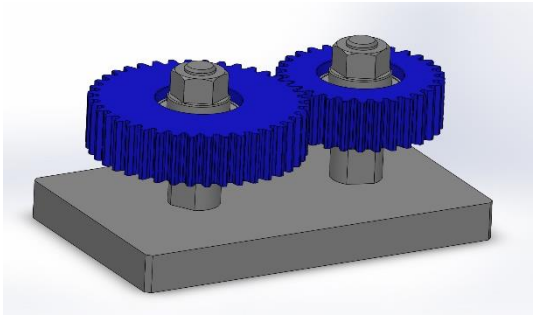
Manufacturing Track

Task 2:
Gear unit assembling

This rule is subject to change.



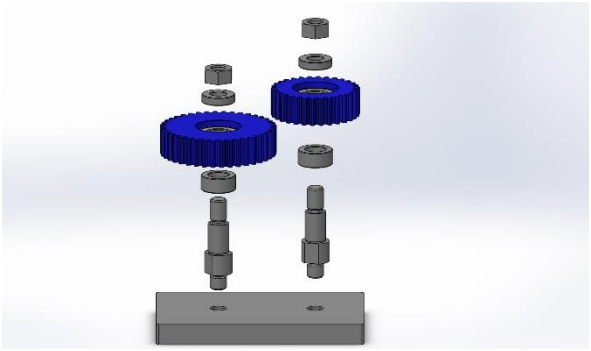
This task consists of the following three subtasks:

Subtask 1. Fasten roller bolts on the base plate
Subtask 2. Insert metal collars and gears
Subtask 3. Tighten gears with a nut

Items (for subtasks 1-3):

I. Parts

1. Base Plate: 6-Surface Milled Mounting Plates
2. Two different sized Spur Gears (30 and 40 Tooth) - Bearing Built-in Type
3. Two Cantilever Shafts
4. Two Metal Collars
5. Two Metal Washers
6. Two Nuts



II. Peripherals

1. Open end wrench (17mm)
2. Nut driver (M12)
3. Parts tray
4. Thread-lock sealant (dummy)

Assembled gear unit is shown in Figure 1. All parts are available from MISUMI. Parts list including order numbers for MISUMI is shown in Table 1. We have confirmed that parts are available from Japan, U.S.A., France, Germany, U.K., China, Korea, Thailand, and India.
Drawing of the gear unit and STL data of the parts are available at https://www.nist.gov/el/intelligent-systems-division-73500/robotic-grasping-and-manipulation-competition-manufacturing

Table 1. Parts list

Part No.	Item	Number of items	MISUMI Order
1	Base Plate	1	HFMQA-SCM-A150-B90-T15-X35-Y45-M12-L70-MA12
2	Spur Gear (30 tooth)	1	GEABDM2.0-30-20
3	Spur Gear (40 tooth)	1	GEABDM2.0-40-20
4	Cantilever Shaft	2	FXNAC15-15-F22-N12-MA12
5	Metal Collar	2	NCLM15-25-11
6	Metal Washer	2	FWSSM-D24-V12-T6
100	M12 Hex Nut	2	LBNR12

Open end wrench (17mm) and nut driver (M12) should be prepared by each team. If hand tools without any modifications are used, bonus points are added.

Part tray must be prepared by each team. Its dimensions should be within 330x250x100[mm] (length x width x height) and more than 200x120x20[mm]. There is no limitation on its color and material, but if magnetic type is used, no bonus points will be added even without fixtures.

Thread-lock sealant is artificial so that the shaft can be easily disassemble. It is a blue colored viscous liquid that replaces the contents of a bottle of Loctite 1329467 243 Blue Medium Strength Threadlockers available at Amazon (Figure 2):
https://www.amazon.com/Loctite-1329467-Medium-Strength-Threadlockers/dp/B009I2UC3Q/ref=sr_1_4?ie=UTF8&qid=1501414335&sr=8-4&keywords=LOCTITE+243
The cap of the bottle is already removed and the robot system need not open the bottle.

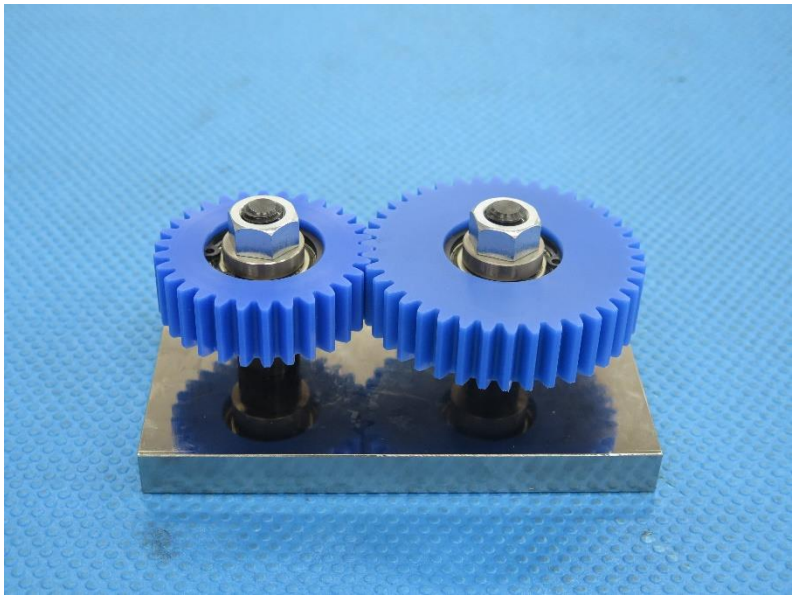


Figure 1. Assembled gear unit

Figure 2. Thread-lock sealant

(The cap will be removed in the competition.)

Gear unit assembly task has been designed as a trial task for Industrial Robotics Category, World Robot Challenge, World Robot Summit. We are considering more difficult tasks for Pre-competition in 2018 and final competition in 2020.

Gear unit assembly task will be divided by three subtasks. Each subtask starts from a given initial condition so that teams who failed to complete the previous task can move onto the next subtask. Teams may also skip some operations depending on the performance of their robot system. When skipped, manual operation would be allowed to move onto the next robotic step. The initial state can also be adjusted. Parts can be placed at predefined locations so that the robot system can pick them up blindly or the competition staff can place them at arbitrary location. The arbitrary location method requires that the robot system have functionality to automatically determine part locations.

Scoring is still tentative but basically points will be accumulated when each operation is successfully completed. Bonus points will be given if teams select difficult conditions, such as arbitrary initial locations, no fixtures, and using hand tools.

Gear unit parts will be provided to each team of the Manufacturing Track of the 2nd Robotic Manipulation and Grasping Competition, thanks to the Industrial Application Category, World Robot Challenge, World Robot Summit. The parts are also available worldwide from MISUMI with reasonable cost (approximately US$150). Using the STL data, teams can make replica parts quite easily using 3-D printers. Note that replica parts would be suitable for grasping test but would not for parts fitting test. For parts fitting practice, it is recommended to use the real parts provided from us or purchased from MISUMI.

The working area is the area where the end-effector of the robot is allowed to move. The maximum size of the working area is 2.0x2.5[m].

Assembly area is the area where the robot system can assemble the gear unit. The size of the assembly area is 0.3x0.3[m]. Teams can specify this area anywhere inside the working area. Any peripherals for assembly, such as jigs, should be inside this area. When the team wants to challenge arbitrary location of the base plate, the team should clearly indicate this area, for example by colored tape, so that the competition staff can place the base plate arbitrary inside this area.

Parts area is the area where the part tray should be located. The size of the parts area is 0.35x0.35[m]. Parts area can be specified anywhere by the team as long as it is inside the working area and no overlap with the assembly area. If a team elects the additional challenge of arbitrary location located parts, the team should clearly indicate this area, for example by colored tape, so that the competition staff can place the part tray arbitrary inside this area and place the parts arbitrary inside this part tray.

The tool area is the area where the hand tools (and thread-lock sealant) should be located. The size of the tool area is 0.2x0.3[m]. Tool area can be specified anywhere by the team as long as it is inside the working area and overlap with neither the assembly area nor parts area. If a team elects the additional challenge of arbitrary located hand tools (and thread-lock sealant), the team should clearly indicate this area, for example by colored tape, so that the competition staff can place the hand-tools (and thread-lock sealant) arbitrary inside this area. Customized tools and hands prepared by the team can be placed anywhere except inside assembly area and parts area. Tools (and thread-lock sealant) must be placed inside the tool area after their use (not necessarily at the same location).

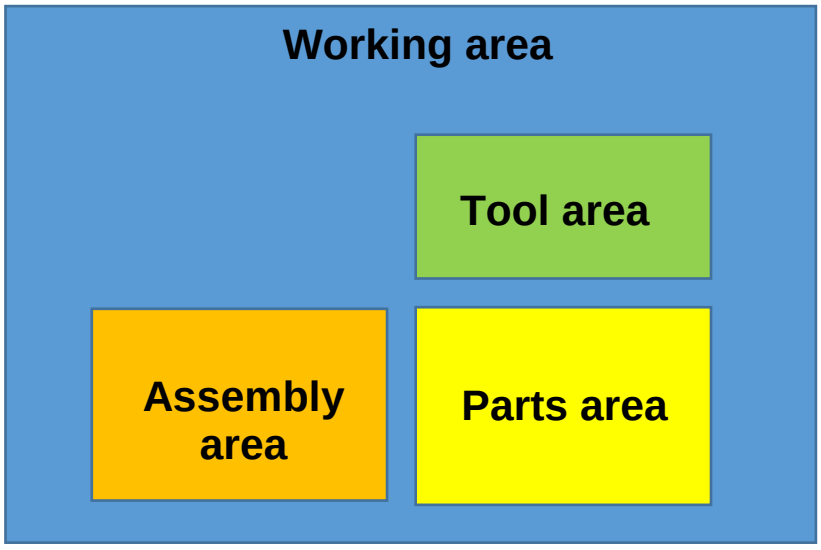


Figure 3. Area definition

(The above layout is just an example. Each area can be assigned anywhere inside the working area as long as they are not overlapped.)

Subtask 1: Fasten roller bolts on the base plate

Difficulty: Level 4

Standard Time: 15 minutes

Achievable Points: 85 (includes maximum possible bonus points) + Time bonus

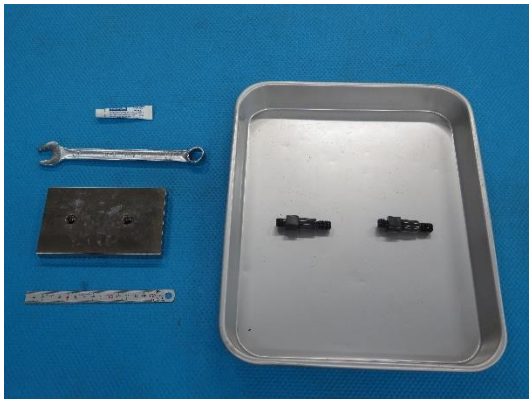
Competition setup:

- Base plate is placed on the table within the assembly area. Its location can be predefined by the team or arbitrary (chosen by the competition staff). Bonus points are given for arbitrary location. But the robot system should complete at least one part assembling to get the bonus.
- The team can introduce fixtures for base plate. Bonus points are given if no fixtures are used. But the robot system should complete at least one shaft tightening task to get the bonus.
- Two cantilever shafts are placed in the parts tray. The tray location can be predefined by the team or arbitrarily chosen by the competition staff. Shaft locations can be predefined by the team or arbitrarily chosen by the competition staff. Parts are not overlapped. Teams can use any items to secure the parts location in the parts tray. Bonus points are given for the arbitrary location method without any fixtures. The robot system must pick up the parts to get the bonus.
- An open-end wrench is placed on a table within the tool area. Its location can be predefined by the team or arbitrarily chosen by the competition staff. Bonus points are given for the arbitrary location method. The robot system must pick up the tools to get the bonus.
- Thread-lock sealant is placed on a table within the tool area. Its location can be predefined by the team or arbitrarily chosen by the competition staff. Bonus points are given for the arbitrary location method. The robot system must pick up the bottle of thread-lock sealant to get the bonus.

Competition:

1. The robot system picks up a cantilever shaft
2. The robot system applies thread-lock sealant to the bolt part (can be skipped)
3. The robot system threads and drives shaft until fully seated on the base plate
4. Repeat 1 to 3 for each shaft

5. The robot system uses the open-end wrench (or customized wrench) to tighten shaft to specified torque
6. Repeat 5 for two shafts.



Initial state of Subtask 1

Goal state of Subtask 1

Figure 4. Subtask 1

(Thread-lock sealant in this figure is not the one specified in this competition. Assembly area, parts area, and tool area must be clearly shown in the competition.)

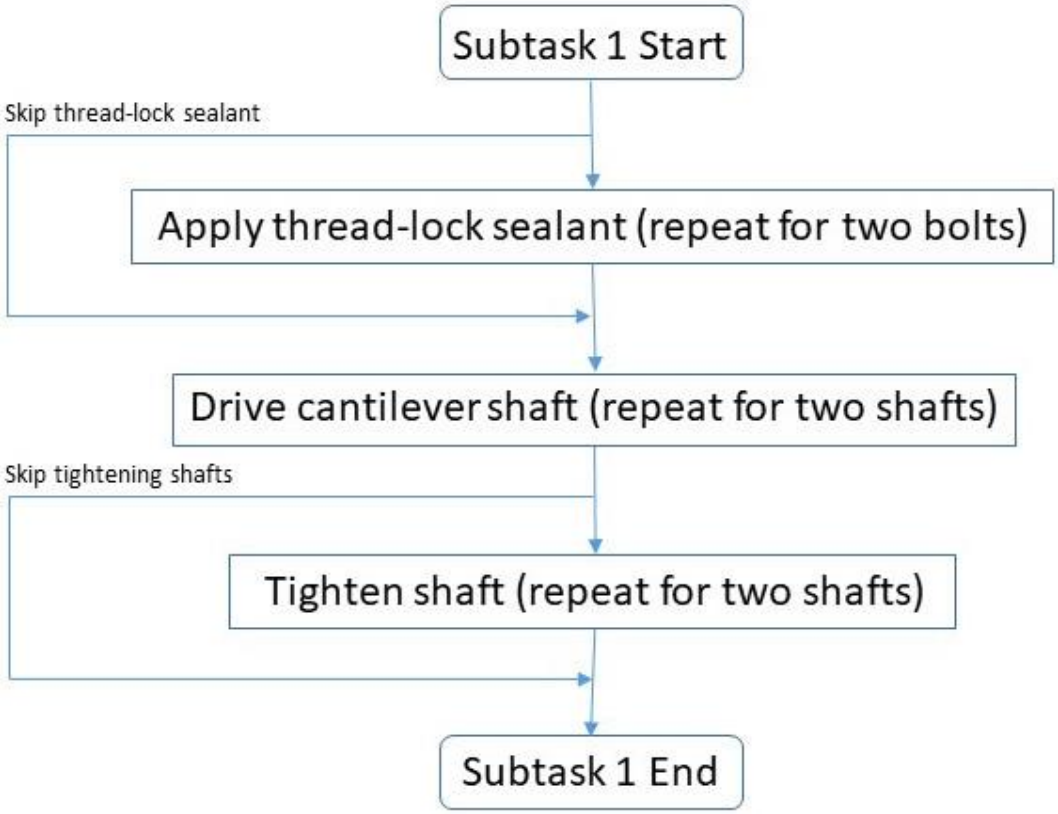


Figure 5. Flow of Subtask 1

Subtask 2: Insert metal collars and gears

Difficulty: Level 5

Standard Time: 30 minutes (including setup time)

Achievable Points: 130 (includes maximum possible bonus points) + Time bonus

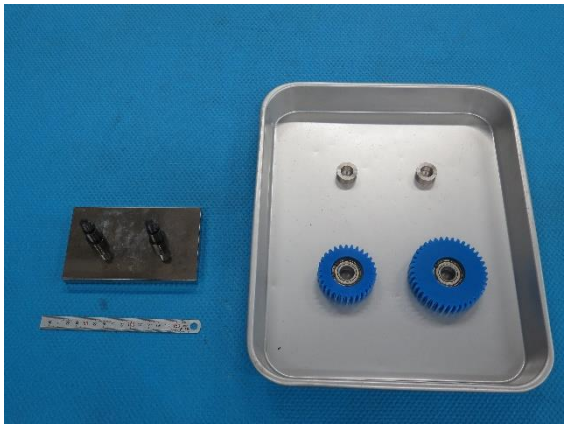
Competition setup:

- The base plate assembled with two roller bolts are placed on the table within the assembly area. Its location can be predefined by the team or arbitrarily chosen by the competition staff. Bonus points are given for the arbitrary location method.
- A team can introduce fixtures for localizing the base plate. No bonus points are given in this subtask even if without fixtures.
- Two metal collars and two different size gears are placed in the parts tray. The tray location can be predefined by the team or arbitrarily chosen by the competition staff. Part locations on the tray can be predefined by the team

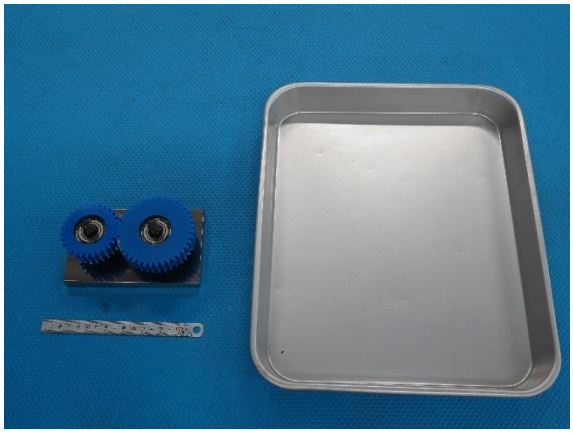
or arbitrarily chosen by the competition staff. Parts placed by the competition staff will not overlap with each other. When using the predefined method, teams can use any items to secure the parts location in the parts tray. Bonus points are given for the arbitrary location method without any fixtures. The robot system must pick up the parts to get the bonus.

Competition:

1. The robot system picks up a collar and insert it onto a shaft.
2. Repeat 1 for the assembly of each collar.
3. The robot system picks up a gear and inserts it onto the shaft.
4. Repeat 3 for assembling each gear onto a shaft. When inserting the second gear, mesh it with the first one



Initial state of Subtask 2



Goal state of Subtask 2

Figure 6. Subtask 2

(Assembly area and parts area must be clearly shown in the competition.)

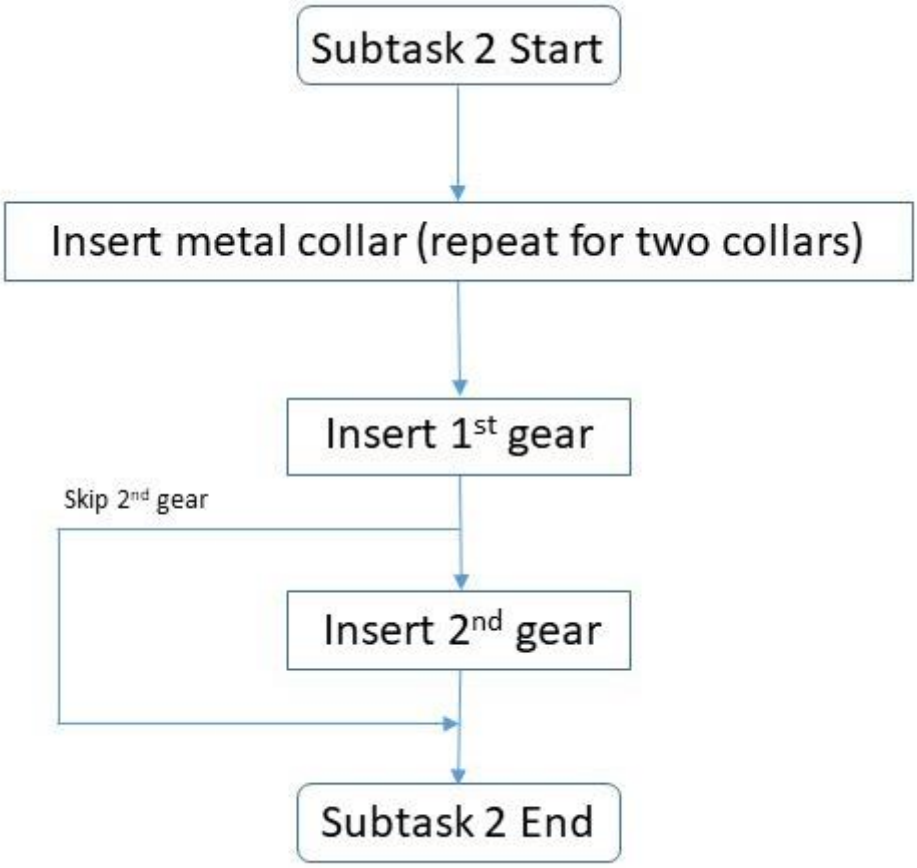


Figure 7. Flow of Subtask 2

Subtask 3: Tighten gears with a nut

Difficulty: Level 4

Standard Time: 15 minutes (including setup time)

Achievable Points: 85 (includes maximum possible bonus points) + Time bonus

Competition setup:

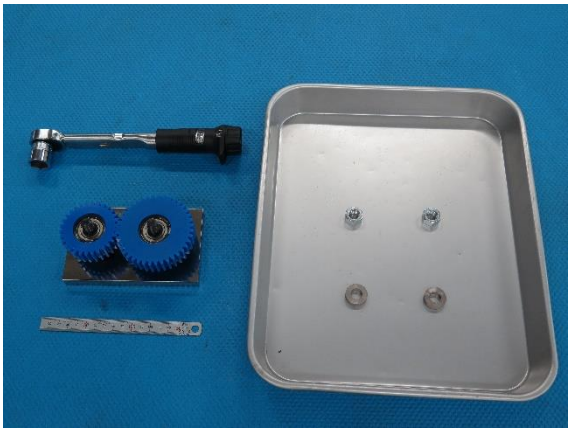
- The base plate assembled with two gears is placed on the table within the assembly area. Its location can be predefined by the team (including the use of fixturing) or arbitrarily chosen by the competition staff. Bonus points are given for the arbitrary location method.
- Two nuts and two washers are placed in the parts tray. The tray location can be predefined by the team or arbitrarily chosen by the competition staff. Parts locations can be predefined by the team or arbitrarily chosen by the competition staff. Parts placed by the competition staff will not overlap with

each other. When using the predefined method, teams can use any items to secure the parts location in the parts tray. Bonus points are given for using arbitrary location method without any fixtures. The robot must pick up the parts to get the bonus.

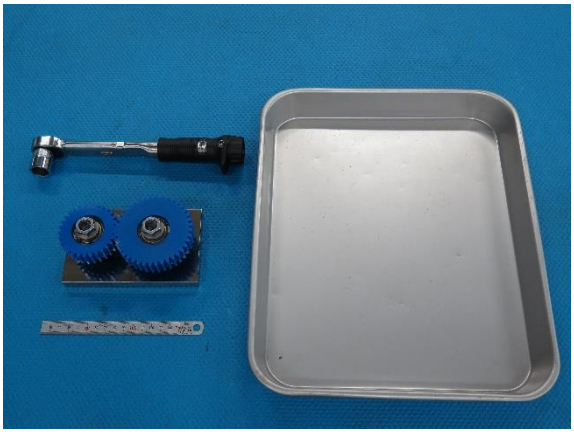
- A nut driver is placed on a table within the tool area. Its location can be predefined by the team or arbitrarily chosen by the competition staff. Bonus points are given for using arbitrary location method. The robot must pick up the tool to get the bonus.

Competition:

1. The robot system picks up a washer and inserts it into shaft.
2. Repeat 1 for assembling a washer onto to each shaft
3. The robot system picks up nut and starts its thread on shaft.
4. Repeat 3 for assembling nut to each shaft
5. The robot system uses the nut driver or customized tool to tighten nut to specified torque
6. Repeat 5 for each nut.



Initial state of Subtask 3



Goal state of Subtask 3 (assembly completed)

Figure 8. Subtask 3

(Assembly area, parts area, and tool area must be clearly shown in the competition.)

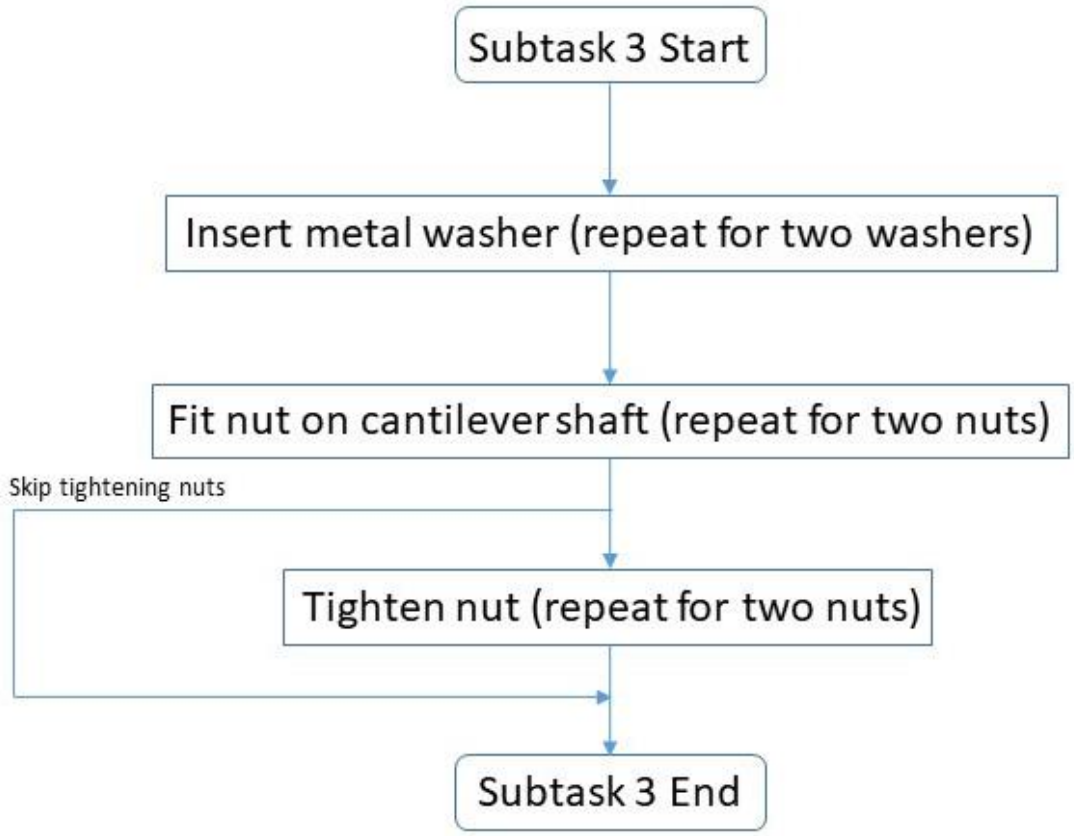


Figure 9. Flow of Subtask 3

Towards "agile one-off manufacturing"

The industrial Robotics Category in WRC aims at realizing future manufacturing systems that can respond to variously changing orders (ultimately, even an order for one-off product) by reconfiguring the system in agile and lean manners. Such robot systems should recognize, grasp, and assemble various parts including flexible parts, and assemble a new product by quickly reconfiguring the system without teaching and jigs (fixtures).

Toward this goal, we expect teams to assemble the gear unit as a single task as shown in Figure 10 in the near future. In WRC/WRS in 2018 and 2020, we are planning to design more difficult tasks than the gear unit. We welcome the teams who participate in Manufacturing Track of 2nd IROS Robotic Manipulation and Grasping Competition to compete at WRC/WRS 2018 and 2020.

Initial state of overall assembly task Goal state of overall assembly task

Figure 10. Overall assembly task

Scoring (tentative and subject to change)

Subtask1		
points		
5	bonus	arbitrary location of base plate
5	bonus	no fixture for base plate
10	bonus	arbitrary location of shaft
5	bonus	arbitrary location of wrench (−2 points when not returned properly)
5	bonus	arbitrary location of sealant (−2 points when not returned properly)
5		apply sealant to the bolt 1
5		apply sealant to the bolt 2
10		drive shaft 1 (100% points for fully seated)
10		drive shaft 2 (100% points for fully seated)
10		tighten shaft 1 (100% points with predefined torque)
10		tighten shaft 2 (100% points with predefined torque)
5	bonus	use hand tool
85	total	

Subtask2		
points		
20	bonus	arbitrary location of base plate
0	bonus	no fixture for base plate (no bonus point for this subtask)
10	bonus	arbitrary location of gear
10	bonus	arbitrary location of collar
5		insert collar 1
5		insert collar 2
30		insert gear 1st (100% points for fully inserted)
50		insert gear 2nd (100% points for fully inserted)
130	total	

Subtask 3		
points		
10	bonus	arbitrary location of base plate
5	bonus	no fixture for base plate

10	bonus	arbitrary location of washer
10	bonus	arbitrary location of nut
5	bonus	arbitrary location of driver (−2 points when not returned properly)
5		insert washer 1
5		insert washer 2
5		fit nut 1
5		fit nut 2
10		tighten nut 1 (100% points with predefined torque)
10		tighten nut 2 (100% points with predefined torque)
5	bonus	use hand tool
85	bonus	

Time bonus

The following time bonus will be added in each subtask when subtask is completed faster than standard time. To get time bonus, all parts (except tools) should be placed in arbitrary locations.

Time bonus = INT((standard time[sec] – spent time[sec]) /10) x 1 point

[Definitions of task completion]
Subtask 1: Two shafts are tightened and points are given.
Subtask 2: Second gear is fully inserted
Subtask 3: Two nuts are tightened and points are given.

Reset

Resetting (and start over) is possible only twice for each subtask. Five minutes are given for starting over. Time counting is suspended during the reset but certain time (1 min for 1st reset and 4 min for 2nd one) is removed from their allotted total time as well as standard time for the corresponding subtask.

Time Shift

60 (=15+30+15) minutes are allotted to each team including setup time for Subtasks 2 & 3. A team can stop the current subtask and move on to the next subtask anytime. A team can spend time for each subtask as long as they want. After 60 minutes, the gear unit assembly task must be stopped.

Note: Time for placing parts and tray at arbitrary location by competition staffs will be excluded from 60 minutes allotted time.

Specified torque

	Shaft	Nut
100% (Full) score	>= 24 [Nm]	>= 12[Nm]
50% score	>= 9[Nm]	>= 5[Nm]
20% score	>= 3[Nm]	>= 1[Nm]

Torque will be measured by releasing the shaft and nut by digital torque wrench which can show the peak torque.