Industrial Robotics Category

Assembly Challenge

Rules and Regulations 2020

The Industrial Robotics Competition Committee

Revision Date: January 16, 2020 (ver. 1.1.0)
# Table of Contents

1 Background ........................................................................................................................................... 1

2 Overview of Competition Tasks ........................................................................................................... 2

2.1 Changes from Past Competition Tasks ................................................................................................. 2

2.2 Outline of the Assembly Challenge for WRS 2020 ............................................................................ 3

2.3 Schedule .................................................................................................................................................. 4

2.4 Prizes for each Competition ................................................................................................................... 4

2.5 Differences in Competition Tasks from WRS 2018 and Background of WRS 2020 Competition Rules .................................................................................................................................. 4

2.6 Purpose of the Surprise Products .......................................................................................................... 7

3 Competition Area ....................................................................................................................................... 7

3.1 System Running Area and Operation Area .......................................................................................... 7

3.2 Power and Air Pressure Sources .......................................................................................................... 8

3.3 Lighting Requirements ............................................................................................................................ 9

3.4 Network Infrastructure .......................................................................................................................... 9

4 Robot Requirements and Limitations ...................................................................................................... 10

4.1 Functional Requirements ...................................................................................................................... 10

4.2 Hardware Requirements ....................................................................................................................... 10

4.2.1 Robot ................................................................................................................................................ 10

4.2.2 Power and Number of Actuators ..................................................................................................... 10

4.2.3 CPU, Memory Storage, etc .............................................................................................................. 10

4.2.4 Costs .................................................................................................................................................. 10

4.3 Software Requirements ........................................................................................................................ 10

4.3.1 Network Utilization ......................................................................................................................... 10

4.3.2 Remote Control .............................................................................................................................. 11

4.4 Placement of Markers ........................................................................................................................... 11
5 General Rules for Competition

5.1 Definitions of Phases during Competition

5.2 Method of Supplying Parts to Robot Systems

5.3 Carrying-out of Assembled Products

5.4 Reset

5.5 Time Extensions due to Trouble

5.6 Task Completion and Scoring

5.7 Penalties

5.7.1 Withdrawal or Suspension from the Competition

5.7.2 Damage to the Field

5.7.3 Interference to Other Teams

5.7.4 Damage to Parts

5.7.5 No Show

5.7.6 Number of Players

5.8 Referees & Safety and Health Management Committee

6 Safety and Health

6.1 Safety and Health Management Policy

6.1.1 Compliance Standards

6.1.2 Safety due to Separation Principle and Functional Safety

6.1.3 Obligation to Adhere to Safety and Health Management Regulations

6.1.4 Safety and Health Management Committee

6.1.5 Safety and Health Advisory Organization

6.2 Safety and Health Regulations

6.2.1 Hardware Requirements

6.2.2 Safety and Health Requirements of Competition Systems

6.2.3 Materials for Advance Submission

6.2.4 Preparation before Starting Competition at the Venue

6.2.5 Requirements to Pass Safety and Health Inspection before Starting Competition at the Venue
1 Background

George Devol applied for his historic patent, Programmed Article Transfer, in 1954. This patent was approved in 1961, and in the same year, Unimate was released from an American company, Unimation, as the world’s first industrial robot. His concept of a programmable transfer machine and operating principles of teaching and playback remain timeless even today, and we could say that it is the fundamental concept behind industrial robots. The fact that most industrial robots today, especially arm-type robots, are operated by the teaching and playback method illustrates the universality of Devol’s ideas.

Now, if we look at the cost for implementing standard robot systems, the expense of the robot itself amounts to no more than 20-30% of the total cost, and in many cases peripheral equipment, peripheral devices, and system integration makes up over 50% of the cost. This is the reason why the industrial robot itself is regarded as an “incomplete product”. Industrial robots, which were supposed to provide functionality as programmable universal machines are often installed as part of a special purpose system and are not re-programmed once they are installed.

Industrial robots with this teaching and playback method based on Devol’s patent may have had a somewhat high initial financial and labor cost to install. In the era of mass production, once the system was configured, they could be used as-is for several years which made up for the initial cost. However, the ever-shortening product life-cycles and diversification of consumer needs is resulting in a demand for high-mix low-volume production that is difficult to meet with this sort of system, and in response, cellular manufacturing using humans (human cell) emerged.

However, labor shortages and increases in labor costs have become problems in recent years in both Japan and elsewhere, and the achievement of a robot system that can handle high-mix low-volume production is in demand. In particular, small- and medium-sized enterprises (SMEs) that operate under strict cost limitations cannot easily implement robots with large integration costs. Therefore, it is essential for us to be able to use industrial robots as programmable universal machines that can be easily and quickly configured and re-configured into systems without paying a high cost for system integration, in order to manufacture different products without waste. This is a necessary requirement for promoting the implementation of robots not only at SMEs but at large-scale enterprises as well.

From the above mentioned background, the Industrial Robotics Category of the World Robot Summit (WRS) aims to realize the future of manufacturing systems “toward agile one-off manufacturing” as a goal, by building agile and lean production systems that can respond to ever-changing manufacturing requirements (even for a one-off product in an extreme case) in high-mix low-volume production through a competition in this category. Table 1 shows the levels of production system, where current production systems as Level 1, and the highest objective of next-generation production systems as Level 5. At WRS we are aiming for at least Level 4.

Assembly is one of the most difficult operations for robots. Assembly tasks are often laborious and costly due to the need to prepare peripheral devices such as parts feeders and jigs. In addition, careful teaching is necessary for parts mating, and fine adjustment of the teaching data is also laborious and time-consuming to overcome the temporary stoppages that can occur frequently after introducing a new manufacturing system. Therefore, the WRS Industrial
Robotics Category has set product assembly as the challenge task in this competition from the numerous tasks in the manufacturing domain.

2 Overview of Competition Tasks
2.1 Changes from Past Competition Tasks

Prior to the WRS 2018 pre-competition, the Industrial Robotics Category had conducted a gear unit assembly competition as a trial task in October 2017 at the IROS site as part of the 2nd Robotic Grasping and Manipulation Competition as shown in Figure 1. The 11 parts used for the gear unit assembly can be seen in Figure 1 (b). All of these parts were easily available from MISUMI around the world. In particular, the shaft and the inner gear bearing were a transition fit which is difficult even for humans if they are not used to it.

At the WRS 2018 pre-competition, the belt drive unit shown in Figure 2 was devised as a more difficult product than the gear unit at the trial-task in 2017. The difficult point of the belt drive unit in comparison to the gear unit was: (1) There were many parts including very small parts such as M3 thread screws. (2) It featured a soft part, namely the belt. (3) Compared to the gear unit, the direction of assembly was not always perpendicular. (4) It included an assembly process that required two arms, namely holding one part while assembling another part. Additionally, some of the parts in the belt drive unit were revealed directly before the competition as surprise parts introducing an element of responding to new production demands in an agile and lean manner in the competition. In the WRS 2018 pre-competition, in addition to the belt drive assembly competition there were also task board and kitting tasks. Please refer to [1] for details of the competition rules of WRS 2018 pre-competition. Also please refer to [2] that summarizes the WRS 2018 pre-competition.

Table 1: Levels of Next-generation Production Systems (Draft Version)

<table>
<thead>
<tr>
<th>Level</th>
<th>Factors during setup changes</th>
<th>Factors during operation</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 5</td>
<td>0 day for new product (Changeover on the same day)</td>
<td>100% continual use (Introduction of universal hands that are able to perform jig-less assembly for multiple products, etc.)</td>
<td>Agility</td>
</tr>
<tr>
<td>Level 4</td>
<td>2 days for new product (Changeover on a weekend or an overnight business trip)</td>
<td>Available for new products only by recombining existing equipment. (Universal hands able to grasp multiple products, etc.)</td>
<td>100% continual use (Introduction of universal hands that are able to perform jig-less assembly for multiple products, etc.)</td>
</tr>
<tr>
<td>Level 3</td>
<td>1 week for new product (Changeover in a week, e.g. during large consecutive national holidays)</td>
<td>50% or more can be reused (Use of specialized hand library, flexible jig, multi arms, etc.)</td>
<td>50% or more can be reused (Use of specialized hand library, flexible jig, multi arms, etc.)</td>
</tr>
<tr>
<td>Level 2</td>
<td>1 month for new product</td>
<td>Reusing only robots</td>
<td>Reduction of temporal stoppage rate by absorbing part variations using sensors.</td>
</tr>
</tbody>
</table>
| Level 1 | For specific products only Changeover is not assumed. | 0% (No reuse is assumed.) | Controls parts variations to ensure an enough utilization rate. Human intervention is required for temporal stoppages. | Many robot systems used today.
2.2 **Outline of the Assembly Challenge for WRS 2020**

The Assembly Challenge is a competition where teams quickly and accurately assemble model products that contain the technical elements necessary for assembling industrial products. In order to meet new production requirements, robot systems are expected to be able to assemble different products in an agile and lean manner.

The following two tasks will be provided at the 2020 competition.

1. **Task-Board task**
   
   Teams compete in the task elements necessary to assemble a belt drive unit. In this task, the parts supplied under the same conditions as the next assembly task are to be assembled at designated locations on the task board.

2. **Assembly task**

   A belt drive unit will be assembled using parts from a provided parts tray. Additionally, assembly of a product with different specifications (surprise product) from the pre-announced product will be required to demonstrate the capability of responding to new production demands, and teams will have to perform agile and lean setup changes. However, the parts that make up the surprise product will be announced in advance so that the teams can design robot hands and the other devises for those parts.

   As with WRS 2018, the parts used for each task will be available from MISUMI as much as
possible, with the consideration so that the tasks can be used in various locations as benchmarks for assembly work. Additionally, as with WRS 2018, samples of parts to be used in the competition will be sent in advance to participating teams.

2.3 Schedule

See Table 2 for the WRS 2020 Competition schedule. The event is scheduled for one week including setup days. The first two or three days are for setting up, and Day 1-3 will be the scored competition, Day 4 will be exhibitions, technical exchange, and awards ceremony. Then, a symposium will be held on Day 5. Team meetings are scheduled in the evening for every day until the assembly is over, starting with the evening before Day 1.

The competition is scheduled to do the task-board task on Day 1, to do assembly task for assembling the normal belt drive units on Day 2, and to the assembly task for assembling the normal and surprise products on Day 3. Table 3 describes the scoring for the product assembly task.

A detailed competition schedule including dates and start and end times will be announced at a later date. Note that the competition schedule is subject to change.

2.4 Prizes for each Competition

At the competition, the top three teams with the highest scores will be awarded. There will also be some society awards presented to teams that excel from various standpoints. Other awards may be set later.

2.5 Differences in Competition Tasks from WRS 2018 and Background of WRS 2020 Competition Rules

The following five points are the major changes between the WRS 2018 and WRS 2020 competitions. Please refer the following sections of the rules for details.

1) The kitting task has been eliminated, and the assembly task begins with the supplied parts kitted on a tray. The parts tray is brought in with a push cart that simulates an automated guided vehicle (AGV), and the assembled products are placed on the cart to be carried out in the same way as bringing in the parts. Additionally, supplying method for only small general-purpose parts like screws will be left up to individual teams.

Table 2: Competition Schedule of the WRS 2020 Assembly Challenge

<table>
<thead>
<tr>
<th>Setup Period (2-3 days)</th>
<th>Staff only</th>
<th>Staff &amp; team only</th>
<th>Open to the public</th>
<th>Closed Session</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Venue Setup</strong></td>
<td></td>
<td></td>
<td>Assembly Challenge</td>
<td>Presentation competition, etc.</td>
</tr>
<tr>
<td><strong>System setup</strong></td>
<td></td>
<td>Team Setup</td>
<td>Competition</td>
<td></td>
</tr>
<tr>
<td><strong>Team members kept out</strong></td>
<td></td>
<td></td>
<td>Task Board task</td>
<td>Exhibition, technical exchanges, awards ceremony</td>
</tr>
<tr>
<td><strong>System setup, adjustment, safety inspection after setup is complete</strong></td>
<td></td>
<td></td>
<td>w/o Surprise Product</td>
<td>(Exchange meeting)</td>
</tr>
<tr>
<td><strong>No Luggage accepted</strong></td>
<td></td>
<td>Luggage loading</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 3: Points Table

<table>
<thead>
<tr>
<th>Day</th>
<th>Task</th>
<th>Points</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 1</td>
<td>Task-board task</td>
<td>100</td>
<td>Better points from two tries</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Time bonus awarded separately</td>
</tr>
<tr>
<td>Day 2</td>
<td>Assembly task w/o Surprise Product</td>
<td>200</td>
<td>Better points from two tries</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Time bonus awarded separately</td>
</tr>
<tr>
<td>Day 3</td>
<td>Assembly task w/ Surprise Product</td>
<td>400</td>
<td>Assemble two normal products and one surprised product</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Only one try</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Time bonus awarded separately</td>
</tr>
<tr>
<td>Total</td>
<td>Technical Evaluation</td>
<td>50</td>
<td>Based on the submitted technical documents and the actual performance in the competition</td>
</tr>
<tr>
<td></td>
<td></td>
<td>750</td>
<td></td>
</tr>
</tbody>
</table>

(2) The contents of the task-board task including the parts supplying method have become more consistent with the assembly task.

(3) In the assembly task, instead of the surprise parts (new parts information that was supplied directly before the task) that were introduced in WRS 2018 as a surprise element, a new idea of a surprise product will be introduced, where the information about the parts will be supplied in advance to some degree, but the teams will be notified of the way how each part should be assembled directly before the task.

(4) A cable insertion task has been added to the assembly task.

(5) Resets can be done any number of times, but for each reset, the team will not be able to resume the competition for a predetermined length of time (assuming about two minutes). A pause declaration can be made when carrying out the finished product and bringing in the parts for the next product, but the number of pauses must match the number of products to be assembled. Calling a pause means that the competition time will stop for a certain period of time (assuming about two minutes). Additionally, the definition of the ‘phases’ during the competition has been changed.

In the WRS 2018, there were task-board task and the kitting task in addition to the assembly task. The reason for this was that although the competition committee aimed for the robotization of a human cell as shown in Figure 3 (a), it was considered too difficult for the teams to robotize of the current human cell where basically a single human assembles a product by taking out necessary parts from a parts bin. Then, as shown in Figure 3 (b), the tasks were broken down into two parts with kitting performed as a pre-assembly stage in order for the assembly to be done with the kitted parts. The task-board task was developed with inspiration taken from the one developed by Van Wyk et al. at NIST for the IROS 2nd Robotic Grasping and Manipulation Competition [3], and the elements of assembling a belt drive unit were extracted and the teams compete on that basic technology for assembly in the task-board task.
Alternatively, WRS 2020 assumes a system in which parts kitting, assembly, and product inspection are modularized as shown in Figure 4. The parts kitting is performed by mobile picking robots (called “mizusumashi” (whirligig beetle) robots in Japanese) that take out parts from the parts bins as necessary according to production requirements [4] and supplies them to a robot at the assembly station. The assembled products are carried to the product evaluation station by another mobile robot [5]. Under this assumption, the competition committee set the competition to be exclusively specialized for the assembly station. At WRS 2020, simple manual carts that simulate AGVs will be used for parts supply and product carrying-out. However, a real AGV has been implemented on an experimental basis at WRS 2019 trial competition. If there are no problems with its operation and introduction, AGVs may be also implemented for the WRS 2020 competition instead of manual carts.
The details of the idea of the surprise products are described in the next section.

The Industrial Robotics Competition Committee has conducted a WRS 2019 industrial robotics trial competition (hereinafter “trial”) at the International Robot Exhibition (iREX 2019) in December 2019. The purpose of this trial is actually to conduct some parts of the WRS 2020 competition tasks in order to verify their appropriateness, especially for the new elements we have introduced. Four teams that participated in WRS 2018 participated in the trial, but the competition was just a trial format, and although teams were scored, there were no prizes or prize money. The results of this trial will not have any effect on the results or selection of teams for WRS 2020. Please note that this version of these rules has been written before the trial, and the rules may be changed depending on the results of the trial (release is scheduled for March, 2020).

2.6 Purpose of the Surprise Products

In the WRS Industrial Robotics Category, we aim to realize a production system that can respond to various production demands (ultimately even one-offs in extreme cases) in agile and lean manner in the high-mix low-volume production. Therefore, the assembly challenge includes surprise products that differ from the product announced in advance in order to compete on making quick setup changes.

At the WRS 2018 in Tokyo, several parts were changed to surprise parts for the belt drive unit on the second day of the assembly task, but since the information about the parts were provided at the competition venue, teams had difficulty to prepare hands and other equipment in advance to fit the surprise parts. With this in mind, the WRS 2020 competition will provide information in advance about the parts that will make up the surprise product (shape and size range, etc.) so that the teams can have enough time for preparing hands and other equipment for those parts. The surprise products will be products of new specifications by changing the combination and arrangement of those parts.

3 Competition Area

3.1 System Running Area and Operation Area

Each team will have an area for running their system including robots as shown in Figure 5 (hereinafter referred to as the System Running Area), and an area for operating and monitoring the system (hereinafter referred to as the Operation Area). Each team will have an area within the System Running Area where they are allowed to go in and out even during the operation phase (see Section 5.1 ”Definitions of Phases during Competition ”) for bringing in new parts and carrying out assembled products at the Bring-in/Carry-out State hereinafter called the Bring-In/Carry-Out Area. People must not enter any area within the System Running Area other than the Bring-In/Carry-Out Area during the operation phase (hereinafter the Robot Working Area).

Working tables will be provided to the requested teams and can be set in the System Running Area. Other necessary items such as additional tables, parts shelves, tool shelves, etc. may be supplied and installed by each team. The Bring-In/Carry-Out Area and the Robot Working Area will be demarcated by a light curtain. A light curtain for a simple boundary as shown in Figure 5 will be provided, but the team may need to provide additional light curtains etc. if setting more complex boundaries. Please note that, regarding the System Running Area the rules will not be changed for the Robot Working Area. However, there may be some major changes regarding
the Bring-In/Carry-Out Area, because it is possible that AGVs will be implemented as mentioned above.

When installing equipment in the System Running Area, teams must consider the visibility inside the System Running Area for the spectators. For example, teams must not place a parts shelf in the spectator’s side of the System Running Area, or cover the System Running Area with a shade. Further, the competition committee may install cameras within the System Running Area and the Operation Area in order to capture the competition scene that may be provided to the spectators. If teams interfere with such shooting, for example by installing a pillar that blocks the camera view, the camera may be attached to that pillar. Spectators will be instructed that flash photography is prohibited.

Care should be taken when installing the ceiling (for example, to install ceiling lights) in the competition area, especially in the System Running Area. Those teams must contact the competition committee in advance and get permission. Details on height restrictions and conditions for using the ceiling will be provided later, in following with the Fire Service Law.

At the competition venue, four teams will be set up in the competition area as shown in Figure 6, and this will make up a single arena. Four arenas will make up the competition area for 16 teams in total. In this arrangement, all of the team areas will have the same shape and the same layout (location of entrance/exit, positional relationship between the System Running Area and Operation Area, etc.).

### 3.2 Power and Air Pressure Sources

A single-phase 100V power supply will be provided. In addition to the 100V power supply, a 3-phase 200V power supply can be made available to the teams who request it. Air pressure sources will also be provided.
3.3 Lighting Requirements

Lighting will be provided from the venue lighting. The competition committee will not install any extra lighting for each team area. Due to this, the brightness and color may be different for each team area. Additionally, the windows of the venue will be blocked off with curtains to prevent direct sunlight, but the brightness level may change depending on the presence or absence of sunlight. Each team may bring their own shades and/or lights, but it must be installed within the team area, and may not influence other teams, and it must not interfere with the operation of the referee or obstruct the view of the spectators. Further, details with regard to height restrictions and ceiling conditions related to the Fire Service Law will be supplied later and must be observed.

3.4 Network Infrastructure

An internet connection will be provided to each team area. However, as it is best effort service, network speed is not guaranteed. Additionally, considering the impact on other teams, bandwidth is capped at 64Mbps. As remote control is banned, the internet connections will be disconnected during the competition tasks.
At the WRS 2020 competition, wired LAN connections will be supplied. The use of Wi-fi and other wireless communication in the 2.4GHz or 5GHz bands will not be permitted as it can affect the competition fields of other categories. Further, each team will not be permitted to supply their own internet connection environment.

4 Robotic Requirements and Limitations

4.1 Functional Requirements

Robots need accident prevention functionality for safety and health. Emergency stop buttons, safety fences, a door with safety switches, and dead man’s devices must operate normally. Any environmental pollution must be prevented. For details on safety and health management, see Section 6.

4.2 Hardware Requirements

4.2.1 Robot

The robots used for the competition can be prepared by each team, borrowed from the competition committee, or, a combination of both may be used. Details on the specification of the lending robots will be announced separately.

There is no restriction on the number of robots, but teams must take into account the limited installation space for robots. There is also no regulation about the weight of a robot, but each team needs to prepare a worktable if the weight exceeds the bearing load of the table provided by the competition committee.

Furthermore, equipment such as devices that generate a loud noise may be prohibited to use if the referees deem that device inappropriate.

4.2.2 Power and Number of Actuators

There are no limitations for the type, number, or power of actuators (motors) used in the robots. However, if the competition committee determines that there is a safety and health issue, there may be the cases where use is restricted. See Section 6.2.1 "Hardware Requirements."

4.2.3 CPU, Memory Storage, etc.

There are no limitations regarding computing ability.

4.2.4 Costs

There is no upper cost limit for robots and peripherals.

4.3 Software Requirements

4.3.1 Network Utilization

During team setup, teams may use the Internet to access, for example, cloud computing, but must be prepared for network trouble. Use of Wi-fi is not permitted. The internet connection will
be terminated during the competition tasks. For details, see Section 3.4, “Network Infrastructure.”

4.3.2 Remote Control

Remote control by personnel is not assumed in this competition because it is an assembly challenge intended for the automation of production sites. Therefore, robots may not be operated remotely in the operation phase. This refers not only to the direct control by a device like a joystick but also the control through voice or gestures. In order to prevent remote control via the Internet, the Internet connection will be terminated during the competition tasks.

4.4 Placement of Markers

In the competition, only the product parts and parts trays supplied on site by the competition committee will be used, and no markers are allowed to be attached to these parts. In addition, colored markers will be attached to the upper four corners of the parts trays in order to assist in detecting its position and orientation (See Figures 8 and 9). Teams may affix markers to the work environment outside the product parts and parts trays. Please note that the way and the purpose of attaching color markers on the parts trays may be changed according to the result of the WRS 2019 trial competition.

5 General Rules for Competition

5.1 Definitions of Phases during Competition

The tasks (the task-board task and assembly task) are made up of a preparation phase, an operation phase, and a reset phase (Figure 7). The preparation phase is the time when the referee supplies each team with the parts that will be used in the task, the team checks them, and sets the necessary parts in the System Running Area. For both the task-board task and the assembly task, the preparation phase will have a designated minimum time period (assuming 10 minutes). Teams must confirm the parts provided, and ask for trades if necessary, during this phase. After that, the referee will set the parts in the parts tray using a designated method. Push carts will be used to bring the parts trays in the System Running Area and set them in their initial position. For the task-board task, teams will use this phase to place the task board in the System Running Area. Teams may not touch the robots or robot systems during the preparation phase. Meanwhile, the referees will check whether there are any problems in the Operation Area or the System Running Area during this phase. However, as noted above, there is the possibility that AGV will be implemented, in which case these rules during the preparation phase may change dramatically.

After preparation is done, the team leader will tell the referee that they are ready to start the Operation Phase. If the minimum required time for preparation phase has not yet elapsed, the team must wait until the required time has elapsed, and then the Operation Phase (Running State) will begin. If such required time has already elapsed. The Operation Phase will begin immediately. During the Operation Phase (Running State), since the robots and other equipment will be working, people are prohibited from entering the System Running Area. Therefore, team members cannot touch the robot, the working environment for the robot, the parts, the tools, etc. during the Operation Phase (Running State). Additionally, since remote control is prohibited, a paper or something must be placed on the keyboard or any other similar devices, and it must be clear that no one is touching any input devices. The team may
determine the order of assembling the parts during the Operation Phase (Running State).

During the Operation Phase, a team may call a pause and change the state from Running State to Bring-in/Carry-out State, in which team members are permitted to enter only the Bring-in/Carry-out Area within the System Running Area. After calling a pause and entering the Bring-in/Carry-out State, the progression of the task time will stop for a predetermined time (assuming about 2 minutes), and team members can use the push cart to bring in new parts and carry out assembled products. However, even during Bring-in/Carry-out State, team members must not touch the robot system at all.

The Reset Phase is a time to recover the system from an error and restore the parts to their initial position. After the reset has been called and the referee has confirmed that the robots have entered a safety mode described later (Emergency Stop Mode or Manual Mode), team members may enter the System Running Area and restore the robot system.

The time bonus, which will be described later, will be awarded based on the remaining time for the task which is calculated by subtracting the time for the Preparation Phase (assuming a minimally required time of 10 minutes), the Operation Phase (where the progress of the competition time is suspended for a fixed amount during the Bring-in/Carry-out State) and the Reset Phase (assuming 2 minutes per time) from the allotted competition time.

Figure 7: Transitions between phases and states by team declarations

5.2 Method of Supplying Parts to Robot Systems

The way the parts are supplied to the robot systems has been changed a lot compared to the WRS 2018 pre-competition in Tokyo. The parts used in the task-board task and the parts for a
single belt drive unit used in the assembly tasks will be supplied by laying them on a single parts tray (Figure 8), except common small parts like screws, washers, nuts, and so on. A black cushion will be placed on the bottom of the parts tray. There will be no partition plates inside the tray, and in principle the parts will be set without overlapping. The placement of the parts on the tray will be done by the referees during the Preparation Phase, and the placement positions and orientations of the parts may change each task (Figures 8 and 9). Information about the parts layout on the tray will not be announced in advance, so the robot must be able to correctly pick up the parts from the tray regardless of where the parts are located in the tray. Further, as will be explained later, when carrying in the parts tray to the System Running Area with the push cart, the vibrations may cause parts to overlap, but teams may not alter the positions of the parts.

The method for carrying the parts tray into the System Running Area is planned to use a push cart, simulating an AGV. Each team will be supplied with the same type of push cart. They are not allowed to use their original push cart. The only actions each team is permitted to do is to place the parts tray on the push cart and push the cart with the tray on it into the System Running Area. Therefore, the teams may not touch the parts tray or the parts in the parts tray when bringing in the parts tray. Picking up parts from the parts tray on the push cart must be done by robots only. Those parts will include the base plate as well in the case of assembly task (Figure 9). In other words, please be aware that although the base plate was permitted to be placed manually by the team members during the Preparation Phase in the WRS 2018 competition, this action will be prohibited in the WRS 2020. If team member touches a part on the parts tray, the referee must place it again. However, as noted above, there is the possibility that AGV will be implemented, in which case these rules will change dramatically.

For small parts (screws, washers, and nuts), based on the assumption that a supply device for those parts would be used in real sites, each team will be permitted to use a screw holder or a screw supplying device as long as they prepare themselves (Figure 10). It is permitted to place those devices on the worktable in the System Running Area beforehand. Those small parts (about 100 pieces for each part) will be provided at once during the team setup period and will not be provided separately at the beginning of each try. Note that teams should not use other small parts than those provided ones.

When bringing in or carrying out the parts tray, teams must follow the safety procedures described in Section 6 (Safety and Health) and safely stop the robot system. It is permitted to bring in and carry out the parts trays one at a time or all them together. Please note that parts trays will be stackable even with parts inside.
Figure 8: Examples of supplied parts laid out on a parts tray (for the task-board task)

Figure 9: Example of supplied parts laid out on a parts tray (for the assembly task)  
(The parts shown here were the ones used in the WRS 2019 trial competition)

Figure 10: Example of parts holder for screws, washers, and nuts  
(The parts shown here were the ones used in the WRS 2018 pre-competition)
5.3 Carrying-out of Assembled Products

In the assembly task, carrying out of completed products is the reverse procedure of bringing in the parts tray by the push cart. The robot must place the finished product(s) on the parts tray and then place the tray on the push cart. The team members should not touch the product(s) directly when carrying it(them) out. In the case of the task-board task, the task ends when all parts are assembled on the task board, so it is not necessary to carry out the task board or the parts tray.

When carrying out completed products from the System Running Area, a pause must be declared by following the safety instructions outlined in Section 6, and stop or suspend the robot system safely. Even if all parts are not assembled, the product can be carried out for scoring. However, even if the assembled product is not completed, it must be placed on the parts tray so that the team members can carry it out. In other words, the product must be placed on the parts tray by the robot. Products may be carried out one at a time or all them together. Once a pause has been declared and the state has been changed from the Running State to the Bring-in/Carry-out State, the progress of the competition time is suspended for a fixed period (assuming 2 minutes). Each team should bring in/carry out the parts trays without rushing.

In order to carry out a product that the robot cannot place on the parts tray (including partially finished products), a reset must be declared. Although, parts are normally returned to their initial state by a reset, team members may place a product in the parts tray by their hands only when they want to carry it out. However, as in an ordinary reset, once reset is declared, the competition can be resumed only after a certain time (assuming two minutes). After placing the product in the tray in the Reset Phase, the team must return to the Operation Phase and declare a pause to stop progress of the competition and carry out the parts tray by the push cart in the same way as normal bringing-in/carrying-out. However, as noted above, there is the possibility that AGV will be implemented, in which case these rules will change dramatically.

5.4 Reset

Teams may choose to reset their systems including the robots if their system does not operate as intended during the Operation Phase. In the event of declaring a reset, it will be possible to transition from the Operation Phase to the Reset Phase by setting the robot to Emergency Stop Mode or Manual Mode that satisfies the safety conditions described later. After recovering the system, teams must return the robots and task objects to their initial state as defined elsewhere, and restart the task. Restart of the task is possible after waiting for a certain time (assuming two minutes). If the resetting took longer than the predetermined time, the task can be restarted at any time. However, if the parts on the parts tray must be restored to their original locations, be aware that the referee will restore the parts layout on the parts tray during the Reset Phase.

Refer to Section 5.1 for actions permitted and prohibited during a reset. No point deductions will be taken for calling a reset. Note that even if a team declares a reset, their competition time will not be extended.

5.5 Time Extensions due to Trouble

Each team is responsible for any trouble that occurs in their team area during the competition
and no time extensions will be given for any of the tasks. This would include, for example, communication failure with a robot. Note that the competition can be suspended according to judgment by the referees. In the event of issues that influence every team, the competition committee may allow an extension of time after deliberation. For example, this would include power outages.

5.6 Task Completion and Scoring

Referees will score in accordance with the scoring criteria of each task. Referees will evaluate the state of the completed task board in the case of the task-board task, and the state of assembled products which are carried out in the case of the assembly task. For incomplete products, partial points will be added in accordance with the scoring criteria. When the required task has been completed earlier than the time limit of the task, extra points will be added as the time bonus based on the remaining time.

5.7 Penalties

This section describes actions when teams breach rules and regulations. Referees will determine the penalties after deliberation if an issue not addressed in this section occurs.

5.7.1 Withdrawal or Suspension from the Competition

If a participating team withdraws from a part of the competition, or if the referees judge that the content of the competition by a team is equivalent to withdrawal, the team may be excluded from the ranking evaluation. The team may also be removed from consideration for various awards. Teams will also be withdrawn if they do not satisfy the safety and health regulation or do not follow the directions of the Safety and Health Management Committee. The Safety and Health Management Committee is described in Section 5.8, and the safety and health regulation are described in Section 6.

5.7.2 Damage to the Field

Teams must not bump into or damage any materials at the competition venue. Any team that causes serious damage that cannot be repaired immediately will be disqualified until that is repaired. This rule applies to damage caused not only by robots but also by team members.

5.7.3 Interference to Other Teams

The team areas are quite close together, and teams must not cause problems to neighboring teams. This policy applies to not only baggage protruding from their own team area, but also to noise, smell, lighting disturbances, and so on.

5.7.4 Damage to Parts

Points shall be deducted if referees determine that a part distributed to a team has been damaged and may no longer be used in the competition. A part deemed necessary to change shall be replaced with a spare part, but a spare part may not be available in some cases, because the number of spare parts is limited. Further, teams may not add markers to the parts provided by the competition committee.
5.7.5 No Show

Teams shall be withdrawn from a task if no team member is present in the team area at the time to start a session or if the team is clearly not ready to start a task.

5.7.6 Number of Players

There is a limit of ten players that may enter the Operation Area and the System Running Area, but the number may be restricted further based on venue layout. It is permitted to switch out team members for each task, but they may not be switched during the task.

5.8 Referees & Safety and Health Management Committee

At least two referees will be assigned to each team during the competition. The team members must obey the instructions of the referees. The referee group for the WRS Industrial Robotics Category is made up of people who are not on teams, and cannot be chosen from the team members. The referees’ decisions are final. However, if an obvious mistake has been made, the decision may be revoked at the discretion of the competition committee chairperson.

The Safety and Health Committee will carry out safety patrols as needed, and point out any unsafe actions and/or points. The Committee may stop a competition task and require safety and health improvements depending on the circumstances. Team members must always obey the instructions of the Safety and Health Committee. The Safety and Health Committee is planning to conduct safety and health inspections during the team setup period.

6 Safety and Health

Needless to say, the management of this competition puts health and safety at top priority. Concrete rules are formulated under the Health and Safety Management Policy. Any inconsistencies related to the protection of safety and health shall be rectified immediately.

6.1 Safety and Health Management Policy

6.1.1 Compliance Standards

Teams shall adhere to the ISO10218 series and higher international standards.

6.1.2 Safety due to Separation Principle and Functional Safety

We aim to prevent accidents that occur as a result of physical contact between participants and objects including items used in the competition and scattered objects from those items. It is essential to introduce measures such as safety fences as a way to prevent this physical contact. The System Running Areas where the competition systems operate and the Operation Areas where participating teams and referees stay are the restricted areas called Team Area, and they are completely separated from the space where spectators are present by either safety fences (System Running Area) or partitions (Operation Areas). Even inside the Team Area, a safety fence is installed between the System Running Area and the Operation Area, and functional safety is implemented and operated based on risk assessment in the area where humans and robots exist side by side. Safety fences and safety circuits are provided by the competition committee. Participating teams must submit risk assessment results in advance. At the competition venue, they are required to connect their competition systems to the safety circuits,
and pass a safety and health inspection before they may participate in the competition.

6.1.3 Obligation to Adhere to Safety and Health Management Regulations

All participants are obligated to protect the safety and health of everyone each other. For example, participating teams must strictly adhere to the Safety and Health Regulations stipulated by the competition committee. Spectators must cooperate with the competition committee by not entering restricted areas and recognizing the dangerous part of the competition tasks. If participating teams do not follow the Safety and Health Regulations and are found to be endangering participants, proper measures will be taken. These measures can range from asking participants to follow safety rules, to stopping of competition tasks, or even disqualification from the competition.

6.1.4 Safety and Health Management Committee

A Safety and Health Management Committee will be formed. This committee members will perform inspections for submitted document, Safety and Health Inspection before starting the competition at the venue, safety patrols during the competition, and point out unsafe acts, systems, and areas. Depending on the situation, competition may be suspended until improvements are made, and teams may be asked to stop their operations or even be disqualified. Teams must follow the instructions by the organization member.

6.1.5 Safety and Health Advisory Organization

An organization that advises on safety and health measures will be deployed in advance of the competition. Participating teams can seek advice from the organization for their safety measures and submitted materials described in below section, if necessary.

6.2 Safety and Health Regulations

6.2.1 Hardware Requirements

See Section 4.2 for hardware requirements. However, the Safety and Health Management Committee may restrict on use of the hardware if they are harmful to safety and health.

6.2.2 Safety and Health Requirements of Competition Systems

Competition systems must have accident prevention functionality installed. There must be emergency stop buttons, safety fences, a door with a safety switch, and an input from motion sensors. If there is a teaching device, there must be a properly working dead man’s switch. All of these must work properly, otherwise permission to participating in the competition will not be given.

All environmental pollution must be prevented. Noise, vibration, electromagnetic noise, harmful rays, air pollution, exhaust gas, waste liquid, toxic substances and any other harmful substances are prohibited from use without proper control or management. Please be especially aware of the output power of laser lights. These information must be included in the risk assessment. Failure to report will result in ineligibility.

If such as roofs, shades, towers, highly raised stages will be used to control natural light and artificial lightings or to install bird eye cameras, lightings, vision sensor system, please make an
application in advance as the fire extinguisher must be reinstalled. Failure to apply can result in a starting delay or, worst, disqualify the competition.

As necessary, competition systems including robots may be fixed to the floor with anchor bolts. If using anchor bolts, please apply in advance to ensure the availability of installation operation. Failure to apply in advance can result in a starting delay or suspension.

6.2.3 Materials for Advance Submission

Each team should submit following documents as an evidence for the risk assessment clarifying the team name, its representative person and the risk assessment implementation date by the prescribed date before the competition;

1. Overall description of the robot system
2. Operation manual of the system including prohibited matters
3. Risk assessment sheet including risk assessment and risk reduction measures
   The risk assessment sheet must also contain the followings;
   (1) Description of safety systems including emergency stop switches and door interlock switches and their safety performance
   (2) Mode switching circuit and its explanation
4. Residual risks list

Required materials are subject to change. Failure to submit them will result in disqualification.

Personal clothing and protective equipment to be worn by people working within the safety fence are defined in Table 4, and all members of the team must comply with it. Include this issue in the submitted materials.

Table 4: Clothing and Protective Gear for Work Inside the Safety Fence

<table>
<thead>
<tr>
<th>Item</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hair</td>
<td>Make sure to bundle long hair</td>
</tr>
<tr>
<td>Work clothing</td>
<td>Make sure to wear long sleeves and long pants that are not baggy</td>
</tr>
<tr>
<td>Helmet</td>
<td>Make sure to wear the proper type of helmet considering the length of use to mitigate head injuries</td>
</tr>
<tr>
<td>Protective goggles</td>
<td>Always protect your eyes. Make sure to wear the proper goggles, such as those that protect the eyes from scattering objects and hazardous rays.</td>
</tr>
<tr>
<td>Gloves</td>
<td>Make sure to wear the proper type of gloves for static resistance and cut resistance for each object. However, gloves are strictly prohibited when using rotation tools because they can become entangled.</td>
</tr>
<tr>
<td>Ear plugs</td>
<td>Make sure to wear the proper ear plugs for impulsive sound and steady noise to protect your hearing ability.</td>
</tr>
<tr>
<td>Safety shoes</td>
<td>Always protect your feet. Make sure to wear the proper type of shoes as necessary.</td>
</tr>
</tbody>
</table>
6.2.4 Preparation before Starting Competition at the Venue

Each team will be provided safety fence and door switches etc. forming a safety circuit with open ended contact points. Each team will install their competition systems within and only within the safety fence (i.e. inside the System Running Area), and the competition systems must be connected to the safety circuit. However, computers and controllers whose housing shape does not change may be set up within the Operation Area. The equipment may not protrude from these areas regardless of where they are set up. The safety circuit consists of a door switch for the safety fence, an emergency stop button, signal lights, movement sensors, and more. Detailed specifications for the safety circuit will be provided separately.

6.2.5 Requirements to Pass Safety and Health Inspection before Starting Competition at the Venue

The Safety and Health Management Committee will examine the safety and health aspects of the systems. An inspection will be held individually for each team. Safety and health inspections determine whether each team satisfies the regulations. Teams that do not meet the criteria will receive a request for improvement.

Teams may not participate in the competition until they pass the inspection.

6.2.6 Execution of Safety Patrols at the Venue

Safety and health patrols will be carried out as needed. Corrective action will be recommended with regards to any safety and health concerns. Detection of undeclared items, competition systems with safety and health problems, non-use of necessary protective equipment, unsafe acts, etc. will be pointed out. Depending on the situation, the competition may be cancelled, the applicable team(s) may be ordered to stop the competition, or the applicable team(s) may be disqualified.

6.3 Operation Modes

The following operation modes are defined for robots and/or the robot systems in order for the systems to run safely. Using different operation modes for the preparation phase, operation phase, and reset phase aims for safe operations, and keeps people from harm.

The following three modes must be implemented.

- Automatic Mode
- Emergency Stop Mode
- Manual Mode (Reduced Speed)

The following mode is recommended to be implemented in order to perform tasks more conveniently.

- Protective Stop Mode

Each mode will be explained as follows.

6.3.1 Automatic Mode:

This is the operation mode for ordinary work, corresponding to the Automatic Mode in the ISO
standard, and there is no restriction on robot operation. During Automatic Mode, people must never enter the System Running Area. The door between the System Running Area and the Operation Area must be closed.

6.3.2 Emergency Stop Mode:

When entering this mode, the robot stops and the power must be shut off. In the event of a system problem, the system should be immediately switched to this mode either automatically or manually. It corresponds to the Emergency Stop (Category 1 or 0) in the ISO standard. During Emergency Stop Mode, people can enter the System Running Area (including the Robot Working Area). The door between the System Running Area and the Operation Area may be opened.

6.3.3 Manual Mode:

It corresponds to Manual Mode (Reduced Speed) in the ISO standard. In this mode, power is supplied to the robot and the servo is on. The speed of the robot is limited to 250mm/second. The human operator can use a teaching pendant or a similar device to control the robot manually. However, if and only if the state is Bring-in/Carry-out State, the human operator is not allowed to control the robot. Human are allowed to enter the System Running Area (including the Robot Working Area). The door between the System Running Area and the Operation Area may be opened.

6.3.4 Protective Stop Mode:

This additional mode can be implemented for the team’s convenience. It corresponds to the Protective Stop (Category 2, 1, or 0) in the ISO standard. The robot is stopped, but power may be supplied. Humans may enter the Bring-In/Carry-Out Area in the System Running Area. However, they must not enter the Robot Working Area. The human operator is not allowed to control the robot. The door between the System Running Area and the Operation Area may be opened. This mode is supposed to be used mainly when bringing in parts and carrying out assembled products.

Figure 10 illustrates a case where all four operation modes are implemented.

Robots with three operational modes (Automatic Mode, Emergency Stop Mode, and Manual Mode) are as illustrated in Figure 11.

Figure 12 shows the relationship between the robot operation modes and task phases, and the conditions allowed in each operation mode. The revolving light must be turned on during the preparation phase and reset phase to show that it is permitted for the human operator to control the robot. The human operator is not permitted to control the robot when this revolving light is turned off.

At present, we are considering the use of the items shown in Figure 13 for safe operations.

The signal tower is a display device used to notify the operator, the referees, and others about the current operating mode of the robot. The mode select switches are push buttons (momentary) used to allow the operator to manually change the operating mode of the robot. The phase select switch and phase information revolving light are items in order to show the
current phase. When the emergency stop switch, safety door switch, or safety light curtain is activated, the robot should transition to the emergency stop mode immediately.

With four modes: **Automatic Mode**, **Protective Stop Mode**, **Manual Mode** and **Emergency Stop Mode**

- **Servo OFF**
  - Emergency Stop Mode: operator can be in system running area, door may be opened

- **Servo ON/OFF**
  - Manual operation allowed, Speed limit (250mm/s)
  - Manual Reduced Speed Mode

- **Servo ON**
  - NO manual operation
  - Protective Stop Mode (*)
  - Delivery to/from bring-in/carry-out area

**Operation Phase**

**Preparation Phase / Reset Phase**

Figure 10: Implementation case with four robot operational modes

With three modes: **Automatic Mode**, **Manual Mode** and **Emergency Stop Mode**

- **Servo OFF**
  - Emergency Stop Mode: operator can be in system running area, door may be opened

- **Servo ON/OFF**
  - Manual operation allowed, Speed limit (250mm/s)
  - Manual Reduced Speed Mode

- **Servo ON**
  - NO manual operation
  - Delivery to/from bring-in/carry-out area without any manual operation during Operation Phase
  - Automatic Mode

**Operation Phase**

**Preparation Phase / Reset Phase**

Figure 11: Implementation case with three robot operational modes
Excluding some of them, it is not necessary for the teams to use all of those switches and devices. However, if some of them are not used, there must be some alternative way to ensure a safe mode transitions, and the team must pass the safety inspection.

Various examples of operation transitions are shown in Figures 14-15.
Switches and Signal Towers

Figure 13: Items planned to use for safe operations

With four modes: Automatic Mode, Protective Stop Mode, Manual Mode and Emergency Stop Mode

Figure 14: Example of mode transition between four operational modes
7 Task-Specific Rules

7.1 Task-Board Task

7.1.1 Outline

In this task the elemental technology for assembling a belt drive unit is extracted and arranged on a task board. In this task, the robot must pick up the parts placed on the parts tray and small parts on the parts holder, and assemble them to the designated locations on the task board. The robot may use appropriate tools as necessary.

Figure 16 shows the parts arranged on the parts tray, Figure 17 (a) shows the task board with assembled parts, and Figure 17 (b) shows its side view. Figure 18 shows the task board in its initial state before the parts have been assembled. The plate and parts shown here are still preliminary version. So, the parts and arrangement in the competition may be different. Please refer to the upcoming rules.

In this task, teams compete for the superiority of the elemental technologies required to assemble a belt drive unit, such as recognition of parts, alignment of parts, insertion of parts, fitting of parts, fastening of parts, and attachment of flexible parts. In some operations, it will be necessary to consider the order of the work, for example first fitting the bearing housing in to the hole of the L-shaped plate then fastening it with bolts. Technical challenges in the task-board task are (1) part recognition and grasping, (2) fitting parts with very small clearances, (3) nut screwing, (4) flexible part (e.g., a belt) and tiny part grasping and assembly, and (5) simultaneous 3-part assembly.

---

1 The idea and design for the task-board task was strongly inspired by the task board designed by NIST, which was used in the 2nd Robotic Grasping and Manipulation Competition [3] held at IROS2017 [6].
Figure 16: Parts on the parts tray for the task-board task

Figure 17: (a) Assembled task board (front view) (b) Assembled task board (side view)

Figure 18: Task board before assembly (initial state)
7.1.2 Rule Details

(1) Parts supply method and task board

This task will use the same parts used in the assembly task. See Appendix A.1 for details on the parts to be assembled. There will be several parts already assembled on the task board. These parts are detailed in Appendix A.2. The parts listed in Appendices A.1 and A.2 are all products made by MISUMI. Details about individual parts can be found on the MISUMI website. 3D-CAD data files for the parts are available to download from the MISUMI website. Unlike WRS 2018, the material of the task board will be metal (Aluminum A5052: No surface treatment) so that the difficulty in fitting parts with tight clearance would be the same as the assembly task. Additionally, in order to match the working direction with the assembly task, the plate on which the parts are to be assembled stands upright on the base plate. The sizes of the two plates will be detailed in Appendices A.3 and A.4. Markers may not be placed on the task board or the parts. Finally, note that the layout of the task board which will be used in the actual task-board task in the WRS 2020 may be different from that shown in Appendix A.4.

After the preparation phase is completed, the operation phase begins, and the robot assembles the parts on the task board. During the operation phase, competitors may not touch the robot, parts, tools, task board, parts tray, or parts holder for small parts.

During the operation phase, the robot system will do the following operations with the parts:

(i) The robot system picks up parts from the parts tray or the parts holder.

(ii) The robot system assembles the parts on the board in predetermined positions.

The above procedure is repeated for each of the parts. However, the set screw is already assembled on the task board (see Appendices A.2 and A.5). Teams must assemble as many parts as possible accurately within the allotted task time. The order in which the parts are assembled may be decided by the team. As the parts will stay on the task board after they are placed, the placed parts may interfere with the operations of the robot system that come after.

If a reset is declared, teams must return all parts to their initial positions except the set screws.

(2) Preparation phase

When the preparation phase starts, the referee will supply teams with a task board and parts. The referee will use a template to place the parts in the operation area to be assembled in the parts tray during the preparation phase. Details about the template will not be made public. Figure 19 shows a jig for placing the idler pulley. This jig will be made out of ABS resin by a 3D printer, but note that the material of this jig may be aluminum. The size will be 50mm x 50mm x 10mm and there will be a through hole in the center of 6.3mm in diameter. The task board will be supplied to the teams in the state shown in Figure 18. Teams can place the task board anywhere within the system running area during the preparation phase. Teams will be able to fix the task board on the working table with a clamp, place a non-slip mat beneath the task board, and place necessary tools during the preparation phase as needed. Teams must prepare the needed tools by themselves. Teams may modify tools as necessary. Tools used may be installed into the robot hand in advance. The preparation phase is scheduled to take at least ten minutes. During the preparation phase, the parts tray may be brought into the system running area by using the push cart.
Figure 19: The jig for placing the idler pulley

Table 5: Points of Task-Board Task

<table>
<thead>
<tr>
<th>Subtask</th>
<th>Target part(s)</th>
<th>Task Description</th>
<th>Points</th>
<th>Completion Level</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Level 0</td>
<td>Level 1</td>
</tr>
<tr>
<td>1</td>
<td>Bearings with housing, 4 x M4 Bolt</td>
<td>Insertion into a hole, Screwing into a tapped hole</td>
<td>0</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>2</td>
<td>Idler pulley, M6 Nut</td>
<td>Fastening a nut and a bolt</td>
<td>0</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>3</td>
<td>6mm Shaft</td>
<td>Insertion into a hole</td>
<td>0</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>4</td>
<td>M3 Set screw</td>
<td>Screwing into a tapped hole</td>
<td>0</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>5</td>
<td>4mm Round belt</td>
<td>Looping over pulleys</td>
<td>0</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>6</td>
<td>Pulley</td>
<td>Placing onto a shaft</td>
<td>0</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>7</td>
<td>M3 Bolt</td>
<td>Screwing into a tapped hole</td>
<td>0</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>8</td>
<td>M4 Bolt</td>
<td>Screwing into a tapped hole</td>
<td>0</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(3) Evaluation method and point allocation

After the end of the time period of the task, the task board will be evaluated as it sits in the System Running Area. If the robot is touching any parts or the assembled product at the end of the task, those parts will not be scored. Points are added based on the number of completed parts. Points are allocated based on the completion level of assembly. The completion level will be set for each part. See Table 5 for the scoring based on the completion levels. A chart of these levels can be found in Appendix A.5. Assembling of flexible parts, tiny parts, and three parts assembled simultaneously with multiple arms will be scored higher.

In the event that all parts are completely assembled, points for a time bonus will be awarded based on the amount of time remaining for the task. In order to get a time bonus, all parts must be completed at level 1. One point will be awarded for every 20 seconds of remaining time for a maximum of 50 points.
On Day 1 of the competition, the competition of the task-board task will be held twice, and better score of the two tries will be applied. The competition time is planned to be 20 minutes.

7.2 Assembly Task

7.2.1 Outline

The purpose of this task is to quickly and accurately assemble a model product that contains the elemental technologies necessary for the assembly of industrial products. At the WRS 2020 competition, teams will assemble the belt drive unit similar to the one used at the WRS 2018 competition (Figure 20). Note that the model product for WRS 2020 is not exactly the same as the model product for WRS 2018. In this task, the robots of each team must pick up parts directly from the provided parts tray, and assemble a belt drive unit from those parts. Also, in order to evaluate the ability to respond quickly to new production demands, the robot system will be required to assemble a new product (surprise product) that will be announced for the first time just before the competition begins. This means that teams will have to make quick setup changes. However, information on parts that will constitute the surprise product will be announced in advance so that hands and other devices can be designed and prepared in advance. If necessary, the robots may use appropriate tools.

The assembly task will be held over the series of two days. The first day of the assembly task (Day 2) will be for assembling a pre-announced normal product. The second day of the assembly task (Day 3) will be an assembly task that includes a surprise product. After the competitions, an exhibition will be held on Day 4.

In addition to the items mentioned in the task-board task, technical challenges in the assembly task are recognizing and grasping various sizes of parts, motion planning of multiple arms, jig-less assembly, and agile response to surprise products. In order to utilize these technologies, teams must be able to include force sensors, vision sensors, and robot hand systems (multiple hands may be used) that can grasp a variety of parts, using robots with appropriate movable range. All should be able to be set up within a short time.

Additionally, details of parts supply and method of carrying out the assembled product are outlined in sections 5.2 and 5.3. Be aware that the parts tray is expected to be used when bringing in parts, as well as when carrying out the assembled product.

In this competition, we aim to realize the future of manufacturing through construction of production systems that can respond to variable production requirements in agile and lean manners (ultimately even for one-off production requirements) in high-mix low-volume production (variate-variable production). We expect teams to realize a system that can be changed over quickly as well as performing rapid production.
7.2.2 Overall competition schedule

The first day of the assembly task (Day 2) will be the day when teams assemble the normal product for which all design information has been released in advance. Each team will carry out two tries. Better score of the two tries will be applied. On the second day of the assembly task (Day 3), teams will assemble both the normal and surprise products alternately within the allotted competition time. This competition is designed to assemble normal and surprise products in a mixed production style. On Day 3, tries will only be conducted once for each team. Note that the schedule of Day 3 is subject to change.

7.2.3 Competition time

Day 2: Assemble two normal products. Task time is scheduled to be 30 minutes. The order of the start time for each team will be determined by the competition committee. There will be two tries, one in the morning and one in the afternoon.

Day 3: Assemble two normal products and one surprise product. Each team will only have one try. Task time is scheduled to be 60 minutes. It is not yet decided when the information about the surprise product will be disclosed, but it will be after setup at the venue. The order of the start time for each team will be determined by the competition committee. Note that the schedule of Days 3 and 4 is subject to change.

7.2.4 Definition of subtasks

The assembly tasks can be done in any order, but the level of completion of the product will be evaluated through the following subtasks. Additionally, during a reset, any subtasks undertaken will be reset to their initial state. The subtasks for the belt drive unit assembly are listed below.
• Subtask A – Attach the motor to the motor fixing plate with screws.
  ➢ Related parts numbers (refer to the parts list appendix): 3, 4, 18
  ➢ Conditions for task completion: All of the screws must be attached without any gaps. The referee will make a visual check.

• Subtask B – Attach the pulley to the motor shaft.
  ➢ Related parts numbers: 4, 5, 19
  ➢ Conditions for task completion: The motor-shaft-pulley must be correctly attached to the motor shaft. Conditions for this are: 1) The face of the pulley and the face of the tip of the shaft are aligned (the degree of alignment will be confirmed visually). 2) The rotation axis of the set screw is nearly perpendicular to the D-cut surface of the motor shaft. Please note that whether or not the pulley is attached to the shaft by the set screw with sufficient torque will be evaluated at the final product evaluation stage.

• Subtask C1 – Attach the bearing holder to the output shaft fixing plate with screws.
  ➢ Related parts numbers: 2, 7, 17
  ➢ Conditions for task completion: The bearing holder must be attached to the output shaft fixing plate in the right direction, and be affixed with four screws.

• Subtask C2 - Insert the output shaft into the bearing holder, and attach the end cap to the output shaft with screws.
  ➢ Related parts numbers: 7, 8, 9, 17
  ➢ Conditions for task completion: The output shaft must be inserted into the bearing holder in the right direction, and the end cap must be fixed with screws.

• Subtask D – Attach the output shaft pulley to the output shaft.
  ➢ Related parts numbers: 7, 8, 9, 10, 11
  ➢ Conditions for task completion: The pulley clamp is facing out and attached to the output shaft. The fixed position must be in contact with the inner ring of the bearing with a spacer in-between (but since it is difficult to evaluate the fixed location through a visual inspection, it will be done by checking the distance between the pulley face and the plate face). Additionally, the end cap and inner ring of the bearing must be in contact.

• Subtask E - Assemble the tension pulley with the output shaft fixing plate
  ➢ Related parts numbers: 2, 12, 13, 14, 15, 16
  ➢ Conditions for task completion: The tension pulley and the related parts are fixed in the correct order on the output shaft fixing plate as specified in the design drawing.

• Subtask F – Assemble the motor fixing plate and the base plate with screws
  ➢ Related parts numbers: 1, 3, 17
  ➢ Conditions for task completion: The motor fixing plate and the base plate must be affixed
with two screws. Plates at the correct angle that do not wobble will be evaluated favorably.

- **Subtask G – Assemble the output shaft fixing plate and the base plate with screws.**
  - Related parts numbers: 1, 2, 17
  - Conditions for task completion: The output shaft fixing plate is fixed to the base plate with two screws. Plates should be fixed with the correct angle and should not wobble.

- **Subtask H – Assemble the belt**
  - Related parts numbers: 6 and the parts assembled in the previous subtasks
  - Conditions for task completion: The belt is correctly fitted in the grooves of the two pulleys, and it has sufficient belt tension through being pushed by the tension pulley.

- **Subtasks I1 and I2 – The Connetcer is inserted into the terminal**
  - Related parts numbers: 4, 20, 21, 22, 23
  - Conditions for task completion: The power cable should be inserted into the terminal block without any protrusion of the terminal cover of the power cable from the top face of the terminal block.

The referee will determine the level of completion of each subtask after the task is over. However, if a product evaluation has been conducted, the completion level check will be done afterwards. This means that if a part falls off or goes slack or loose during the product evaluation, the subtask for that portion will be evaluated as incomplete.

If all subtasks are determined to be completed (excluding subtasks I1 and I2), then the product will be deemed completed, and completion bonus points will be added to the score.

Please note the above subtasks are defined for the normal product, and the surprise product will have different definitions.

**7.2.5 Details of Subtask I1 and I2**

This subsection describes the connector insertion process which is required by Subtask I1 and I2. The motor used in the task will be provided with power cables that have rod-type crimp terminals as shown in Figure 21. The cable insertion task involves inserting the rod-type crimp terminals at the end of the power cables into the designated locations on a clutch lock terminal block which has already been affixed to the base plate. Parts information about the terminal block and rod-type crimp terminals to be used can be found in the appendix. The cables are red and black wires equivalent to AWG No.22 wire cut to about 14cm. The covering at both ends is removed by about 1cm, and performed soldering to the motor and crimping of the terminals, respectively. The type and length of the power cable are subject to change.
Figure 21: The appearance of the motor to be provided for the assembly task, and a close-up view of the rod-type crimp terminals

Figure 22: A snapshot when cable insertion task (Subtask I1 and I2) is successfully completed

Figure 23: Conceptual diagram of the surprise product which was actually introduced in the WRS 2019 trial competition

7.2.6 Product evaluation

After the task is completed, teams can ask the referee to evaluate their assembled products. Product evaluation will involve checking whether the belt drive unit functions correctly, and points will be assigned based on the level of achievement. Teams can request their product evaluation regardless of whether the product is perfectly completed or not.

7.2.7 Surprise product

The surprise product for WRS 2020 will have the same winding function as the normal product. Information about the parts used for the surprise product (the approximate shape and
size, etc.) will be released with enough time for the teams to prepare hands and other necessary devices for those parts. Figure 23 is a conceptual diagram of the surprise product planned for the WRS 2019 trial competition. Note that Figure 23 is just an example of the surprise product and in the WRS 2020 other types of surprise product may be introduced.

Table 6: Points Table of Assembly Task

<table>
<thead>
<tr>
<th>Description</th>
<th>Points</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Subtasks</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F, G</td>
<td>2 (each)</td>
<td>4 points in total</td>
</tr>
<tr>
<td>B, C1, C2, D</td>
<td>3 (each)</td>
<td>12 points in total</td>
</tr>
<tr>
<td>A</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>E, H, I1, I2</td>
<td>5 (each)</td>
<td>20 points in total</td>
</tr>
<tr>
<td>All subtasks (excluding subtask 11 and 12) are completed</td>
<td>30 (+50 for surprise)</td>
<td></td>
</tr>
<tr>
<td>Product evaluation (visual and function)</td>
<td>30 (+50 for surprise)</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100 (normal)</td>
<td>200 (surprise)</td>
</tr>
</tbody>
</table>

Points of Day 2

<table>
<thead>
<tr>
<th>Description</th>
<th>Points</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Belt Drive Assembly (Max. 2)</strong></td>
<td>100 (each)</td>
<td>200 points in total</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>200</td>
<td>Not including time bonus</td>
</tr>
</tbody>
</table>

The time bonus is as follows:

\[
\text{Time bonus} = \text{INT}((\text{standard time[sec]} - \text{spent time[sec]}) / 10) \times 1 \text{ point}
\]

(The upper limit of the time bonus points is 90 points.)

Points of Day 3

<table>
<thead>
<tr>
<th>Description</th>
<th>Points</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Belt Drive Assembly (Max. Two Normal Products)</strong></td>
<td>100 (each)</td>
<td>200 points in total</td>
</tr>
<tr>
<td><strong>Belt Drive Assembly (One Surprise Product)</strong></td>
<td>200</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>400</td>
<td>Not including time bonus</td>
</tr>
</tbody>
</table>

The time bonus is as follows:

\[
\text{Time bonus} = \text{INT}((\text{standard time[sec]} - \text{spent time[sec]}) / 10) \times 1 \text{ point}
\]

(The upper limit of the time bonus points is 180 points.)
7.2.8  Scoring

Only products that have been transported to the designated area outside the System Running Area within the allotted competition time will be subject to evaluation and scoring. Scoring is done by adding points according to the completeness of each subtask. The evaluation of the completeness of each subtask will be evaluated based on the state of the assembled parts related to the corresponding subtask. If all subtasks (except I1 and I2) are completed, completion bonus points will be added. Table 6 shows the points for the assembly task. Please note, the scoring policy may be changed based on the feedback from the WRS 2019 trial competition.

7.2.9  Time bonus

Teams assemble a maximum of two belt drive units on Day 2 and three on Day 3. If all product assembly required for the task has been completed before the end of the competition time limit, a time bonus will be awarded based on the amount of remaining time. A completed product is defined as a product that has all subtasks completed (but excluding subtasks I1 and I2) and passes the product evaluation task.

8  Documents for submission

The documents to be submitted before the competition is held are listed in Table 7. The submission deadline is scheduled to be about two weeks before the competition. Exact dates will be released at a later date. However, the documents listed here are preliminary, and there may be additions or removals from the list of documents for submission. Details about each document for submission will be announced to the teams.

The contents determined at this moment are shown as follows. Please note it may change in the future.

(A) Technical Document

Teams should prepare the following six pages of technical documentation in a PowerPoint format that includes the content that would be difficult to understand from the competition alone. In particular, the slide of 5, Summary should indicate what level the team's system is, based on Table 1, and include the basis for that evaluation, as well as the appeal points and efforts of the team towards social implementation in the future.

1. Team Introduction
2. Overall Outline of the System
3. Assembly Task: Hardware and software efforts regarding the operations for bring-in/carry-out by the cart for picking parts from the parts tray
4. Assembly Task: Hardware and software efforts regarding the assembly operations (including for a surprise product)
5. Summary: Summary of the team appeal points (agile and lean) and efforts towards social implementation
The technical documentation will be used for evaluating each team for academic awards and it will also be referred to for scoring technical points.

(B) Video clip introducing the team and system

A video clip introducing the team, team members, and the robot system that the team has built. Overall length should be approx. 2 minutes.

(C) Risk Assessment Sheet

See section 6.2.3 for details.

(D) Exhibition Presentation File

Teams asked by the judging committee to join an exhibition must prepare their exhibition presentation file and submit it to the committee after the exhibition. The presentation file submitted will be kept by the competition committee. Teams will be notified about their participation in the exhibition after the points are all finalized on Day 3. Exhibition presentation files can be based on the (A) technical documentation, with edits and additions made as necessary.

(E) Symposium Presentation File

Teams who will present at the symposium must submit their presentation file after their presentation is finished. The submitted presentation file will be kept by the competition committee. Symposium presentation files can be based on the (A) technical documentation, by modifying it and adding new information as necessary.

Table 7: List of Materials for Submission

<table>
<thead>
<tr>
<th>Required?</th>
<th>Item</th>
<th>Format</th>
<th>Submission Deadline</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓</td>
<td>Technical Documentation</td>
<td>PowerPoint File</td>
<td>Late Sept.</td>
<td></td>
</tr>
<tr>
<td>✓</td>
<td>Team and System Introduction Video</td>
<td>Mpeg File</td>
<td>Late Sept.</td>
<td></td>
</tr>
<tr>
<td>✓</td>
<td>Risk Assessment Sheet</td>
<td>pdf</td>
<td>Late Sept.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Exhibition Presentation File</td>
<td>PowerPoint File</td>
<td>After the exhibition is held (Only for exhibition teams)</td>
<td>Modified file based on the technical documentation</td>
</tr>
<tr>
<td></td>
<td>Symposium Presentation File</td>
<td>PowerPoint File</td>
<td>After the symposium is held (Only for teams who presented in the symposium)</td>
<td>Modified file based on the technical documentation</td>
</tr>
</tbody>
</table>
9 Symposium

A symposium of the WRS Industrial Robotics Category will be held on the next day of the final day of the competition (Day 3), October 12 (Monday). The goals of this symposium are:

- Technical exchange between participating teams,
- Feedback from teams about reflection points of the WRS 2020,
- Opinions from teams regarding future competitions.

Details about the symposium will be announced later. Like the one held in WRS 2018, it will all be held in the morning. Participation in the symposium will only be open to involved parties (teams, committee, sponsors and secretariat), but the press will be allowed to listen-in.

Participation in the symposium is voluntary. Considering the purpose of the symposium, however, teams are strongly encouraged (at least one member per team) to participate in this symposium. Further, top winning teams are strongly encouraged to present at the symposium.

10 Schedule

The schedule leading up to the WRS 2020 competition is as follows, but please note that it may change without prior notice.

Year 2019

June Outline of competition rules released for recruitment purposes (finished)
June to August Participating team recruitment period (finished)
September to November Team selection (finished)
December Trial competition (at iREX 2019) (finished)

*the trial competition is unrelated to team selection and results for WRS 2020
Decision and notification of teams that passed the first review (finished)

Year 2020

January Release of task rules for participating teams (this rule, finished)

Teams who wish to be provided rendering robots for the competition will be notified their robot specifications and when the robots will be provided at this point (tentative).

Announcement of the contents of the Final Examination (Stage gate) (finished)

* Announcement has been done only to the teams that pass the first review.

March Release of task rules (final major revision based on the results of the WRS 2019 trial competition) for participating teams.
Submission of the materials for the Final Examination (Stage gate)

<table>
<thead>
<tr>
<th>Month</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>April</td>
<td>Final review (Stage-gate)</td>
</tr>
<tr>
<td>May</td>
<td>Final screening notifications</td>
</tr>
<tr>
<td></td>
<td>Release of task rules (final version) for participating teams (tentative)</td>
</tr>
<tr>
<td>August</td>
<td>Team site visit</td>
</tr>
<tr>
<td>October</td>
<td>WRS 2020 Competition</td>
</tr>
</tbody>
</table>

11 Conclusion (Robotics for Happiness)

The underlying theme of the WRS is “Robotics for Happiness.” Before concluding the rules, we would like to consider what “Happiness” means for the WRS Industrial Robotics Category.

In order to achieve the goal of the Industrial Robotics Category, ‘agile one-off manufacturing,’ it is necessary to use industrial robots as ‘programmable universal machines’ that are able to respond to different purposes. Ultimately, we, the Industrial Robotics Category, aim at realizing the circulation-based production society as shown in Figure 24. Looking from the production system side, not only the reuse of production assets such as robots but also the reuse of production software is expected in this type of circulation-based production society. On the product side, this society would of course reuse/recycle materials and components as well as reflect the product demand immediately in production plans. Besides that, information about how and where products are used would be leveraged in the subsequent product designs. Further, it should be pointed out that the circulation of entities and software in industrial assets and products is related to the concept of Cyber Physical System (CPS) which has recently attracted attention in INDUSTRIE 4.0 [7] and so on.

If circulation-based production systems can be established in this way, the burden on the environment could be reduced and we could also achieve a society where desired products can be obtained in an appropriate timing at an appropriate price. We believe that this is the “Happiness” that the WRS Industrial Category can bring to the world.

We are looking forward to having many participations not only from the teams that participated in the WRS 2018 pre-competition, but also from all other teams who agree with the concept of this competition. And we also look forward that they show off the technology that will lead to the next generation of production systems in the Assembly Challenge of the WRS 2020.
Figure 24: Circulation-based Production Society

References


Appendix A.

A1_TaskBoard_assembled
Completion configuration of WRS 2020 Task-Board.

A2_TaskBoard_Setup
Setup configuration of WRS 2020 Task-Board.

A3_01-base-01
Geometric feature, dimension and tolerance of the base plate of WRS 2020 Task-Board

A4_02-plate-01
Geometric feature, dimension and tolerance of the 02-plate of WRS 2020 Task-Board

A5_Completion_Level
Completion level of WRS 2020 Task-Board.

Appendix B.

B1-decomposition_state
Exploded view of assembled product unit of WRS2020.

B2_01-base-01
Geometric feature, dimension and tolerance of the base plate of WRS 2020 Assembly Task

B3_02-plate-01
Geometric feature, dimension and tolerance of the motor fixing plate of WRS 2020 Assembly Task.

B4_03-plate2
Geometric feature, dimension and tolerance of the output shaft fixing plate of WRS 2020 Assembly Task.

B5_PartsListAssemblyTask_WRS2020
Detailed parts list of WRS2020.

Industrial Robotics Competition Committee
World Robot Summit

* 16th January, 2020
publish the first version.
<table>
<thead>
<tr>
<th>No.</th>
<th>Model number*</th>
<th>Part name</th>
<th>Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SBARB6200ZZ-30, 4 x SCB4-10</td>
<td>Bearings with housing, M4 Bolts</td>
<td>Insertion into a hole, Screwing into a tapped hole</td>
</tr>
<tr>
<td>2</td>
<td>MBGNA30-2, SPWF6</td>
<td>Idler pulley, M6 Nut</td>
<td>Fastening a nut and a bolt</td>
</tr>
<tr>
<td>3</td>
<td>PSSSFHRT10-75-M4-FC55-G20FAQ6-25-B5</td>
<td>6mm Shaft</td>
<td>Insertion into a hole</td>
</tr>
<tr>
<td>4</td>
<td>MSSFS3-3</td>
<td>M3 Set screw</td>
<td>Screwing into a tapped hole</td>
</tr>
<tr>
<td>5</td>
<td>MBT4-400</td>
<td>4mm Round belt</td>
<td>Looping over pulleys</td>
</tr>
<tr>
<td>6</td>
<td>MBRA30-2-P6</td>
<td>Pulley</td>
<td>Placing onto a shaft</td>
</tr>
<tr>
<td>7</td>
<td>SCB3-10</td>
<td>M3 Bolt</td>
<td>Screwing into a tapped hole</td>
</tr>
<tr>
<td>8</td>
<td>SCB4-10</td>
<td>M4 Bolt</td>
<td>Screwing into a tapped hole</td>
</tr>
</tbody>
</table>

* Products by MISUMI
No. | Model number* | Part name | QTY
---|--------------|-----------|---
0  | SCB4-10      | M4 Bolts  | 4
3  | SBARB6200ZZ-30, SCB4-10 | Bearings with housing, M4 Bolts | 1
4  | MSSFS3-3 **  | M3 Set screw | 1
5_1 | MBGNA30-2, TWASS10-6-3 | Idler pulley, Washer | 1
5_1 | MBGNA60-2, TWASS14-10-1 | Idler pulley, Washer | 1
6  | PSSFAQ6-25-B5 | 6mm Shaft | 1

* Products by MISUMI

** This part is screwed into the L-plate in advance (Offset 2mm).

Top view (1:5)

Part No. | Part name         | Last update 2019-Nov.-20
---------|-------------------|-------------------------
010      | TaskBoard_Setup   | 0.500

World Robot Challenge 2020

Designed by M. Shibata

Checked by H. Dobashi
A5052 (No surface treatment) is used.

Unless otherwise specified, dimensional tolerances are according to JIS B0405 Medium grade.

<table>
<thead>
<tr>
<th>Part No.</th>
<th>Part name</th>
<th>Last update 2019-Oct.-24</th>
</tr>
</thead>
<tbody>
<tr>
<td>000</td>
<td>01-base-01</td>
<td>0.500</td>
</tr>
</tbody>
</table>

World Robot Challenge 2020

Designed by M. Shibata

Checked by H. Dobashi
* A5052 (No surface treatment) is used.

* Unless otherwise specified, dimensional tolerances are according to JIS B0405 Medium grade.

### Part No. 000

Part name 02-plate-01

Last update 2019-Oct.-24

<table>
<thead>
<tr>
<th>Scale</th>
<th>Proj. method</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.500</td>
<td>3rd. angle projection</td>
</tr>
</tbody>
</table>

Designed by M. Shibata

Checked by H. Dobashi

World Robot Challenge 2020
Definitions

- **Contact: X_Y**: Contact with X and Y (e.g. “Contact: bolt_plate” means that the bolt contacts the main plate).

- **NoContact: X_Y**: No contact with X and Y (e.g. “NoContact: bolt_plate” means that the bolt does not contact the main plate).

- **Screw: X_Y**: Screwing with X and Y (e.g. “Screw: bolt_nut” means that the bolt is screwing with the nut).

In case that all conditions are satisfied, the completion level is given for the part.

Checkpoint by referees

Check by thickness gauge (0.3mm)
* The gap is less than the gauge.
Completion Level (2/2)

Definitions

- **Contact: X1_X2 ..._Xn:**
  
  \[= \text{Contact: } X1_X2 \& \text{Contact: } X2_X3 \& \ldots \& \text{Contact: } Xn-1_Xn\]

- **NoContact: X1_X2 ..._Xn:**
  
  \[= \text{NoContact } X1_X2 \text{ or } \text{NoContact } X2_X3 \text{ or } \ldots \text{ or } \text{NoContact } Xn-1_Xn\]

- **NoScrew: X_Y:** No screw exists where screw should exist between X & Y

- **Screw: X1_X2 ... _Xn:** Screwing with X1, ... and Xn

- **Flat: X_Y:** Two surfaces X & Y are nearly aligned

- **NoFlat: X_Y:** Two surfaces X & Y are not nearly aligned
To check the completeness, referees use a thickness gauge.

The referees pinch at the end of the word “0.30mm” when using the gauge.
Completion Level (Parts #1)

Level 0

Contact: housing frange_L plate

Screw: bolts_thread
Contact: housing frange_bolt_head
Contact: housing frange_L plate

Level 1

Screw: bolts_4 threads
Contact: housing frange_4 bolt_heads
Contact: housing frange_L plate

Check by thickness gauge (0.3mm)
Completion Level (Parts #2)

**Level 0**

Screw: bolt_nut

**Level 1**

Screw: bolt_nut
Contact: Ider pulley_L plate
Contact: nut_L plate

Placement is not related to this level.

Check by thickness gauge (0.3mm)
Completion Level (Part #3)

Level 0

Contact: shaft_bearing

Level 1

Contact: shaft_bearings

Referees check whether the part contacts the bearings with eyes.
Completion Level (Part #4)

(Initial condition)

Flat: screw bottom_L plate

The set screw is pre-assembled into the L plate in advance.

Level 1

Screw: screw_thread
NoFlat: screw bottom_L plate

Check by ruler
(The height h: 1mm < h < 3mm)
Completion Level (Part #5)

Level 0

Contact: round belt_pulley groove

Level 1

Contact: round belt_pulley grooves

*The belt should work as a transmission mechanism.

Check whether the belt loops the grooves
Completion Level (Part #6)

**Level 0**

Contact: cylindrical surface (part)_shaft edge

**Level 1**

Contact: cylindrical surface (part)_cylindrical surface (shaft)

Referees check whether the part contacts the shaft with eyes.

OK
Completion Level (Part #7)

Level 0

Screw: bolt_thread
NoContact: bolt head_L plate

Level 1

Screw: bolt_thread
Contact: bolt head_L plate

Check by thickness gauge (0.3mm)
Completion Level (Part #8)

**Level 0**

- Screw: bolt_thread
- NoContact: bolt head_L plate

**Level 1**

- Screw: bolt_thread
- Condition “Contact: bolt head_L plate” will be added in the future.

Check by thickness gauge (0.3mm)
The countersink is on the back.

All slots have a counterbore of 1 mm depth on the back.
World Robot Summit 2020 Assembly Task

Part No. | Part name       | Last update | Scale | Proj method |
---------|-----------------|-------------|-------|-------------|
        | 02-PLATE        | Jan-13-20   | 1.000 |             |

Designer S. Kotosaka

6x\(\Phi 3.4\) P.C.D. 31

60°

2x\(\Phi 4.5\)

6x\(\Phi 3.4\)

25

5

33

35

6

58

15

2x\(\Phi 4.5\)
 Parts list for WRS2020 Assembly Task (without suprise task) 2020.Jan.14

<table>
<thead>
<tr>
<th>No.</th>
<th>Name of part</th>
<th>Note.</th>
<th>Qty.</th>
<th>Retailer</th>
<th>MISUMI order number</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>01-BASE</td>
<td>Base plate</td>
<td>1</td>
<td>manufactured</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>02-PLATE</td>
<td>Output shaft fixing plate</td>
<td>1</td>
<td>manufactured</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>03-PLATE2</td>
<td>Motor fixing plate</td>
<td>1</td>
<td>manufactured</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>04_37D-GEARMOTOR-50-70</td>
<td>70:1 Metal Gearmotor 37Dx54L mm 12V (Helical Pinion)</td>
<td>1</td>
<td>Pololu</td>
<td><a href="https://www.pololu.com/product/4744">https://www.pololu.com/product/4744</a></td>
<td>with power cable No. 22, No. 23.</td>
</tr>
<tr>
<td>5</td>
<td>05_MBRFA30-2-P6</td>
<td>Pulley for Round Belt (4mm) - Setscrew P.D. 30mm</td>
<td>1</td>
<td>MISUMI</td>
<td>MBRFA30-2-P6</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>06_MBT4-400</td>
<td>Polyurethane round belt (welded joint product) P.D. 4mm L=400mm</td>
<td>1</td>
<td>MISUMI</td>
<td>MBT4-400</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>07_SBARB6200ZZ_30</td>
<td>Bearings with Housings (Double Bearings)</td>
<td>1</td>
<td>MISUMI</td>
<td>SBARB6200ZZ-30</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>08_SSFHRT10-75-M4-FC55-G20</td>
<td>Drive shaft (Straight) D10x7</td>
<td>1</td>
<td>MISUMI</td>
<td>SSFHRT10-75-M4-FC55-G20</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>09_EDCS10</td>
<td>End Cap for Shaft</td>
<td>1</td>
<td>MISUMI</td>
<td>EDCS10</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>10_CLBPS10_17.4</td>
<td>Bearing Spacers For Inner Ring (output pulley)</td>
<td>1</td>
<td>MISUMI</td>
<td>CLBPS10-17.4</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>11_MBRAC60-2-10</td>
<td>Pulley for Round Belts Clamping Type P.D. 60mm</td>
<td>1</td>
<td>MISUMI</td>
<td>MBRAC60-2-10</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>12_CLBUS6-9-9.5</td>
<td>Bearing Spacers For Inner Ring (tension pulley)</td>
<td>1</td>
<td>MISUMI</td>
<td>CLBUS6-9-9.5</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>13_MBG30-2</td>
<td>Idler for Round Belt - Wide</td>
<td>1</td>
<td>MISUMI</td>
<td>MBGA30-2</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>14_BGPSL6-9-L30-F7</td>
<td>Bearing Shaft Screw</td>
<td>1</td>
<td>MISUMI</td>
<td>BGPSL6-9-L30-F7</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>15_SLBNR8</td>
<td>M6 Hex Nut. (Fixing for idler shaft)</td>
<td>1</td>
<td>MISUMI</td>
<td>SLBNR8</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>16_SPWF6</td>
<td>M6 Flat Washer (Fixing for idler shaft)</td>
<td>2</td>
<td>MISUMI</td>
<td>SPWF6</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>17_SCB4-10</td>
<td>10mm M4 Socket Head Cap Screw (metric coarse thread)</td>
<td>9</td>
<td>MISUMI</td>
<td>SCB4-10</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>18_SCB3-10</td>
<td>10mm M3 Socket Head Cap Screw (metric coarse thread)</td>
<td>6</td>
<td>MISUMI</td>
<td>SCB3-10</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>19_MSSF3S-6</td>
<td>6mm M3 Hex Socket Set Screw (metric coarse thread)</td>
<td>1</td>
<td>MISUMI</td>
<td>MSSF3S-6</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>20_TW1004</td>
<td>Clutch lock terminal block (compact)</td>
<td>1</td>
<td>MISUMI</td>
<td>TW1004</td>
<td>Supplied with part number 1 (base panel) attached with screw.</td>
</tr>
<tr>
<td>21</td>
<td>21_H0.5/14D</td>
<td>Weidmuller Wire-end ferrule</td>
<td>2</td>
<td>MISUMI</td>
<td>H0.5/14D</td>
<td>Crimped on the ends of the wires of part numbers 22 and 23.</td>
</tr>
<tr>
<td>22</td>
<td>22_NAUL1015_22_BK</td>
<td>NAUL1015 UL compliant wire (black)</td>
<td>1</td>
<td>MISUMI</td>
<td>NAUL1015-22-BK-10</td>
<td>Motor power line. Supplied with soldered to motor.</td>
</tr>
<tr>
<td>23</td>
<td>23_NAUL1015_22_R</td>
<td>NAUL1015 UL compliant wire (red)</td>
<td>1</td>
<td>MISUMI</td>
<td>NAUL1015-22-R-10</td>
<td>Motor power line. Supplied with soldered to motor.</td>
</tr>
</tbody>
</table>