing before being placed in a kit and transported to a drop-off location. Additional processing includes operating equipment through physical manipulation or a wireless interface. The challenge includes the perception of objects in the environment, successfully avoiding any collisions while manipulating and transporting the objects.

Competition Environment

The competition takes place in an arena approximately 10 feet by 10 feet in size. The arena features stations with the items and machinery the robot needs to complete the competition tasks. A map of the arena is also provided. The objects used for manipulation will be announced and provided to teams ahead of time, and will be both detectable and manipulable with the Fetch Mobile Manipulator.

The competition environment specifics will be available before the competition, along with an environment provided for Gazebo simulation. Free cloud based simulation is possible using ROS Development Studio by TheConstruct. Qualification can be done via: TheConstruct simulation, local simulation, or a real robot, using one of the parts with *any ROS version*. The minimum expected behaviour to qualify is to show a robot pick up one of the parts and place it into a bin. Qualified teams can schedule remote access to a real robot and environment located at Fetch Robotics. Email opensource@fetchrobotics.com or see our website for details.

2 Arena Setup



3 Objective & Definitions

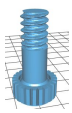
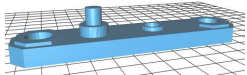
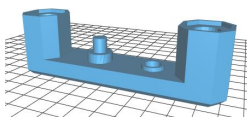
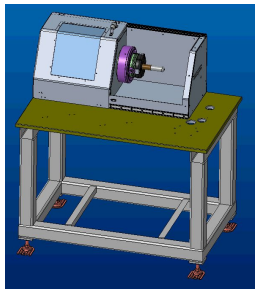
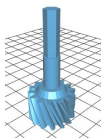
The objective is to fill as many orders (assembled kits) as possible in forty five (45) minutes. The robot can start anywhere inside the arena.

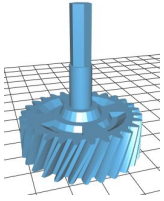
Order

An order consists of picking six (6) items from their respective locations, placing them into the provided kit, and placing the kit at the drop-off location.

Items

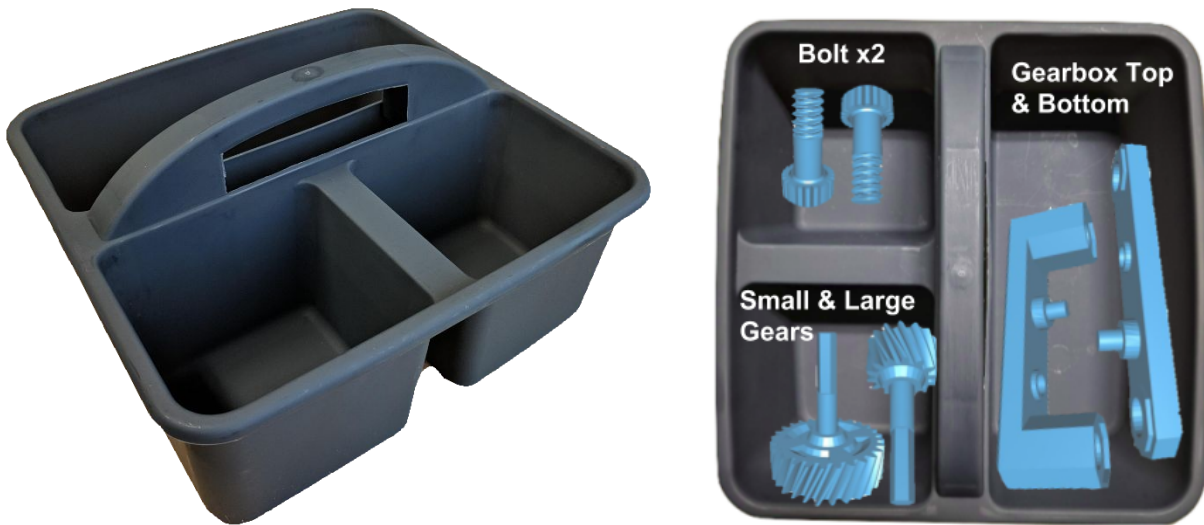
Items are 3D printed parts of a gearbox assembly. New items for kits can be found in their default location. The 3D printed parts and links to the CAD files and printer settings are also provided so teams can create their own parts for training before the competition. Models and environment are available at <https://github.com/fetchrobotics/fetchit>.

Item	Per Kit		Default Location
Kit	1		There will be kits at the Kit Station
Bin	0		The bin will start at the Screw Bin Pick Station
Bolt	2		Bolts will bin in the Bin
Gearbox Top	1		Gearbox Top will be at the Pick Station
Gearbox Bottom	1		Gearbox Bottom will be at the Pick Station
SCHUNK Machine	0		The SCHUNK machine will be at the Machine Station. This station simulates machining a part. A wireless interface to the machine will be used. The robot will place a part in the machine's SCHUNK Chuck and trigger it to close. The machine will only allow the part to be released after 2 minutes. The robot will take the part from the chuck and place the part in the kit. Before the machine will turn on, the safety door must be slid closed.
Small Gear	1		Small Gear will be next to the Machine, and must be machined.

Large Gear	1		Large Gear will be next to the machine, and just added to kit.
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At the start of each team's turn, there will be a number of items at each station. Once a station runs out of an item, it will be replenished.

Kit



Approximate Dimensions:

Length: 24 cm

Width: 24 cm

Height: 13 cm

Color will vary.

Parts must be placed into the kit in the compartments shown above. There will be a scoring penalty for parts placed in the wrong compartment of the kit (See the section on Scoring).

Stations

Kit Station

The empty kits used to deliver the parts start at this station. The kits will be on a table at the station. Kits will be approximately evenly spaced and not touching. Once all kits have been taken from the station, more kits will be put at the station to replace them.

SCHUNK Machine/Gear Pick Station

This station features two types of gears on a surface. The gears will be approximately evenly spaced and not touching. The robot must place the larger gear into the SCHUNK Machine located next to the gears. The SCHUNK Machine will simulate machining the part. This process will take two (2) minutes, after which the robot can retrieve the large gear from the machine and place it in the kit. In addition, the small gear must be placed into the kit. These tasks can be done in any order. If all parts of one type have been picked from this station, the parts will be replenished.

Gearbox Pick Station

At this station, the top and bottom parts for the gearbox will be in bins. The parts will be approximately evenly spaced and not touching. The robot must put one of each of the top and bottom gearbox parts into each kit. If all parts of one type have been picked from this station, the parts will be replenished.

Screw Bin Pick Station

The screws will be in a bin at this station. They may be touching and not evenly spaced. The robot must put two screws into each kit. If all parts of one type have been picked from this station, the parts will be replenished.

Drop-Off Location

This is the station where kits must be dropped off. Kits may be placed anywhere on the surface at the drop-off location. An additional point will be awarded for placing the kit in a smaller, marked region for simulated inspection by a SICK Inspector sensor, and triggering the inspection. Once a completed kit is placed at this station, the time will be recorded and used as the total delivery time in the event of a tie (See the section on Scoring). Complete kits will be removed to make room for more kits after the robot has moved away from the Drop-Off Location.

Note: The above stations can be visited in any order, items can be placed in the kit in any order, and the kit can be moved to and filled at any station.

Time

Each team will have up to forty five (45) minutes to complete as many orders as possible. Before their turn, each team will have an hour to set up in their arena. If the team is not ready to start on time, they can have an additional five (5) minutes of setup time, at the expense of one (1) point. This penalty is applied at the end of a total run, and isn't cleared during a do-over.

During the forty five (45) minute competition, the team is allowed one do-over. They can restart the competition, resetting the environment and robot, but not the time. This do-over will wipe penalties from dropped items and collisions, but not late start penalties.

Team Interaction

The Team is not allowed to enter the arena during the competition run. Additionally, they are not allowed to interact with the robot via any means during the competition run.

4 Scoring

Only full kits delivered to the drop-off station count towards the score. The panel of judges will be comprised of experienced roboticists, and their decisions are final.

Action	Points
Full kit delivered (all 6 items and kit at drop-off station)	7
Delivering the kit to SICK Inspector, and trigger inspection	+1
Dropped Item	-1
Collision with Environment (minor)	-1
Kit delivered with extra item(s)	-1 (per extra item)
Kit delivered with item in incorrect section of kit	-1 (per misplaced item)
Kit delivered with item(s) missing	0

Example: One full delivery (with no missing items) is worth seven (7) points. If one item is dropped during the run (assuming a replacement was then successfully placed in the kit), then the final score would be six (6).

Example: Partially completed kits are worth zero (0) points. If a team starts by delivering three (3) empty kits to the final station to fill there, but time runs out, and only one kit is complete, and no items were dropped, the final score would be seven (7).

Example: Misplaced items are worth -1 points and extra items are worth -1 points. These penalties can compound. A kit delivered with an extra gear in the wrong section of the kit will incur a penalty of -2 points and be worth 5 points.

Dropped parts

If a robot drops an item or the kit on the floor of the arena, the robot is expected to avoid the dropped part while navigating. The penalty for dropped parts is one (1) point per item. If an full kit is dropped, this is seven (7) points in total (six (6) items and the kit). Dropped items, at the discretion of the judges, will be cleared once the robot is a safe distance from the item.

Collisions with Environment

Collisions between the Robot and the Environment will result in deduction of points. Soft/Controlled Collisions between the end effector and the environment during manipulation is accepted at the judges' discretion.

If there is an uncontrolled collision with the environment that does not result in damage to the environment, the penalty is one (1) point, at the judges' discretion. If the collision results in damage to the environment or the robot, or if the robot has to be emergency stopped (at the judges' discretion) then the team must use their do-over see the Time section above. If no do-overs are left, the robot is damaged, or the judges deem the code unsafe, the team must end their run. Any time spent repairing the robot or environment will continue to be deducted from the team's overall time slot.

Example Delivery

The robot starts at the Kit Station and picks up a kit.

The robot drives to the SCHUNK Machine Station. The robot puts the large gear into the SCHUNK Machine and closes the door. The machine runs for two (2) minutes. While the machine is running, the robot picks the smaller gear and places it into the kit. After the machine is finished, the robot retrieves the large gear from the machine and puts it into the kit.

The robot drives to the Gearbox Pick Station. The robot picks each of the gearbox parts individually and places them in the kit.

The robot drives to the Screw Bin Pick Station. The robot picks a screw from the bin at this

station. While transferring the screw to the kit, the robot drops the screw on the floor. The robot picks two (2) new screws from the bin one at a time and places them into the kit.

The robot drives to the Drop-Off Station avoiding the dropped screw. The robot places the completed kit at the Drop-Off location.

This is just an example, the stations can be visited in any order as long as the kit is filled. This would earn a team six (6) points (seven (7) points for a completed kit, minus one (-1) for the dropped part).

Note: The panel of judges will be comprised of experienced roboticists and all judges' decisions are final.

5 Winning

To win a Fetch Mobile Manipulator, a minimum score of fourteen (14) points is required. The team with the highest score above fourteen (14) points wins.

In the event of a tie, the team that made their deliveries in the shortest total time will win. Once a kit is complete and at the drop-off location, the time will be recorded. The time of the final kit delivered within a team's turn will be used as their total delivery time.

In addition, runner-up prizes will be SICK LiDAR sensors provided by SICK/EandM. Other additional runner up prizes may be added to the prizes list.

Prizes

First: Fetch Mobile Manipulation Research Robot

Second: MRS1000 4-layer LiDAR (1) and TiM561 LiDAR (1) provided by SICK/EandM

Third: MRS1000 4-layer LiDAR (1) and TiM561 LiDAR (1) provided by SICK/EandM

Other Prizes: TBD

6 The Robot

Hardware

The competition will use standard, unmodified Fetch Mobile Manipulators. Teams can bring their own Fetch Mobile Manipulator. A limited number of Fetch Mobile Manipulators will be made available on site for use in the competition and for limited use for testing before the competition, possibly as shared resources.

Software

Teams planning to use Fetch-provided robots should send a bash script to install source packages/debs/clone their slow-building repos at least two weeks ahead of the competition so their slow-building software can be pre-installed on their accounts. The Fetch-provided robots will use ROS Melodic on Ubuntu 18.04.

7 Competition Dates

May 19, 2019: Staff Setup Day

Fetch Staff will be setting up the competition space. The space will not be open to teams at this time.

May 20, 2019: Team Setup Day

Teams can setup and test their entries. Teams will be able to schedule approximately 1.5 hours each to use Fetch-provided hardware in the arena. Teams with their own hardware can also schedule 1.5 hours to use their hardware in the arena.

May 21, 2019: Competition Day 1

Teams will have one (1) hour competition slots that start at the beginning of the hour. Teams can arrive one (1) hour before their competition slot to start preparing their robot in their arena. On the hour, the team's competition turn starts. At 45 minutes after the hour, the competition slot ends, and the team vacates. The next team's turn starts on the next hour.

May 22, 2019: Competition Day 2

This works the same as the previous day, but if a team ends their run early, they will vacate the arena and not use the remainder of their time slot.

Example Schedule:

Schedule	Arena 1	Arena 2
9:00 am	Team 1 arrives and sets up their robot in the arena.	

10:00 am	Team 1's competition turn starts	Team 2 arrives and sets up their robot in the arena.
10:45 am	Team 1's turn ends and they vacate the arena.	
11:00 am	Team 3 arrives and sets up their robot in the arena.	Team 2's competition run starts.

If a team wants to end their run early, they can use the remainder of their time slot as they wish to practice or make changes ahead of their run on the second day.

ELIGIBILITY

To be eligible to enter the competition, each team member must be above the age of majority in the country, state or province of his or her residence at the time of entry. RESIDENTS OF QUEBEC, OR JURISDICTIONS WHERE THE COMPETITION IS PROHIBITED BY LAW, ARE NOT ELIGIBLE TO PARTICIPATE. Officers, directors, employees and contractors of Fetch and its affiliates, and their respective advertising and competition agencies, representatives, and agents are ineligible to participate in this competition. If the team is entering as part of or on behalf of a company, academic institution or other entity, these Official Rules are binding on each team member individually and such entity. If any team member is acting within the scope of his or her employment or as an agent of another party, each team member warrants that such party has full knowledge of and consented to the team's participation in the competition, including to the terms of these Official Rules. Each team member further warrants that participation does not violate his or her employer's policies and procedures.

ENTRY ORIGINALITY AND LICENSING

Each team member warrants that all software code entered in the competition will be the original work of the team and will not infringe or violate the intellectual property or proprietary rights of any third party, and agrees to make available all entered code to Fetch and third parties as free and open source software under the Apache 2.0, BSD, or similar license. Each team member acknowledges that the team's entry may be competitive with or similar to Fetch technology, and agrees that such team member will not be entitled to any compensation as a result of Fetch's use of any such similar or competitive technology material it develops or obtains from other sources.

PRIZE

Total Approximate Retail Value of all prizes to be awarded: \$140,000. The prize will be delivered to the recipient designated by the winning team at the time of entering the competition. No cash or other substitution of prizes is permitted, except at the sole option of Fetch and Sponsors for a prize of equal or greater value. Fetch and Sponsors will not replace any lost or stolen prizes. Winners are solely responsible for all federal, state, provincial and local taxes, if any, that apply to prizes. Winners are required to complete and submit a W-9 to Fetch or Relevant Sponsor prior to delivery of a prize. If any prize notification is returned as undeliverable, if a team does not respond within the required number of days specified by Fetch or Relevant Sponsor, or if a potential winning team decides to decline the prize for any reason, Fetch or Relevant Sponsor shall have no further obligation to such team and the applicable prize will be forfeited and may be awarded to a runner-up team.

PRIVACY AND PUBLICITY

Each team acknowledges and agrees that Fetch may collect, store, share and otherwise use personally identifiable information provided during the registration process and the competition, including, but not limited to, name, mailing address, phone number, and email address. All information collected is subject to and will be used in accordance with Fetch's Privacy Policy (<https://fetchrobotics.com/privacy-policy>) for administering the competition. Except where prohibited by law, by participating in the competition, each team member consents to the use by Fetch and its related and affiliated companies of his/her name, address (city, state), photograph, likeness, biographical information and/or statements made by or attributed to the team member (if true) relating to Fetch or to the competition for advertising, publicity and promotional purposes in any and all media now or hereafter known, worldwide in perpetuity, without further notice, permission and/or compensation.

EACH TEAM MEMBER ACCEPTS THE CONDITIONS STATED IN THESE OFFICIAL RULES, AGREES TO BE BOUND BY THE DECISIONS OF FETCH, WARRANTS THAT HE OR SHE IS ELIGIBLE TO PARTICIPATE IN THIS COMPETITION, AND AGREES TO RELEASE, INDEMNIFY, AND HOLD HARMLESS FETCH AND ITS AFFILIATES, AND THEIR RESPECTIVE OFFICERS, DIRECTORS, EMPLOYEES, REPRESENTATIVES, AND AGENTS, FROM AND AGAINST ANY AND ALL CLAIMS, LOSSES, LIABILITY, AND DAMAGES OF ANY KIND ASSERTED AGAINST ANY OF THEM, INCURRED, SUSTAINED, OR ARISING IN CONNECTION WITH THE USE, ACCEPTANCE, OR MISUSE OF THE PRIZE OR WHILE PREPARING FOR, PARTICIPATING IN, AND/OR TRAVELING TO OR FROM ANY COMPETITION-RELATED ACTIVITY, INCLUDING, WITHOUT LIMITATION, ANY PERSONAL INJURY OR PROPERTY DAMAGE, OR FROM THE RESPECTIVE TEAM MEMBER'S BREACH OF ANY AGREEMENT OR WARRANTY ASSOCIATED WITH THE COMPETITION, INCLUDING THESE OFFICIAL RULES.

IN NO EVENT WILL FETCH BE LIABLE TO TEAM MEMBERS FOR ANY DIRECT, SPECIAL, INCIDENTAL, EXEMPLARY, PUNITIVE OR CONSEQUENTIAL DAMAGES (INCLUDING LOSS OF USE, DATA, BUSINESS OR PROFITS) ARISING OUT OF OR IN CONNECTION WITH TEAM

MEMBER'S PARTICIPATION IN THE COMPETITION, WHETHER SUCH LIABILITY ARISES FROM ANY CLAIM BASED UPON CONTRACT, WARRANTY, TORT (INCLUDING NEGLIGENCE), STRICT LIABILITY OR OTHERWISE, AND WHETHER OR NOT FETCH HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH LOSS OR DAMAGE.