



# **Industrial Robotics Category**

## **Assembly Challenge**

Rules and Regulations 2018

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The Industrial Robotics Competition Committee

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## 1 Background

George Devol applied for his historic *Programmed Article Transfer* patent in 1954. This patent was approved in 1961, and in the same year, the *Unimate* was released from an American company, Unimation, as the world's first industrial robot. His concept of programmable transfer machine and operating principle called teaching and playback have still remained timeless even today, and they are definitely basic concepts for industrial robots. The fact that most industrial robots, especially arm type robots, in use today are operated by the teaching and playback method demonstrates an appreciation of universality of his ideas.

Here, let's see the problems of the current industrial robots. Considering the cost for implementing standard robot systems, we find the expense of the robot itself makes up no more than roughly 20% to 30% of the total costs. In addition to the cost of peripheral equipment and peripheral devices, system integration—as to integrate all these equipment into a single system—makes up more than 50% of the total costs. 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, in fact often became merely a special purpose system that would not be re-programmed once they had been built up. From that reason, conventional industrial robots based on the teaching and playback method are becoming difficult to cope with the demand of high mix low-volume production in recent years. Furthermore, phenomena returning to use human workers, such as the cell production method, are happening in production sites.

However, Japan and the rest of the world are facing labor shortage and increasing labor costs. The world requires adaptable robotics systems to be implemented even in high mix low-volume production. In particular, small- and medium-size companies that operate under strict cost limitations cannot easily implement robots with large integration costs. Therefore, it is inevitable for us to be able to use industrial robots as "programmable universal machines" so that we can easily configure systems without paying high cost for system integration and reconfigure the systems in agile and lean manners to manufacture different products. Such requirement must be satisfied in order to promote the implementation of robots at small- and medium-size companies as well as major enterprises.

The World Robot Summit (WRS) Industrial Robotics Category aims to realize the future of industrial robotics 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 by setting a goal as '**toward agile one-off manufacturing**'. Table 1 shows the levels of next-generation production systems where the current production systems are set at Level 1 and the highest objective in next-generation production systems are set at Level 5. We are aiming for at least Level 4 at the WRS.

Assembly is one of the most difficult operations for robots. Assembly tasks are often laborious and costly for preparing peripheral devices such as parts feeders and jigs. In addition, a careful teaching is needed for precise parts alignment, and fine adjustment of the teaching data is also laborious and time consuming to overcome 'temporary stoppage' that could occur frequently right after the introduction of new manufacturing systems. 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

The WRS Industrial Robotics Category designed the competition of gear unit assembly as a

trial task in 2017, which was one of the tasks for Manufacturing Track [1] at the 2nd Robotic Grasping and Manipulation Competition held at the 2017 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2017) [2]. At the WRS 2018, a Belt Drive Unit, which includes a greater degree of difficulty than the gear unit, is to be assembled.

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

	Factors during setup changes		Factors during operation	Remarks
	Agility	Leanness	Operation rate improvement	
<b>Level 5</b>	0 day for new product (Changeover on the same day)	100% continual use (Introduction of universal hands able to perform jig-less assembly of multiple products, etc.)	Machine learning (Temporal stoppage prevention/cycle time improvement)  Fully automated recovery (Even big stoppages)	Ultimate goal  Autonomous motion planning, etc.
<b>Level 4</b>	2 days for new product (Changeover on a weekend or an overnight business trip)	Available for new products only by recombining existing equipment. (Universal hands able to grasp multiple products, etc.)	Automatic recovery from temporal stoppage (Learning through observing human intervention, etc.) Human intervention is required for big stoppages.	Target level at WRS  Small number of universal hands
<b>Level 3</b>	1 week for new product (Changeover in a week, e.g. during large consecutive national holidays)	50% or more can be reused (Use of specialized hand library, flexible jig, multi arms, etc.)	Operation rate improvements (Prevention measures against temporal stoppages, etc.)  Automated proposals of improvements.	Offline planning  Reduction of specialized tools with multi arms, etc.
<b>Level 2</b>	1 month for new product	Reusing only robots	Reduction of temporal stoppage rate by absorbing part variations using sensors.	Levels possible with current technologies
<b>Level 1</b>	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.

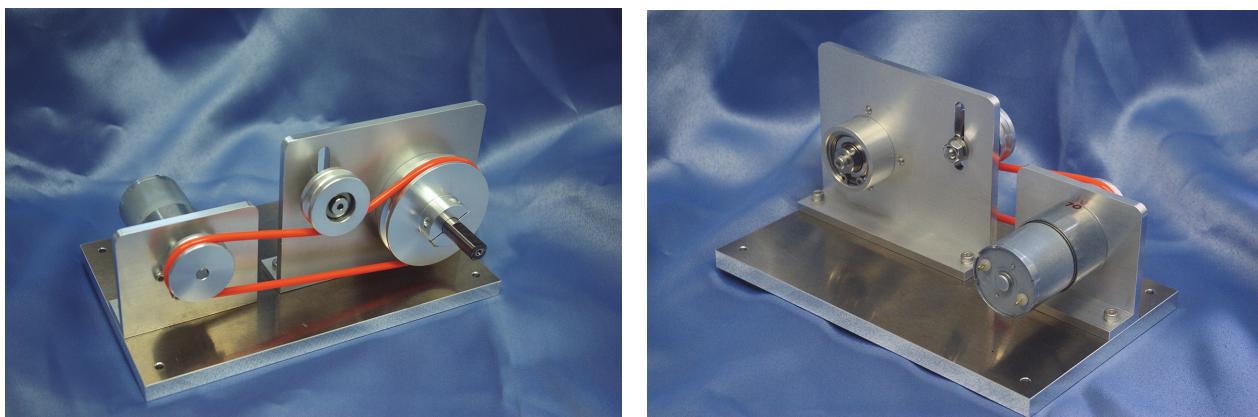


Figure 1: Overview of the Belt Drive Unit for the Assembly Challenge at the WRS 2018  
(The size of the base plate is 200 mm × 120 mm)



Figure 2: Transition of the Competition Tasks and the Technical Challenges from the 2017 Trial Task to the WRS 2020 in the Industrial Robotics Category

An image of the product fully assembled is shown in Fig. 1. Note that, in addition to the assembly of the parts designated in advance, teams shall also assemble parts announced at the competition venue (surprise parts). This assembly requires an agile and lean system reconfiguration. At the WRS 2020, an even more difficult product shall be assembled. Figure 2 shows the transition of the competition tasks and the technical challenges from the 2017 trial tasks to the WRS 2020.

## 2.1 Overview of the Tasks

The following three tasks related to the assembly of the Belt Drive Unit will be given in the WRS 2018.

### 1. Task Board

Teams will compete on basic technologies for assembly by assembling a task board that contains the necessary technical elements for assembling the Belt Drive Unit.

### 2. Kitting

Teams will compete on the speed and accuracy of kitting, which is regarded as a preparation task for the Belt Drive Unit assembly, where the necessary parts should be picked from the parts bins and be laid in the part-kitting trays.

### 3. Assembly

Teams will compete on the speed and accuracy of assembling the Belt Drive Unit using the parts laid out in the part-kitting trays kitted and prepared in advance by the competition committee. Teams will also compete on the ability for an agile setup change to cope with

a requirement of assembling new parts with different specifications from those announced in advance (surprise parts) as a new production demand.

Each team will be required to submit technical documents by a date designated before the competition is to be held. The technical documents should be submitted in a presentation file format with roughly five slides. The documents should describe information that would be hard to understand through the competition tasks alone, such as an introduction of the team, an overview of the systems, and efforts taken in each task as well as efforts taken toward agile and lean production. In particular, the technical documents must clarify a level equivalent to that outlined in Table 1. The technical documents will be used in the scoring for the Society Awards and will be used as reference documents of technical points in the assembly task. See Chapter 8 for more information about the materials to be submitted.

## 2.2 Points for Each Task and Total Points

Table 2 shows the points awarded for each task. The full score is 550 points, but teams may be awarded more than a total of 550 points because a time bonus may be given if the conditions for the time bonus are satisfied. See Chapter 6 for more information about the scoring of each task.

## 2.3 Schedule

Table 3 shows the schedule of the WRS 2018. The WRS 2018 will be held alongside with the Japan Robot Week. The event will be held from Monday October 15<sup>th</sup>, 2018 to Monday October 22<sup>nd</sup> for eight days. The first two days will be used to set up the venue for the event. Teams will compete over the following five days (Day 1 to Day 5) to get points. The last day will be for a symposium. On Day 1, teams will compete in the task-board task. Teams will compete in the kitting task on Day 2. Then, teams will compete in the Belt Drive Unit assembly task using the parts already announced in advance on Day 3 and some surprise parts on Day 4, respectively. A get-together meeting for the teams is planned in the evening of Day 4, after all competitions of the Industrial Robotics Category have been completed. An exhibition and award ceremony are planned for top-ranking teams on Day 5. In addition, a symposium (closed to the public) is scheduled to be held on the last day as a place for technical exchange among the participating teams. Since we are planning to exchange ideas about the contents of the competitions at the WRS 2020 in this symposium, each team is strongly recommended to participate in this event.

Table 2: Points Awarded for Each Task

Day	Task	Points	Remarks
Day 1	Task Board	100	Time bonus awarded separately
Day 2	Kitting	150	Time bonus awarded separately
Day 3	Assembly	100	Without surprise parts; Time bonus awarded separately
Day 4		200	With Surprise parts; Time bonus awarded separately
	Total	550	

Table 3: Competition Schedule

13th	14th	15th	16th	17th	18th	19th	20th	21st	22nd
Setup days				Day 1	Day 2	Day 3	Day 4	Day 5	Post Competition
				Time open to the public				Closed session	
Venue setup	Team setup	Assembly Challenge				Exhibition	Symposium	Get-together meeting	Carrying-out
		Task-Board task	Kitting task	Assembly task					
Team entry prohibited	System setup/adjustments, Safety and health inspection after setup			Without surprise parts	With surprise parts	Exhibition and award ceremony			

As shown in Table 3, teams will have access to the venue from the morning of the 15<sup>th</sup> to begin receiving and unpacking packages as well as to set up. A team leaders meeting is also planned on the 15<sup>th</sup>. Safety and health inspection will be carried out on the 15<sup>th</sup> and 16<sup>th</sup>. This inspection will be conducted separately for every team. The safety and health inspection determines whether or not each team satisfies the inspection criteria. Any team that does not satisfy the inspection criteria will be required to make improvements and may be disqualified from participating in the competition task.

In the evening of Day 5, teams must withdraw all of their equipments from the competition venue. The symposium on the 22nd is scheduled to end by about 1 p.m. More information about the competition schedule will be provided at a later date.

## 2.4 Purpose of the Surprise Task

The WRS Industrial Robotics Category aims at realizing future manufacturing systems that can respond to variously changing orders (ultimately, even an order for a one-off product) by reconfiguring the system in agile and lean manners. Therefore, at the Assembly Challenge, teams compete on the ability for an agile setup change to cope with a requirement of assembling new parts (surprise parts) with different specifications from those announced in advance as a new production demand. These surprise parts will be announced right before the start of the competition (60 minutes in the case of the WRS 2018). The assembly of the product including the surprise parts is called the surprise task.

At the WRS 2018, just a few of the parts shall be replaced by the surprise parts for the assembly of the Belt Drive Unit. At the WRS 2020, however, even more difficult surprise tasks may be required, for example, assembling a completely new product.

## 3 Competition Area and Competition Procedure

The Challenge plans to invite 16 teams to participate. Each team will be assigned a team area. As shown in Fig. 3, the team area consists of an area where the team can run robots and other systems (hereinafter system running area) and an area for operations (hereinafter operation area). The system running area provides enough space to install two arm type robots operating simultaneously as shown in Fig. 4. A work table will be provided but a parts rack, where parts bins are placed, should be prepared (if necessary) by the teams. A single-phase 100 V power source will also be provided. A three-phase 200 V power source will also be made available at the request of any team in addition to the single-phase 100 V power source. An air pressure source will also be provided. A drawing of the system running area will be provided in advance.

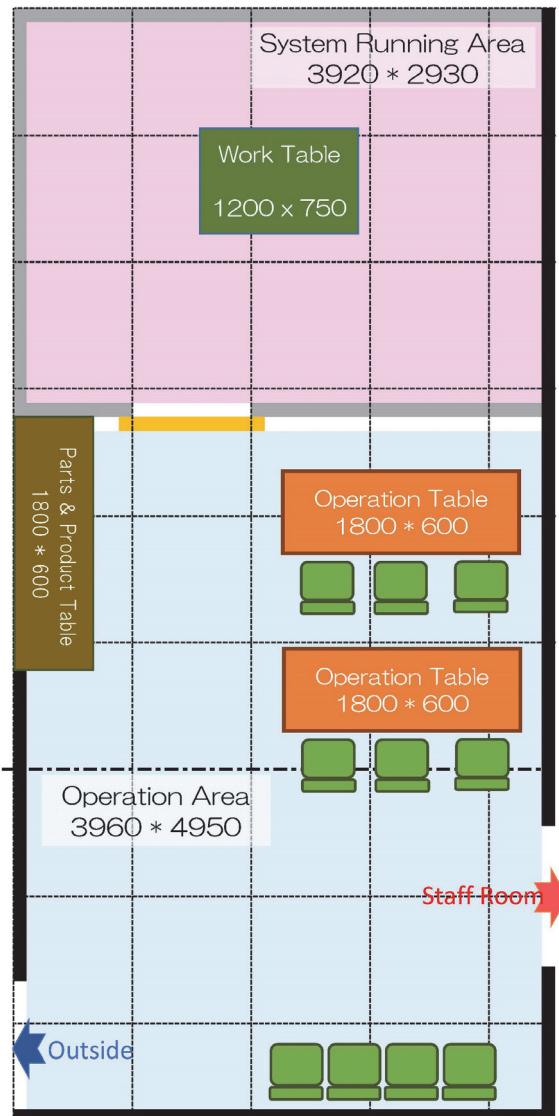


Figure 3: Term Area Consisting of System Running Area and Operation Area

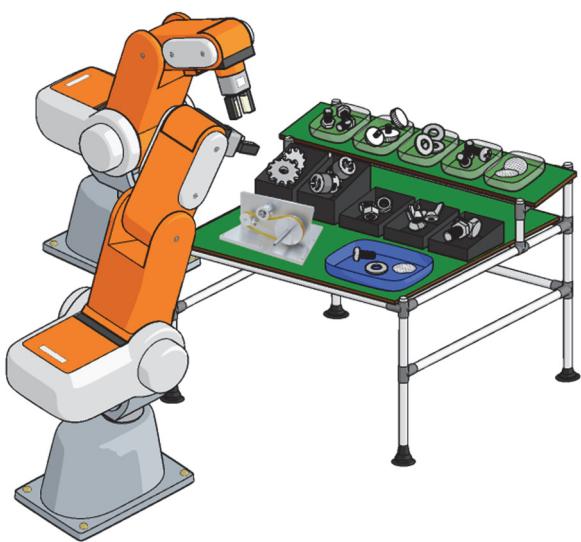


Figure 4: Image of Device and Material Layout including Robot Arms, Parts Rack, and Table in the System Running Area

Note that it is not necessary to use all of the provided materials and power sources (work table, air pressure source, etc.) and the teams are allowed to prepare their own materials independently. When arranging the devices and materials in the system running area, teams must consider the visibility from the spectators. For example, the part rack should not be placed on the traffic side of the system running area and the system running area should not be enclosed or covered by a shade. Note that the competition committee might want to set cameras inside the system running area and the operation area for providing live video to spectators and recording the operation during the competition. If a team puts up a pole that interferes with the view of a camera installed by the competition committee, the competition committee might want to install that camera to that pole. The competition committee will ban flash photography by spectators.

The number of team members allowed to enter the operation area is restricted to ten; however, this number may become less due to the layout change of the venue. Members are allowed to change for each task, but they must not be replaced during a task period.

Teams are allowed to start preparations on the team setup day. The number of people is not restricted on the team setup day, however, preparations by roughly ten people are desirable due to the narrowness of the work space.

### 3.1 Lighting Requirements

Teams may use the lighting provided at the venue for their lighting. The competition committee will install no additional lighting in each team area. Therefore, the brightness, hue and other attributes of the lighting may differ depending on the condition of each team area. In addition, curtains will be used to block out direct sunlight from the windows of the venue, but the brightness may vary according to the weather conditions. Each team may use shades or bring in their own lighting, but it must keep these items in the team area and not interfere with other teams. In addition, each team must be careful not to disturb the operation of refereeing or block the view of the spectators with these items.

### 3.2 Network Infrastructure

Internet connection in each team area shall be provided. Since it is a best effort system, however, it does not guarantee any connection speed. Considering the network load sharing with other teams, the communication band shall be limited to 64 Mbps.

The WRS 2018 will configure a wired LAN. Use of a wireless LAN will be prohibited because it may interfere with tasks in other categories. Furthermore, each team may configure their own Internet environment, but use of a wireless LAN via a Wi-Fi mobile router will also not be permitted.

### 3.3 Time Extensions Due to Trouble

Each team is responsible for any trouble that occurs in their team space 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. However, in the event of issues that impact every team, the competition committee may allow an extension of time after deliberation. For example, this would include power outages.

### 3.4 Competition Time and Scoring

This section describes competition time and scoring. Deductions due to penalties will be explained in Section 3.5.

### 3.4.1 Competition Time

The competition time for each task is made up of the preparation phase and operation phase. The preparation phase is for preparing the initial condition for the task (or returning to the initial condition after reset which is described in Section 3.4.2) in the system running area and operation area. Teams are permitted to enter the system running area during the preparation phase. Once the preparations are completed, the team leader shall signal the start of their operations to a referee to begin the operation phase. In the operation phase, everyone shall be restricted from entering the system running area because the robots and other equipment will be running. In addition, because remote control is prohibited, teams must demonstrate that they are not touching any input devices such as a keyboard by placing paper or a similar material over their input devices.

When a team chooses a “reset” as described hereafter, the team must stop the operation of the robots and other equipment, and return to the preparation phase. The time bonus described hereafter will be given based on the time that remains after subtracting the time taken in both the preparation phase and operation phase from the allotted time limit.

### 3.4.2 Reset

Teams may choose to reset their systems such as the robots, if these systems do not operate as intended during the operation phase. In the event of a reset, the task will return to the preparation phase from the operation phase. Teams shall return the materials to the designated state as specified in each task and start the task again. Moreover, no point deductions will be taken due to a reset, but teams will lose the time taken for the preparation phase and for redoing the task. Be aware that no extension to the time limit for the competition task will be given even if a team declares a reset.

### 3.4.3 Task Completion and Scoring

Referees will score in accordance with the scoring criteria of each task. Basically, referees will evaluate the state of the completed task board, part-kitting trays and products when the competition time has expired in each task. For the incomplete ones, partial points shall be added, in accordance with the scoring system. When the required task has been completed earlier than the time limit of the task, the additional points shall be added in accordance with the remaining time as a time bonus.

## 3.5 Penalties

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

### 3.5.1 Withdrawal from the Competition

If a participating team withdraws from a part of the task, or if the referees judge that the content of the competition by a team is equivalent to withdrawal, this team may be excluded from the evaluation of the ranking. Also, it may be removed from subjects of various awards. Teams will also be withdrawn if they do not satisfy the safety and health criteria or do not follow the directions of the Safety and Health Management Committee. The Safety and Health Management Committee is described in Chapter 4 and the safety and health criteria are described in Chapter

7.

### 3.5.2 Damage to the Field

Teams must not bump into or damage any materials at the competition venue. Any team who causes serious damage that would not be repaired shall be disqualified. Furthermore, this rule and regulation applies to the damage caused not only by a robot but also by team members. However, the placement of markings is permitted based on the rules and regulations for each task.

### 3.5.3 Interference to Other Teams

As team space is quite close together, a team must not cause problems to neighboring teams. This policy applies to the cases not only protruding their belongings out of each team's designated space but also making noise, smell, lighting disturbances and so on.

### 3.5.4 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.

### 3.5.5 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.

## 4 Referees & Safety and Health Management Committee

At least two referees shall be assigned per team during the tasks. Teams must always follow the instructions of their referees. In the Industrial Robotics Category, the referee team shall tentatively be made up of people who are not the participating team members and shall not be chosen from the teams. The decision of the referees shall be final. However, these decisions may be withdrawn when an obvious mistake has been made.

The Safety and Health Management Committee conducts regular safety patrols and designates unsafe actions and areas, if any. The Committee may stop a competition task and require improvements depending on the circumstances. Teams must always follow the instructions of the Safety and Health Management Committee. The Safety and Health Management Committee is scheduled to conduct a safety and health system inspection on the 15<sup>th</sup> and 16<sup>th</sup>.

## 5 Requirements and Limitations

### 5.1 Hardware Requirements

#### 5.1.1 Robots

The robots used for the competition may be either ones prepared by each team or ones lent by the competition committee. A combination of both may also be possible. The type and specifications of the robots on loan to teams have been announced separately.

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

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

### 5.1.2 Power / Number of Motors

There are no restrictions on the type, number and power of motors used in the robots. However, the competition committee may restrict the use of such motors if they are determined to be a problem from the view point of safety and hygiene.

### 5.1.3 CPU, Memory, Storage, etc.

There are no regulations related to the computing functionality.

### 5.1.4 Cost

There is no cap on the costs for the robots or peripheral equipment. However, teams must pay careful attention to their own belongings at the competition venue.

### 5.1.5 Duty to Install an Emergency Shutdown System

An emergency shutdown system must be installed in each robot system developed by the team. Regarding safety measures of robots and other systems, the teams must follow the safety regulations indicated separately.

## 5.2 Software Requirements

### 5.2.1 Network Utilization

Cloud computing that uses the Internet may also be available, but teams must consider network troubles. Wireless network is not allowed.

### 5.2.2 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 applies to not only the direct control via a device like a joystick, but also the control through voice, gesture and any other means of human intervention.

In order to prevent teams from teleoperating their robots over the Internet, the Internet connection might be shut down during the competitions.

## 5.3 Functional Requirements

Accident/incident protection functions for safety and health are required. Emergency stop buttons, safety fences and a door with a safety switch, a dead man switch shall work properly. Any environmental pollution shall be prevented. Details about safety and health management will be given in Chapter 7.

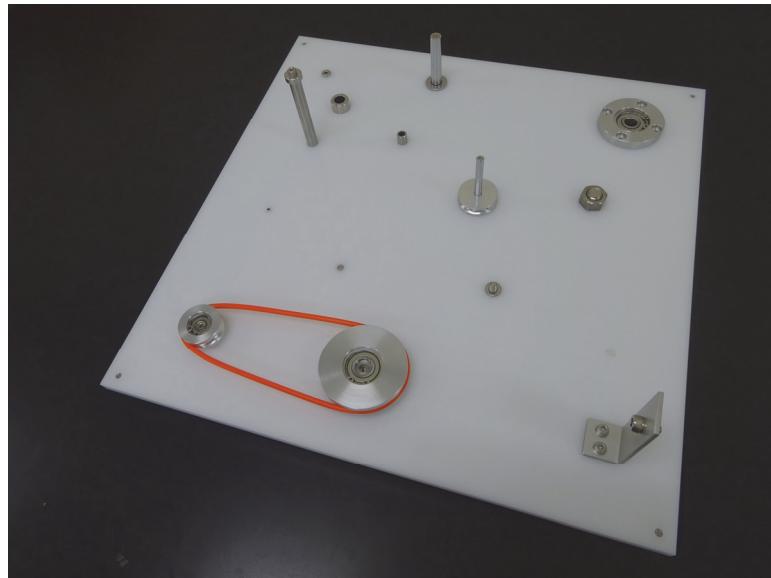


Figure 5: Task Board when Assembly was Completed

## 5.4 Placement of Markings

Each task stipulates rules and regulations to follow for the placement of markings on objects. These markings include QR codes, AR codes, IC tags and so on.

# 6 Description of Competition Tasks

The Assembly Challenge is composed of three tasks: the task-board task, the kitting task, and the assembly task. In addition, technical documents submitted by the teams will be reviewed in order to evaluate technical aspects that cannot be seen only from the performance of the tasks. The team rankings will be determined by the results of these three tasks. Note that the descriptions for each task shown below are tentative. The evaluation procedure and restart status after reset are all subject to change.

## 6.1 Task-Board Task

### 6.1.1 Overview

In this task, the robot of each team is required to assemble parts laid out on a placement mat on the designated locations on the task board (Fig. 5)<sup>1</sup>. Teams will not know the initial layout of parts in advance because the placement mat will be distributed right before the task. The appropriate tools may be used as necessary. Through this task, teams will compete on the elemental technologies necessary to assemble the Belt Drive Unit.

### 6.1.2 Expected Technological Elements

The main technological elements expected for this task include object detection technologies and motion planning technologies.

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<sup>1</sup> The idea and design of the Task Board for the WRS 2018 were largely inspired by the task board designed by the NIST, which was used for the 2nd Robotic Grasping and Manipulation Competition held at IROS 2017 [2].



Figure 6: Placement Mat (Mat Size: 400 mm × 400 mm)

### 6.1.3 Expected equipment

The main equipment expected for this task includes vision sensors, force sensors, robots, robot hands, and tools.

### 6.1.4 Parts

Parts related to the Belt Drive Unit assembly shall be used. The parts shall be laid out on the placement mat placed on the work table in the preparation phase. See Appendix A.1 for the parts to be used. All of the parts are Misumi-brand parts. See the Misumi website for more information about the parts. 3D-CAD data of the parts can be downloaded from the Misumi website. No markings attached to these parts are allowed.

### 6.1.5 Task Board

Teams shall place the task board on the work table when starting the task. The task board may be placed anywhere inside of the designated area. Some parts such as the bolts for the nuts to assemble will be installed on the task board in advance. See Appendix A.2 for more information about the initial setting of the task board before the competition task starts. Also see Appendix A.2 for more information about the parts already assembled on the task board in the initial setting. Markings may be attached to the task board to detect the position and orientation of the task board. See Appendix A.1 for more information about the parts that should be assembled on the task board and a diagram of the task board after all the parts have been assembled. The parts listed in Appendixes A.1 and A.2 are all Misumi-brand parts. See the Misumi website for more information about the parts. 3D-CAD data of the parts can be downloaded from the Misumi website.

See Appendixes A.3 and A.4 for process drawings of the task board. The layout of each part of the task board is planned to change just before the competition.

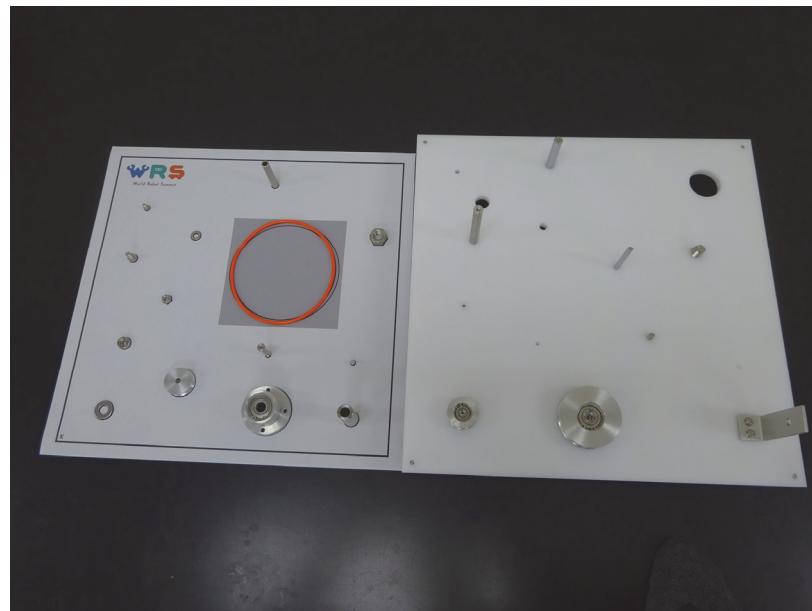


Figure 7: Initial Setup of the Task-Board Task  
 (Board Size: 400 mm × 400 mm)

#### 6.1.6 Placement Mat

Figure 6 shows an example of the placement mat. Teams have to arrange parts on the placement mat by hands as shown in Fig. 7 during the preparation phase (the details of the competition task phases will be described in Section 6.1.7) after the competition task starts. There are multiple types of placement mats specifying different part layout. One of those placement mats will be distributed at random to each team. Teams shall put the placement mat on the work table in the preparation phase. Markings may be attached to the placement mat to detect the position and orientation of the placement mat. Furthermore, the details of the placement mat, including the layout of the parts, will not be released in advance.

#### 6.1.7 Detailed Description

The competition shall be made up of a preparation phase and an operation phase. The task board, placement mat, and parts will be placed initially in a designated area outside of the system running area before the task starts. When the task starts, teams will set the task board and placement mat in the appropriate position and then arrange the parts as indicated in Fig. 7 by their hands all during the preparation phase. Each part shall be arranged on the designated place on the placement mat. Teams are allowed to place the round belt anywhere within the gray area on the placement mat because it is a flexible object. Each part shall be placed on the placement mat with the designated contact surface of the part being contacted to the placement mat. See Appendix A.5 for the designated contact surface of each part. The teams can arrange the parts in any direction as long as the parts are placed within the designated place/area and the designated contact surface has contact with the placement mat. Referees will confirm the accuracy of the part layout done by teams. Teams may make the necessary preparations, such as fixing the placement mat with a vice and tape, installing a soft mat beneath the placement mat, securing the task board with a vice, installing a non-slip mat beneath the task board, laying out necessary tools, and teaching their robots, during the preparation phase. Teams will then declare the start of the operation phase to a referee once all preparations are completed. Thereafter, the operation phase will begin, and the robot will assemble the parts to the task board. During the

operation phase, teams are not allowed to touch the robot, the parts, the tools, the task board, or the placement mat. The sizes of the task board and the placement mat are set to 400 mm × 400 mm.

In the operation phase, the robot system will conduct the following procedure for parts as shown in Fig. 7; (i) the robot system shall pick up part(s) from the placement mat, (ii) the robot system shall then assemble the part(s) to the task board in the designated location. The above procedure shall be repeated for each part. However, the set screw is pre-assembled into the task board in advance (see Appendixes A.2 and A.5). Teams will try to accurately assemble as many parts as possible within the time limit of the task. The team may decide the order to assemble the parts. Since the assembled parts remain in position on the task board, they may interfere with the robot system in the subsequent procedure. The board, placement mat and parts to be used in the competition task will be provided from the staff to referees 15 minutes before the start of the competition. Please note that teams cannot touch this board and placement mat until 10 minutes before the start of the competition. The team can prepare the tools as necessary. Tools modified in advance may be used according to the procedure. The tools to be used may also be attached to the robot hand in advance. When the competition ends, the team must stop their robot operation immediately. If the team does not stop the operation, the referee gives a warning for the team. After the warning, the points are deducted (10 points deduction).

#### 6.1.8 Evaluation Method

When the competition ends, points will be awarded with the task board still placed inside the system running area. Basically, points are given based on the number of completed parts. Points are also assigned based on the completeness of the assembly. Evaluation items include whether the nut is fully seated on the task board and whether the set screw has been fully screwed in.

Table 4 shows a list of points awarded for the task-board task. The level of completeness is set for each part. Figure 8 shows an example of the level of completeness. This example is for the task related to Part #8 in Table 4. The higher degree of completeness of the task is achieved, the more points are given. Details about the evaluation criteria for the level of completeness and a scoring sheet are described in the referees' manual for the task-board task. As shown in Table 4, teams will earn high points for the operation of flexible objects (round belt), dual-arm operations, and the operation of small parts (set screws/washers). In evaluation after the operation phase, the front surfaces of the washers and nuts do not distinguish from the back surfaces of those.

If all of the parts are assembled with enough completeness, extra points will be given as a time bonus based on the amount of time remained until the time limit of the task (1-point addition per 20 seconds: max 50 points). Parts not assembled on the task board should be placed on the placement mat when the time limit of the task is reached. If some parts, which were not assembled to the task board, are not on the placement mat, deductions will be taken based on the number of parts (2-point deduction per part). Therefore, when a part is within the robot system or jig, the points are deducted. Tools placed in the designated area during the preparation phase must also be placed in the designated area when the time limit of the task is reached. If some of these tools are not placed in the designated area, deductions will be taken based on the number of tools (2-point deduction per tool). The minimum number of points that can be awarded is 0. The completeness of all the parts must be Level 2 or higher to earn the time bonus. Teams will not earn a time bonus if markings are placed on the task board or the placement mat. Lubricant may not be used on the parts or the task board.

Table 4: List of Points for Task-Board Task  
 (The Part #5 (rotary shaft) is assembled into the task board in advance (see Appendixes A.2 and A.5).)

Part #	Target Parts	Task	Points			Max	
			Completion Level		Level 3		
			Level 1	Level 2			
1	Bearings with Housing	Insertion into a hole	2	5	/	5	
2	6mm bearing retainer pin	Insertion into a hole	2	5	/	5	
3	17mm spacer for bearings	Insertion into a hole	2	5	/	5	
4	9mm spacer for bearings	Insertion into a hole	2	5	/	5	
5	-	-	-	-	-	0	
6	4mm round belt	Looping over pulleys	2	6	10	10	
7-1	M6 nut	Fasten a nut and bolt	2	6	10	10	
7-2	M6 bolt						
8	M12 nut	Fasten a nut and bolt	2	5	8	8	
9	M6 washer	Placing onto a bolt	2	6	/	6	
10	M10 washer	Placing onto a shaft	2	6	/	6	
11	M3 setscrew	Screwing into a tapped hole	/	6	10	10	
12	M3 bolt	Screwing into a tapped hole	2	6	10	10	
13	M4 bolt	Screwing into a tapped hole	2	6	10	10	
14	Pulley	Placing onto a shaft	2	5	/	5	
15	M10 end cap	Placing onto a shaft	2	5	/	5	
			Total	100			



-2 points  
 - Bolt and nut have contact  
 - Board and nut have contact



Level 1: 2 points  
 - Bolt and nut have contact



Level 2: 5 points  
 - Bolt and nut are fastened



Level 3: 8 points  
 - Bolt and nut are fastened  
 - Board and nut have contact

Figure 8: Examples for Completeness of Task  
 (M12 Nut Fastened to Bolt; Procedure for Part #8 in Table 4)

### 6.1.9 Reset

In an event such as system failures, teams can declare “reset” and start again from the initial setup. More specifically, teams shall return to the preparation phase and remove all of the parts assembled on the task board, and then place all the parts on the placement mat again before starting the task again. However, teams cannot touch the set screw when resetting because the set screw was pre-assembled into the task board in advance.

### 6.1.10 Schedule

Each team will compete the task-board task twice on Day 1. The better score of the two trials shall be adopted. Four teams will compete at the same time. A drawing is planned to determine the order of the competition task. A session, which contains team introduction by the MC (master

of ceremony), actual competition, and wrap-up after the competition, has 30 minutes (see Fig. 9). The competition time is 20 minutes. The board, placement mat and parts to be used in the competition task will be provided to each team 10 minutes before the start of the competition. Please note that all team members have to leave from the system running area 10 minutes before the start of the competition. The placement mat will be provided after the referee confirmed that no one is in the system running area. After the provision of the board, placement mat and parts, teams can check them by themselves. Teams can also use several sensors (including a camera) to check the parts and placement mat before the start of the competition.

## 6.2 Kitting Task

### 6.2.1 Overview

In the kitting task, the robot of each team is required to pick up the ordered parts, which are necessary to assemble the Belt Drive Unit, from each parts box (parts bin) and place them in the part-kitting trays with the specified locations and poses. Teams will compete to prepare as many of these parts sets as possible within the competition time.

### 6.2.2 Expected Technological Elements

The main technological elements expected for this task include object detection technologies as well as object grasping and motion planning technologies.

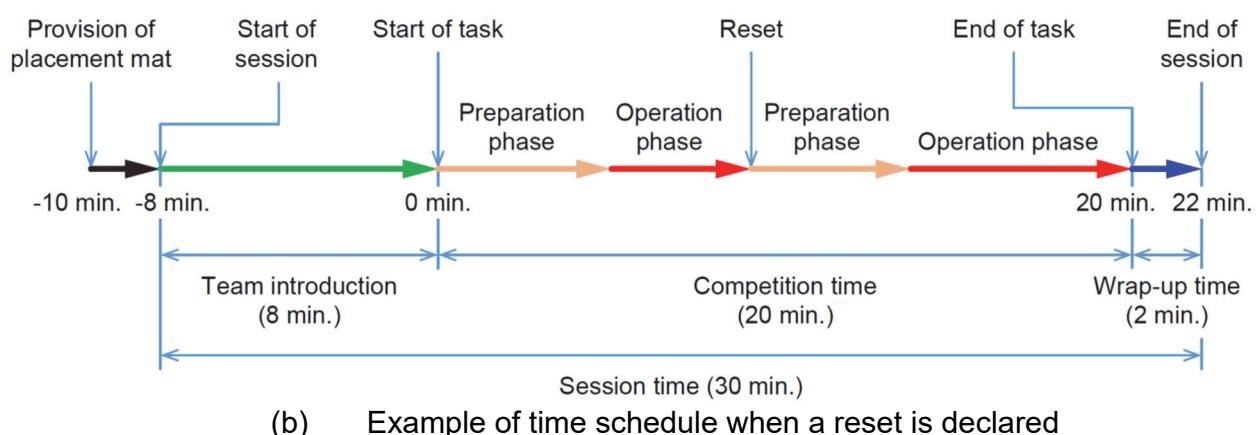
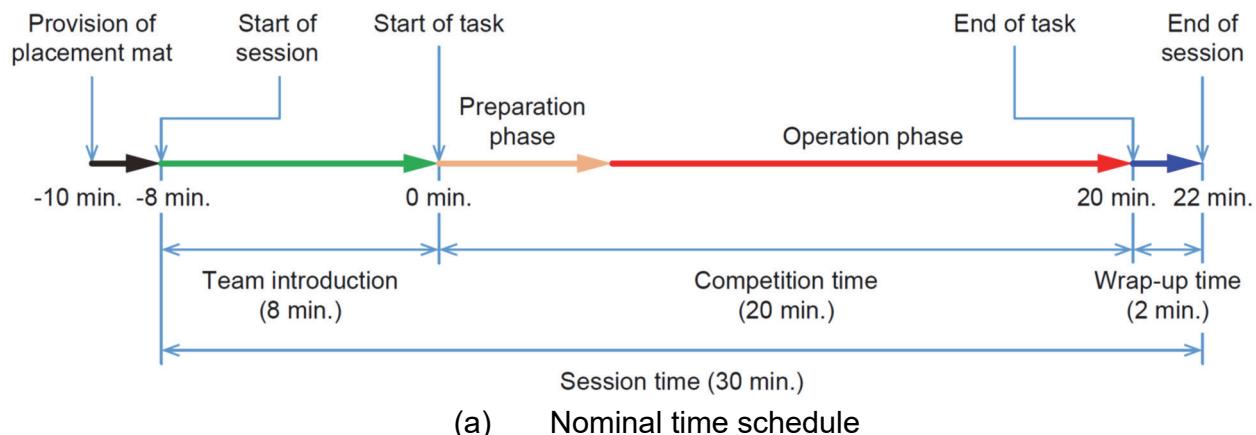


Figure 9: Timetable for Task Board Task (Day 1)

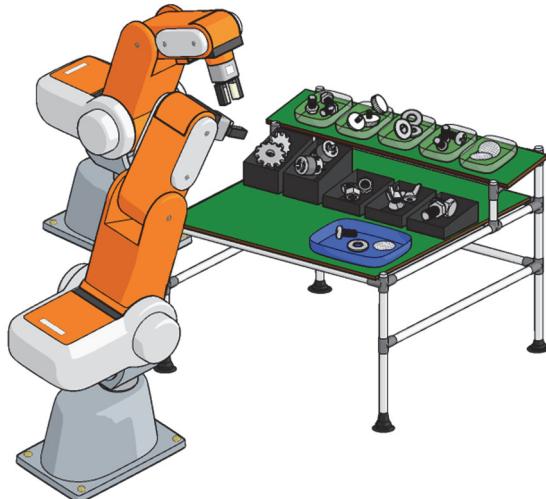


Figure 10: Layout Example of the Kitting Task (Conceptual Image)

### 6.2.3 Expected Equipment

The main equipment expected for this task includes robots, robot hands, force sensors, vision sensors, parts, parts bins, part-kitting trays, a parts rack (optional), and a work table.

### 6.2.4 Parts

A list of parts to be picked will be given to each team as a set list before the task starts. The set list will be provided to the teams as digital data, for example, files saved in a USB memory. The contents of the set list will be different for each team.

The parts used in this task are the same ones used in the assembly task. Markings to those parts are prohibited.

Multiple parts bins are placed within reach of the robot on the work table. Teams can set the parts bins freely and can use a parts rack as necessary (use of a parts rack is voluntary and not mandatory). The number of parts bins used for the task is ten, but their combination is not fixed. The combination (small: 5, medium: 4, large: 1) shown in Figure 11 is just one example. However, the area occupied by the parts bins never expands any further. Multiple pieces of the same part shall be put randomly in each parts bin. The number of parts in the parts bins is different for each competition. Figure 11 is just one example. Markings can be put on these bins so that the robot can know which kind of parts are inside those bins as well as the positions and orientations of the bins themselves. See Appendix B for the parts bin to use.

If a parts rack is used for the parts bins, the parts rack shall be placed on top of the work table. Teams are allowed to attach markings to the parts rack so that their robot can detect the position and orientation of the parts rack. Moreover, the parts rack can be secured to the work table.

The part-kitting tray is a flat tray and its inside is divided by several partitions. There are two part-kitting trays for the kitting task. See Appendix B for the part-kitting tray to use. The ordered screws should be inserted in the screw holder in an upright position. A cushioning has been fitted in the bottom of sections for thin parts such as washers. Teams may position the part-kitting trays freely as long as it is on the work table. Teams are allowed to attach markings to the trays so that their robot can detect the positions, orientations, and types of the part-kitting trays.

Teams shall use the parts, parts bins, and part-kitting trays specified by the competition committee. In addition, teams will be given CAD models for the specified parts in advance. The dimensions, weight, and color information for the parts bins and the part-kitting tray will be

provided in advance. Specifications for the partitions in the part-kitting trays, the screw holder, and the cushioning are provided in Appendix B (the competition committee are not planning to distribute the actual samples of these items). Information about the layout of parts and how they are divided by the partitions is provided in Appendix B. One set of part-kitting trays used in the competition is given to each team for practice in advance at the competition venue.

If necessary, teams can prepare their own parts rack where the specified parts bins can be arranged as they like. Note that no parts rack will be provided by the competition committee. A work table will be provided by the competition committee, but teams can prepare their own work table. The parts rack and the work table prepared by the teams must satisfy the rules and regulations.

A conceptual image of the overall layout is shown in Fig. 10. These parts and other items to be used are subject to change before the competition.

### 6.2.5 Detailed Description

Teams shall be required to pick up necessary parts specified in the set list from the parts bins and place them in the part-kitting trays by their robot. Teams may set the parts bins and part-kitting trays anywhere so that their robots can easily access to them. Each part shall be placed at designated location and orientation in the part-kitting tray. Screws shall be inserted in the specified holes of the screw holder in an upright position, considering the easy access to the parts in the following assembly task. Teams shall prepare as many parts sets specified by the set list as possible within the competition time. However, there is an upper limit on the number of parts sets that teams can prepare (3 sets are tentatively planned at this stage). Each set list includes a total of 10 parts. A set list with the information, for example, such as shown in Table 5, will be provided as a text file in the csv format as a comma-separated list.

Before the task starts, the part-kitting trays are placed in a specified area outside of the system running area. When the task starts, teams can move the trays to a place where the kitting task can be performed by their robot. The completed part-kitting trays shall be carried to a specified area outside of the system running area within the time limit of the competition. Teams are allowed to supply and take the part-kitting trays out by their hands. For safety reasons, however, teams must suspend all systems when entering the system running area. Teams may take part-kitting trays out even if not all of the parts have been placed when the team determines that it is impossible to continue. The part-kitting trays may be carried out of the system running area one by one, or, some trays together.

Referees will randomly change the state of parts in the parts bins before the competition starts so that the teams cannot start from an easy condition intentionally made by the teams. A conceptual drawing of the overall layout of the kitting task and a snapshot of the actual parts, parts bins, and part-kitting trays are shown in Fig. 11.

Table 5: Example of Set List

Set	No.	Part ID	Part name	Note
1	1	17	17_SCB4-10	10mm M4 Hexagon socket head bolt
	2	17	17_SCB4-10	10mm M4 Hexagon socket head bolt
	...	...	...	...
	10	6	06_MBT4-400	Polyurethane round belt
2	1	18	18_SCB3-10	10mm M3 Hexagon socket head bolt
	2	12	12_CLBUS6-9-9.5	Bearing Spacers For Inner Ring
	...	...	...	...
	10	13	13_MBGA30-2	4mm round belt idler pulley
3	1	16	16_SPWF6	M6 washer
	2	13	13_MBGA30-2	4mm round belt idler pulley
	...	...	...	...
	10	4	04_37D-GEARMOTOR-50-70	Geared motor

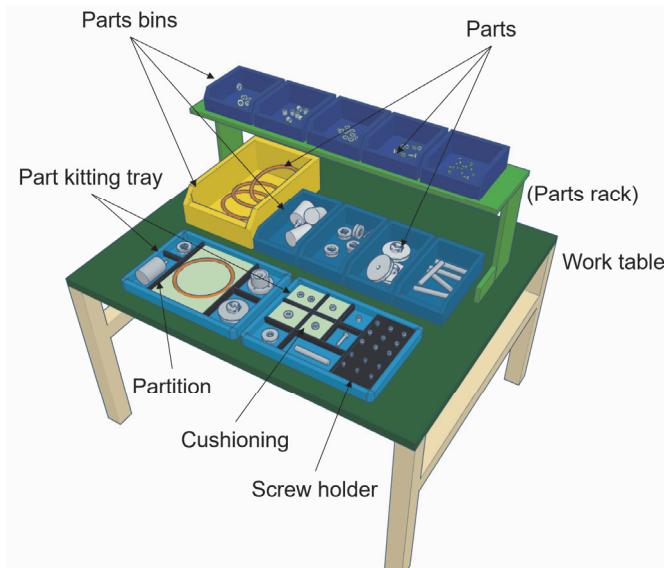


Figure 11: Conceptual Drawing of the Overall Layout of the Kitting Task and a Snapshot of the Actual Parts, Parts Bins, and Part-kitting Trays.

**Table 6-1: Point List for the Kitting Task**

Items	Points	
Points when parts are placed correctly in the designated area of the tray (2 points/part x 10 parts/set)	20	Points/set
Complete set points [Not applicable if any part for deduction included]	30	Points/set
Total points per set	50	Points/set

**Table 6-2: Deduction Point List for the Kitting Task**

Items	Points	
for each set list	Parts protrude from the designated area of the tray	-1 Point/part
	Parts are placed in the wrong area of the tray	-1 Point/part
	More parts than the designated number are in the designated area of the tray	-1 Point/part
	Parts dropped during the task have been placed in the designated area of the part-kitting tray	No deduction
	Parts dropped during the task have been returned to the original parts bins	No deduction
at the end of task	Parts are left on the work table (including in the trays which were not carried out) / on the floor	-1 Point/part
	Parts are held by the robot system / jig	-1 Point/part
	Parts are left in the different parts bins	-1 Points/part

### 6.2.6 Evaluation Method

Points are determined according to the state and status of the parts set carried to a designated area outside the system running area within the time limit for the competition task allotted to each team. Table 6-1 shows a point list. Points are given based on the number of completed parts sets. Partial points are also assigned to the incomplete parts sets based on the number of parts placed in those sets. Extra points will be given as a time bonus if all the parts set are completely prepared within the task period. Deductions will be taken for parts which are not placed properly in the specified locations and orientations in the part-kitting trays. However, temporary placement is allowed to change the orientations of parts. A deduction will be taken if a part is dropped off during the task or if more parts than the designated number are picked up from the parts bin. However, a deduction will not be taken if such an extra part is returned to the parts bin. See Table 6-2 for the details of deductions. Time bonus points will not be awarded if there is an incomplete part set or a parts set subject to the deduction. If teams can make a completed parts set, 50 points (= 20 points for 10 parts place + 30 points for task completed) are given them. The kitting task has a maximum of 150 points (= 50 points / set x 3 sets) if all of the designated number or parts sets are completed (excluding the time bonus). The minimum number of points that can be awarded is 0. The time bonus is as follows:

$$\text{Time bonus} = \text{INT}((\text{standard time}[sec] - \text{spent time}[sec]) / 20) \times 1 \text{ point}$$

(The upper limit of the time bonus points is 50 points.)

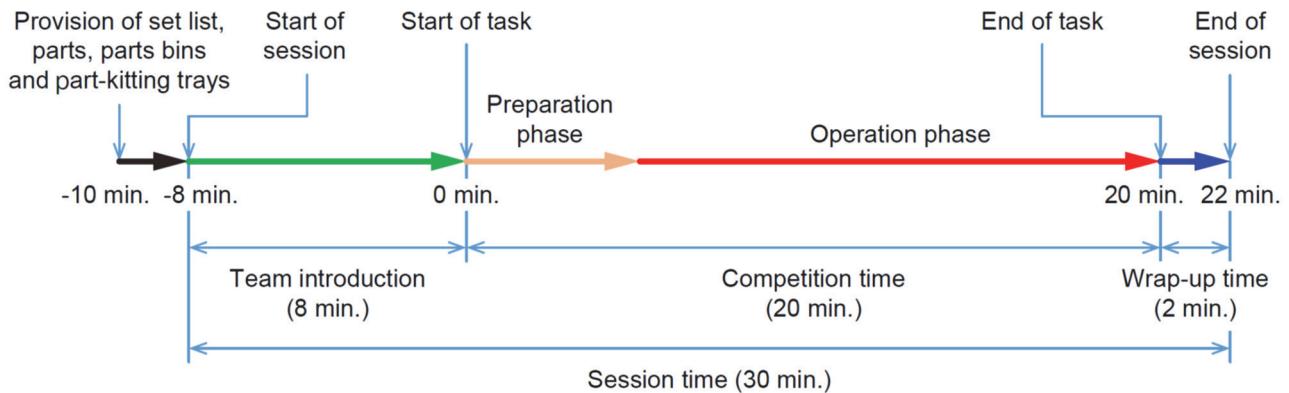


Figure 12: Timetable for Kitting Task (Day 2)

### 6.2.7 Reset

If teams choose to reset, they shall restart just from the initial state of the incomplete parts set that they had been working on. In this case, the team shall restart from an empty state of the part-kitting trays that they had been working on. This work will be done by the referee. The time taken for the reset will be included in the competition time.

### 6.2.8 Schedule

Each team shall attempt the kitting task twice on Day 2. The better score of the two trials shall be adopted. Four teams will compete at the same time. A drawing is planned to determine the order of the competition task. A session, which contains team introduction by the MC, actual competition, and wrap-up after the competition, has 30 minutes. This time breaks down into the first 8 minutes for team introductions (2 minutes per team), 20 minutes for the competition task, and the remaining 2 minutes for warp-up time (see Fig. 12). The set list will be given to each team ten minutes before the competition task. Please note that all team members have to leave from the system running area 10 minutes before the start of the competition. The set list will be provided after the referee confirmed that no one is in the system running area. At the end of the competition, if the system is not stopped quickly by the team regardless of the warning of the referee, 10 points will be deducted.

## 6.3 Assembly Task

### 6.3.1 Overview

In this task, teams shall compete on the speed and accuracy for assembly of a model product that includes technological elements necessary to assemble industrial products. For the WRS 2018, the Belt Drive Unit has been designed for the model product. More specifically, teams shall compete on the ability of their robot system to assemble the Belt Drive Unit from the parts taken from the part-kitting trays. This task takes place over two days. On the first day of the assembly task (Day 3), teams are required to assemble the original Belt Drive Units from the parts whose specifications are announced in advance. On the second day of the assembly task (Day 4), teams are required to assemble not only the original Belt Drive Units but also a new Belt Drive Unit that contains some surprise parts. The surprise parts are designed differently from the parts used in the original Belt Drive Unit, while keeping the nature of the model product. The details of surprise

parts shall be announced at the appropriate time just before the task starts on Day 4. On Day 3, two sets of parts necessary for assembling the Belt Drive Units shall be provided to each team. On Day 4, however, three sets of parts including one set with surprise parts shall be provided to each team. Each team is required to assemble as many Belt Drive Units that function correctly as possible.

This competition aims at realizing the future manufacturing by developing agile and lean production systems which can respond to the variously changing manufacturing demands in high mix low-volume production (ultimately the one-off manufacturing).

An overview of the Belt Drive Unit used in this task is shown in Fig. 1. In addition, the main dimensions are indicated in Fig. 13. See Appendix C for more information about the parts to use.

### **6.3.2 Expected Technological Elements**

The main technological elements expected for this task include assembly planning technology, grasping and motion planning technologies for precision assembly, coordinated multi-arm control technology, and agile system configuration technology.

### **6.3.3 Expected Equipment**

The main equipment expected for this task includes force sensors, vision sensors, robots with the appropriate range of motion, robot hands able to handle all of the parts (multiple types of hands may also be used), and assembly tools as necessary.

### **6.3.4 Supplying Parts and Taking Assembled Products Out**

Part-kitting trays containing the parts will be prepared by the competition committee. Partitions are used to prevent the parts from mixing in the tray. These part-kitting trays will be the same as the part-kitting trays used in the kitting task. Team members cannot touch the parts in the part-kitting trays without permission. If a part is oriented undesired way or another issue arises, the part may be re-positioned in advance with the permission of the referees. The part may also be re-positioned if the part is so close to the partition that picking can be determined to be difficult from that location. Note that three plates (base plate, motor fixed plate, and output shaft fixed plate) will be provided separately and they are not in the part-kitting tray. The team members can arrange these three parts freely on the work table during the preparation phase. But these plates must be set separately. They are not allowed to contact with each other.

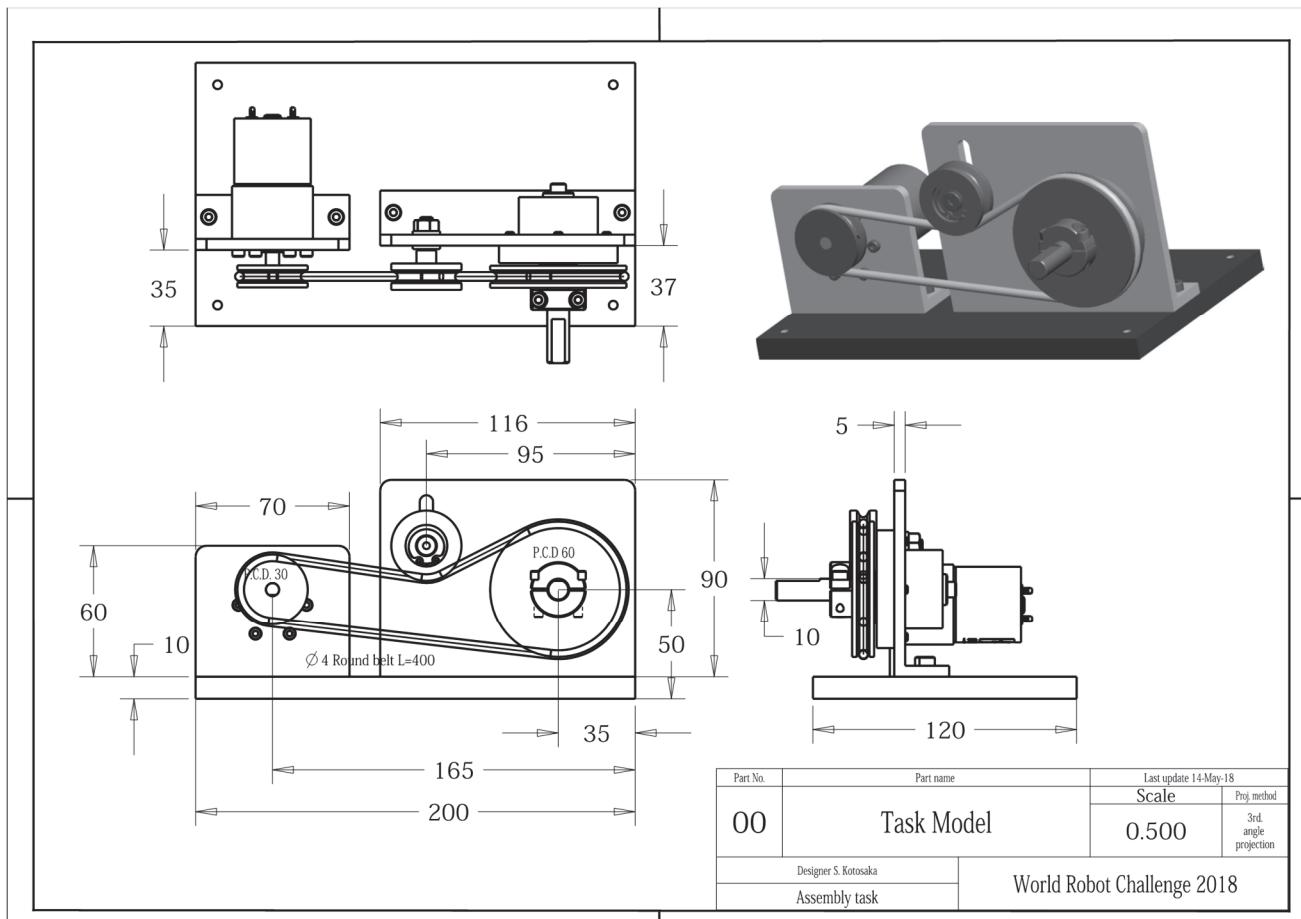


Figure 13: Assembly Drawing of the Belt Drive Unit

As described in Appendix C, one Belt Drive Unit requires a total of 33 components composed of 19 different types of parts. However, the set screw (part #19) is installed to either of two thread holes of the pulley (part #5) before the competition by the committee. Therefore, a total of 32 components composed of 18 different types of parts are used at the start of the competition. Teams can adjust the set screw in the pulley manually in the preparation phase. All of the parts except the three plates and the motor are Misumi-brand parts. See the Misumi website for more information about each of the parts. 3D-CAD data of the parts can also be downloaded from the Misumi website. More information about the three plates is included in Appendix C.

However, the number and types of parts for the product, including the surprise parts, will not be released until information about the surprise parts is unveiled at the competition. CAD models or other information of the surprise parts will also not be released until the appropriate time before the competition task starts (see Section 6.3.8).

These parts are subject to change up to the competition.

Before the task starts, the part-kitting trays containing the parts for the Belt Drive Unit and other parts which cannot be placed inside the tray, such as the base plate, are placed on the parts & product table in the operation area (Figure 3). When the task starts, teams must bring them into the system running area in the preparation phase. When the assembly is completed, assembled products should be carried out to a designated area outside of the system running area within the time period of the task. Teams may bring parts and part-kitting trays into the system running area or take completed products out from the system running area by their hands. However, teams are required to follow the safety procedures outlined in Chapter 7 to stop their robot systems safely when taking completed products out from the system running area. This is a 0, 1, or 2 stop for the

stop category according to the IEC 60204-1 (JIS B 9960-1). Teams can take a product out even if not all of the parts have been assembled when the team determines any further efforts pointless. Assembled products may be carried out one by one, or, some products together.

No markings must be attached to the parts. However, teams are allowed to attach markings to the working environment where robots perform the assembly task. Teams may install their own jigs and sensors in the system running area. A work table shall be provided to teams, but they can bring their own table if necessary. Teams are allowed to adjust the orientation of the D-cut face of the motor shaft manually in the preparation phase. Note, however, that the committee will not provide any tool for this adjustment. Each team must prepare the tool if necessary. In addition, the committee is planning to put a small sticker, something like WRS logo, to the upper right corner of the top face of the base plate so that one can easily identify the top face (The holes at the four corners of the plate are counter-bored only at the bottom face side).

The conceptual image of the system layout is basically the same as the kitting task (see Fig. 10).

### 6.3.5 Detailed Description

The competition time shall be made up of a preparation phase and an operation phase. In the preparation phase, teams can prepare their working environment (e.g. installing jigs) and bring in the parts as described previously. Robots must not perform any assembly tasks in this phase. Teams will then declare the start of the operation phase to a referee once all preparations are completed. Thereafter, the operation phase will begin, and the robot will assemble the Belt Drive Units. During the operation phase, teams should go outside the system running area and cannot touch the robots, the working environment, or the parts at all, except when a reset is declared (refer Section 6.3.7 for details of reset).

The assembly may be executed in any order, but the level of completion of the assembled product is evaluated in sub-task basis shown below. In the case of a reset, teams shall return to the beginning of the sub-task that they had been working on. The sub-tasks of the Belt Drive Unit assembly are as follows:

- Sub-task A -- Assembling the motor to the motor fixing plate with the screws
  - The corresponding parts (refer the updated part list in the appendix): Parts #3, #4, and #18
  - Completion condition of the sub-task: All screws are tightened until fully seated. The referee will visually check this condition.
- Sub-task B -- Assembling the motor-shaft-pulley to the motor shaft
  - The corresponding parts: Parts #5 and #19
  - Completion condition of the sub-task: Motor-shaft-pulley is correctly attached to the motor shaft by satisfying the following conditions: (i) The surface of the pulley and the surface of the end of the shaft are not deviated from the same level as long as inspected visually, (ii) The rotation axis of the setscrew is almost perpendicular to the D-cut surface. Note that sufficiency of the tightening torque for the set screw will be checked in the product evaluation stage after the competition ends.
- Sub-task C -- Assembling the output shaft, screws to secure the output shaft, washers, double bearings, and the screws to attach the bearings to the output shaft fixing plate

- The corresponding parts: Parts #2, #7, #8, #9, #10, and #17
- Completion condition of the sub-task: The bearing holder is attached to the output shaft fixing plate in the correct direction and the four screws are tightened until fully seated. The out-put shaft is inserted in the correct direction until the correct position (the end cap is in contact with the inner ring of the bearing) and the end cap is fixed with the screw.
- Sub-task D -- Assembling the output-shaft-pulley to the output shaft
  - The corresponding part: Part #11
  - Completion condition of the sub-task: The pulley is crimped on the output-shaft so that its cramping hub is outward. The pulley is in contact with the inner ring of the bearing through the spacer collar (however, since the cramping position of the pulley is difficult to be checked visually, the distance between the pulley surface and the plate surface will alternatively be measured).
- Sub-task E -- Assembling the tension pulley to the output shaft fixing plate
  - The corresponding parts: Parts #12, #13, #14, #15, and #16 and the assembled parts in Subtasks C and D
  - Completion condition of the sub-task: The tension pulley and its related parts are fixed to the output shaft plate in the correct order according to the assembly drawing.
- Sub-task F -- Assembling the motor fixing plate and the base plate with the screws to connect both
  - The corresponding parts: Part #17 and the assembled parts in Subtasks A and B
  - Completion condition of the sub-task: The motor fixing plate is correctly fixed to the base plate with two screws by satisfying the following conditions: (i) the orientation of the plate is correct and (ii) there is no play between two plates.
- Sub-task G -- Assembling the output shaft fixing plate and the base plate with the screws to connect both
  - The corresponding parts: Part #17 and the assembled parts in Subtasks C, D and E
  - Completion condition of the sub-task: The output shaft fixing plate is correctly fixed to the base plate with two screws by satisfying the following conditions: (i) the orientation of the plate is correct and (ii) there is no play between two plates.
- Sub-task H -- Assembling the belt.
  - The corresponding parts: Part #5 and the assembled parts in the previous subtasks
  - Completion condition of the sub-task: The belt is looped over the two pulleys, by correctly setting to the grooves of the pulleys, and the belt tension is sufficiently applied by the tension pulley.

Note that when falling, loosening, or rattling of a part is confirmed at the stage of the final product evaluation, the subtask corresponding to that part will be evaluated as “incomplete”

even if it has been evaluated as “complete”.

Note that the above descriptions of the sub-tasks hold true of the assembly tasks with or without surprise parts.

### 6.3.6 Evaluation Method

Points are determined according to an evaluation of the product assemblies carried out to a designated area outside of the system running area within the time limit for the competition task as well as an evaluation of the fitness of the agile and lean robot system. As shown in Table 7, certain points are allocated to each subtask. Besides these points for subtasks, 0 to 14 points will be given according to the result of the performance evaluation of the assembled product. Product evaluation test will be conducted at the end of the competition task. The basic score awarded to each team is the total of the points for the completed sub-tasks and the points of the product evaluation.

The level of completeness of each sub-task is evaluated according to the state of the parts, such as fastening state of screws and the direction of the parts attached to the plates, rather than the process and order of assembly (Refer to Section 6.3.5).

It is permitted to bring out an uncompleted product from the system running area to the area designated outside, even if some sub-tasks have not been completed yet. This means that teams may give up the current assembly task and move on to the next product. However, the time bonus described later will not be given in such cases. In addition, note that if a team skip the sub-task that involves the surprise parts, which are included in the second product on Day 4, or do not earn any points from that sub-task, any points will not be awarded from the third product, no matter how well it has been assembled.

As described in Section 6.3.6, if parts are fallen, loosen, or rattling after final product evaluation, the subtask corresponding to that part will be evaluated as “incomplete”. So, team can choose to try final product evaluation or not to try for each product. However, the time bonus described later will not be given in case of avoidance of final product evaluation.

Teams will be awarded a time bonus if all of the targeted product assemblies are fully completed in less time than the time limit for the competition task.

On Day 3, the fitness of an agile and lean robot system will also be evaluated according to the technical documents that are submitted for 0 to 10 points.

In general, the evaluation procedure for the assembly task that includes surprise parts performed on Day 4 is the same as the evaluation on Day 3 mentioned above. However, more points will be awarded to the teams based on the evaluation of how to respond to an order with surprise parts in agile and lean manners. Breakdown of these points will be determined in appendix. Note that the surprise parts are only provided in the part-kitting trays of the second product. Parts supplied for the first and third products are the same as Day 3.

Table 7 Point List for the Assembly Task

## Point List for Each Belt Drive Unit (Day 3 and Day 4)

Description		Points	Remarks
Subtasks	B, D, F, G	3 (each)	12 points in total
	A	4	
	C, E, H	5 (each)	15 points in total
Product evaluation (visual and function)		14	Bonus points are given separately for the surprise parts on Day 4
Total		45	

## Point List for Day 3

Description		Points	Remarks
Belt drive assembly (maximum of 2 units)		45 (each)	90 points in total
Agile and lean fitness evaluation		10	Based on the technical documents
Total		100	Time bonus is not included
The time bonus is as follows: $\text{Time bonus} = \text{INT}((\text{standard time[sec]} - \text{spent time[sec]}) / 20) \times 1 \text{ point}$ (The upper limit of the time bonus points is 50 points.)			

## Point List for Day 4

Description		Points	Remarks
Belt drive assembly (maximum of 3 units; includes 1 unit with surprise parts)		45 (each)	135 points in total
Evaluation of how to respond to an order with surprise parts in agile and lean manners		65	Breakdown pending
Total		200	Time bonus is not included
The time bonus is as follows: $\text{Time bonus} = \text{INT}((\text{standard time[sec]} - \text{spent time[sec]}) / 20) \times 1 \text{ point}$ (The upper limit of the time bonus points is 100 points.)			

### 6.3.7 Reset

In the event the robot system fails or in the event the robot system fails in the assembly process and the team determines an autonomous recovery difficult, they can declare a “reset” to stop the assembly and start the manual recovery. The recovery refers to the process to return to the initial setup of the sub-task from the current state of the sub-task underway right before the reset was declared. At this time, plates can be set contacting with each other if the initial setup of the sub-task is such condition. Manually advancing the sub-task is never permitted. Teams must ensure safety according to the safety regulations described later before beginning the recovery. This reset can be regarded as a temporary stop at the actual manufacturing line.

### 6.3.8 Schedule

On the first day of the assembly task (Day 3), teams will compete for assembly task without

surprise parts. On the second day of the assembly task (Day 4), the assembly task shall include surprise parts. Day 4 assumes a mixed flow production line where the original Belt Drive Units and new Belt Drive Units including surprise parts should be assembled simultaneously.

In the competition task on Day 3, four teams will compete at the same time. A drawing is planned to determine the order of the competition task. Each team will have two trials to complete the challenge. The better score of the two trials will be adopted for the points of the competition task of Day 3.

On Day 3, a session, which contains team introduction by the MC, actual competition, and wrap-up after the competition, has 45 minutes. This time breaks down into the first 8 minutes for team introductions (2 minutes per team), 30 minutes for the competition task, and the remaining 7 minutes for the performance evaluation of the assembled products (see Fig. 14).

Parts, which have been kitted in the part-kitting trays, and the plate parts will be given to each team 10 minutes before the competition task starts at the latest. Please note that all team members have to leave from the system running area before the start of the competition. The parts and part-kitting trays will be provided after the referee confirmed that no one is in the system running area. The competition (assembly task) will start after team introductions. Each team may bring the provided parts and trays into the system running area and prepare for activating the robots (preparation phase). Note that the robots must be in “safe mode” (refer to the safety manual in the appendix) during the preparation phase. Each team can move to the operation phase by their own decision. In the operation phase, the robots can operate and perform the assembly task. Teams may declare a “reset” (refer to Section 6.3.7) and set the robot system to an appropriate operation mode, so that they can enter the system running area and reset the current subtask to its initial condition. Teams can also enter the system running area for carrying the completed products out and for bringing in the parts and trays for the next product to be assembled. Note that the robot system must also be set to an appropriate operation mode also in these cases. The competition time to perform the assembly task on Day 3 is 30 minutes, which includes the time for preparation phase and resetting. After completion of the assembling task, the product evaluation will be performed only for the products which were carried out from the system running area by the team. This concludes one session of the assembly task on Day 3.

On Day 4, the assembly task that includes surprise parts will be held. Four teams will compete in the assembly at the same time just as on Day 3. A drawing is planned to determine the order of the competition task just as on Day 3. Unlike Day 3, however, each team will have only one chance to complete the challenge.

On Day 4, a session, which contains team introduction by the MC, actual competition, and wrap-up after the competition, has 80 min. This time breaks down into the first 8 minutes for team introductions (2 minutes per team), 60 minutes for the competition task, and the remaining 12 minutes for the performance evaluation of the assembled products (see Fig. 15). Information of the surprise parts will be provided at least 60 minutes before the session starts. The timing of providing the actual surprise parts is 10min before the competition task starts.

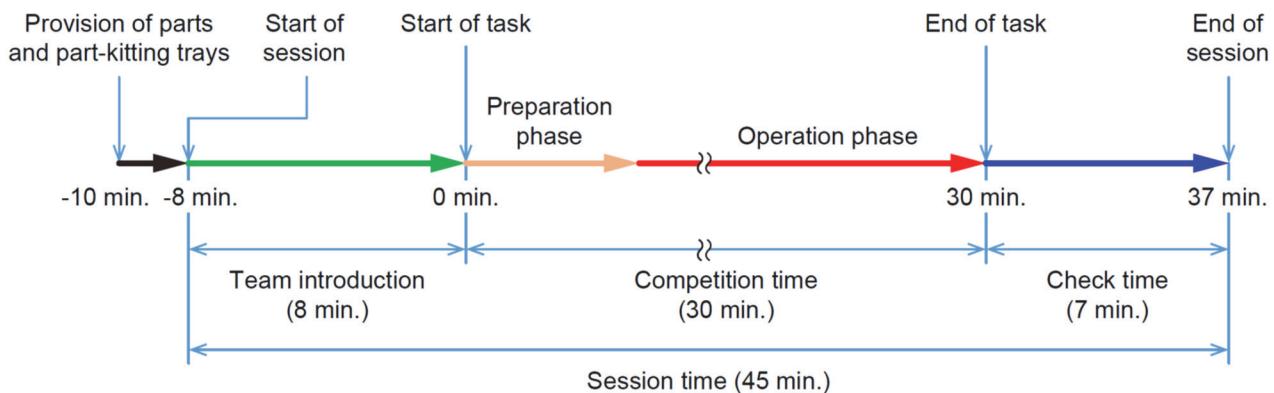


Figure 14: Timetable for Assembly Task (Day 3)

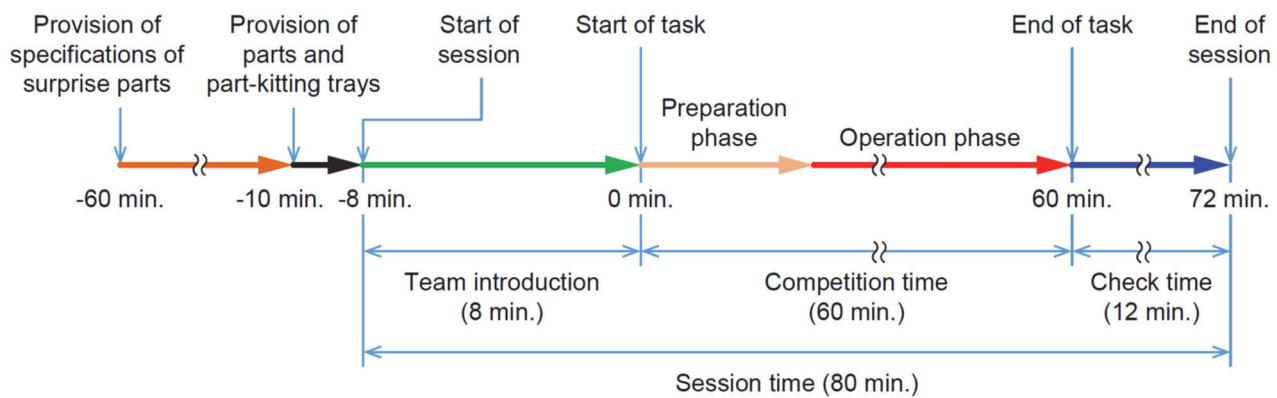


Figure 15: Timetable for Assembly Task (Day 4)

## 6.4 Promotion of Energy Saving

Realization of an energy saving society is an urgent mission for us. The WRS is also aiming at realizing an energy saving society through the challenges and exhibitions. In the industry domains, operation time of the factory is the most important factor for energy consumption. Even when the robots and other peripherals are idling, certain amount of energy is consumed. Therefore, cycle time, which is equivalent to time required for assembling one product in our case, should be shorter and a temporary stop of the system and the following error recovery should be prevented as much as possible. Besides that, system reconfiguration for a new product should be done as quickly as possible, because no value is generated during the reconfiguration phase. In other words, “productivity” and “agility” are the keys for energy saving in the industrial robotics category.

To encourage the teams to make efforts for energy saving, the Assembly Challenge introduces the following scoring policies:

### 1. Time bonus for the task-board task

If assembly of all of the parts is completed within the task period, points will be given as a time bonus based on the amount of time remaining until the time limit of the task. Reset should be avoided because the task should be started from the initial setup.

### 2. Time bonus for the kitting task

If all the required parts sets are completely made within the task period, points will be given as a time bonus based on the amount of time remaining until the time limit of the task. No time bonus will be awarded if there is an imperfect parts set. Reset should be avoided

because the task should be started from the initial condition for the current kitting.

The maximum number of parts sets for the kitting task are planned to be three.

### 3. Time bonus for the assembly task

If assembly of all of the required number of products is completed within the competition time, points shall be given as a time bonus based on the amount of time that remains in the competition time for the task. Reset should be avoided because the task should be started from the initial condition of the current sub-task. Therefore, “productivity”, i.e. how quickly the system can assemble the target products without any failures is very important to get the time bonus.

In the second day of the assembly task (Day 4), teams are required to assemble a new Belt Drive Unit using surprise parts. To cope with this new demand, teams must reconfigure their system during the competition time. Therefore, “agility”, i.e. how quickly the system can be reconfigured for a new demand, is also very important to get the time bonus.

The maximum number of Belt Drive Units to be assembled in the assembly task is planned to be two on Day 3 and three on Day 4, respectively. On Day 4, teams have to assemble three units in the order of the original Belt Drive Unit, the new Belt Drive Unit with surprise parts, and then another original Belt Drive Unit.

## 6.5 Exhibition

Exhibitions have been scheduled in the morning and afternoon of Day 5. Exhibitions will only be held by teams designated by the judging panel, such as high-rank award winning teams and each Society Award winning team. The teams who will perform an exhibition will be notified at the end of the competition on Day 4. The purpose of the exhibitions is to demonstrate the performance of distinguished teams to spectators in an easy-to-understand manner. In order for many people to see this, the person in charge of the presentation for the team must always stand on a special stage and provide an explanation. A live video stream of the team’s robot is planned for the special stage. In the exhibitions, teams are encouraged to provide information they were unable to show in the competition (image recognition, motion planning screens, etc.). Each team may also use the slides (or revisions or new materials based on those slides) from the technical documents submitted in the PowerPoint format before the start of the competition in their exhibition. Furthermore, teams may show video taken during the competition by the competition committee as necessary.

Each team will be given 30 minutes for their exhibition. Teams are not required to fully replicate the competition tasks in the exhibitions, and they may freely perform the exhibition so that they can appeal their innovations.

Table 8: Examples of Evaluation Items

Network/software	Technologies such as network and software technologies that are hard to understand from outside
Hands/hardware	Technologies appealing in hardware such as universal robot hands
System integration	Technologies appealing in terms of total system design
Innovative ideas	Innovative ideas emphasizing the creativity even if not brought out its performance sufficiently in the competition

## 6.6 Society Awards

Various Society Awards are planned in addition to the awards for top three teams in total points, but the details are still pending. Examples of the evaluation items for Society Awards are indicated in Table 8. The Society Awards are basically judged based on the technical documents submitted by each team by considering the aspects that cannot be evaluated from the competition performance alone. Teams are encouraged to refer the levels shown in Table 1 as the evaluation items for the Society Awards.

# 7 Safety and Health

Safety and health are the highest priority concerns for the competition. The industrial robots and other equipment used in this competition may come with great risk if they are not configured with the proper safety measures. All teams must adhere strictly to the safety regulations. If the referees judge that actions of a certain team are dangerous or if they recognize that a certain team is violating the safety regulations, that team will not be allowed to participate in the competition.

## 7.1 Safety and Health Management Policy

The Safety and Health Management Policy was formulated according to safety and health considerations for all participants involved in the competition from the team members participating in the competition tasks to the referees, spectators, and the press.

### 7.1.1 Definitions of Terminology

The definitions of terminology related to safety and health management are indicated in Table 9. Also refer to Fig. 16 for the definitions of areas.

### 7.1.2 Scope of Risk Assessment and Responsible Entities

The organizer of the competition will oversee the safety management of the entire competition venue. The competition committee will implement risk assessment of the border between the public area and the team areas for the Assembly Challenge (green border in Fig. 16) and evaluate the appropriateness of the risk assessment implemented by the teams. Teams are responsible for risk assessment in the team area, which can be regarded as a virtual factory.

Table 9: Definitions of Safety and Health Management Terminology

Competition venue	The entire venue that includes the area where the general spectators can enter as well as the team areas
Public area	The area accessible by the general spectators
Team area	The area accessible by the team members in the competition venue (virtual factory)
Operation area	Area where the team members can operate the system during the competition
System running area	Area where competition systems such as robots are installed and run during the competition. System running area can be accessed only from the operation area.
Competition systems	Systems to execute competition tasks made up of equipment and devices brought by teams
Safety fence	Partitions to fully divide the system running area and other areas. An entrance will be setup with a door that has a safety switch.
Safety circuit	Circuit to transition the status of the competition system to a safety state
Safety switch	Switch for opening and closing contact points to open and close the entrance door of safety fence
Emergency stop button	Switch made in the designated color and shape to press in order to transition the competition systems into a safety state
Signal lights	Lamps to display multiple indication colors for the operational state of the competition systems. The signal lights must comply with the IEC60204-1.

### 7.1.3 Governing Regulations

Teams shall adhere to the ISO10218 series and other standards on which ISO10218 series are based on.

### 7.1.4 Safety and Health First

Operation of the competition shall prioritize safety and health above all else. Any inconsistencies related to the protection of safety and health shall be rectified immediately.

### 7.1.5 Complete Separation Principle

The system running area to operate the competition systems shall be completely separated from other areas with a safety fence to prevent any accidents that could occur due to the physical contact between participants and scattering objects or parts from objects used in the competition tasks. In other words, the most possible risk that should be considered in advance by the risk assessment is physical contact. Therefore, the safety fence is required as a way to mitigate that risk. The safety fence will be provided by the competition committee.

### 7.1.6 Obligation to Adhere to Safety and Health

All participants are obligated to protect the safety and health for everyone. For example, teams must strictly adhere to the Safety and Health Regulations stipulated by the competition committee. Spectators must not enter restricted areas and recognize the danger of the competition tasks while cooperating with the competition committee. The proper measures will be taken if participants do not adhere to the Safety and Health Regulations, including direction on the adherence to the safety regulations, stop of competition tasks, and disqualification from the competition in the event of actual danger or the potential of danger to the participants.

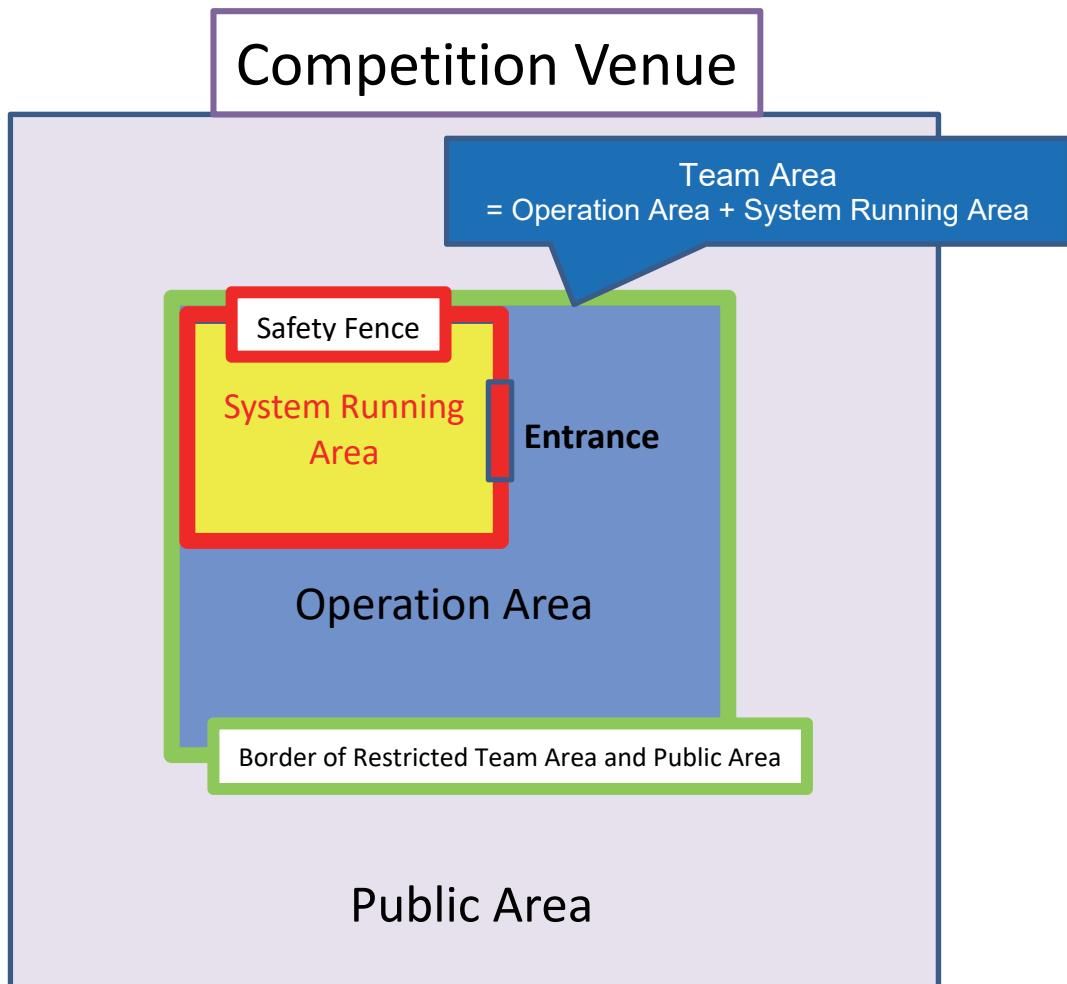


Figure 16: Definition of Areas

Teams have a duty to implement risk assessment and submit evidence of that implementation.

The competition committee or the referees will conduct a safety inspection before competition (during setup) and make requests for improvements based on the inspection results. Team are responsible to undergo inspections to monitor safety, respond to requests for improvements according to the results as well as accept disqualification from participation in the competition in the event the team is determined to be ineligible.

### 7.1.7 Amendments to the Safety and Health Regulations

Measures, including the Safety and Health Regulations, may be amended immediately as necessary for the purpose of protecting safety and health.

## 7.2 Safety and Health Regulations

### 7.2.1 Safety Fence and Safety Circuit

Each team will be provided with a safety fence and a door switches for safety fence. Each team shall install competition systems inside the safety fence after preparing a safety circuit, and they must always connect the competition systems and safety circuit. However, computers and controllers that cannot change the housing shape are not limited to inside of the safety fence but can also be set up in the operation area. The equipment may not protrude from these areas regardless of where they are set up. The safety circuit must include a door switch for the safety

fence, an emergency stop button, and signal lights (Table 10) . Detailed specifications of the safety circuit will be provided separately.

### **7.2.2 Environmental Pollution Control and Management**

It is prohibited to discharge acoustic noises, vibrations, electromagnetic noises, hazardous rays, air pollutions, emissions, waste liquids, toxic or deleterious substances without proper control and management.

### **7.2.3 Submission of a Risk Assessment Evidence and Preparation of a Safety Manual**

Teams must submit an evidence of their risk assessment, including risk assessment table, residual risk list (list of measures), technical files, and declarations of conformity by the deadline designated before the competition (See item #6 in Table 11). Teams are strongly encouraged to prepare a safety manual for their competition systems that includes all the items indicated in Table 11.

### **7.2.4 Execution of Inspections Before Competition Tasks**

Referees will inspect the safety and health while teams set up for the competition. Corrective actions may be recommended if there are any safety and health concerns.

### **7.2.5 Execution of Safety and Health Patrols**

The referees regularly conduct safety and health patrols. Recommendations for corrective actions, stop of the competition task, recommendations for adherence to safety regulations, and elimination from participation may occur due to safety and health concerns.

### **7.2.6 Requirements to Wear Safety Clothing and Protective Gear**

The clothing and protective gear for individuals who will work in the safety fence are outlined in Table 12 and all team members must adhere to these requirements.

### **7.2.7 Amendments to the Safety and Health Regulations and Supplementary Documents**

The Safety and Health Regulations may be amended immediately as necessary for the purpose of protecting Safety and health. In the future, the competition committee will issue supplementary documents for the safety and Health Regulations that the teams must adhere to. Teams shall be fully notified when amendments and supplementary documents are issued.

## **8 Materials that should be Submitted by the Teams**

The materials that teams must submit by the teams are listed in Table 13. Team must submit those material to the competition committee secretariat **no later than October 5, 2018 at 5:00PM (JST)**. However, the materials listed in this chapter are still tentative and subject to additions or retractions in the future. Teams will be notified of the details for each of the materials at a later date.

The contents decided upon at this time are indicated below. Be aware that the content below is also subject to change in the future.

Table 10: Safety Circuit

Door switch	Connection terminals will be provided to teams. Therefore, teams shall connect their own safety circuits.
Emergency stop button	Connection terminals will be provided to teams. Therefore, teams shall connect their own safety circuits.
Signal lights	Teams will be provided with a VCC and GND for signal lights via a connection terminal according to the IEC60204-1, such as red, yellow, blue, green, and white. Teams shall short-circuit these two points to illuminate the signal lights.

Table 11: Safety Manual Items (Item (6) should be submitted as a risk assessment evidence)

(1) Definition of operational modes such as the teaching mode and automatic operation mode
(2) Response of the system when the emergency stop button is pressed
(3) Response of the system when the safety fence door is opened.
(4) Diagnostic methods for items above (1 to 3)
(5) Operational procedures to raise awareness of the team members, including unsafe actions that are prohibited
(6) A risk assessment table, residual risk list (list of measures), technical files, and declarations of conformity

### (A) Technical documents

The technical documents shall be made up of the five pages with items outlined below in the PowerPoint format, and it should describe information that would be hard to understand by spectating the competition alone. In particular, on the fifth slide for the summary, teams must clarify the level of their developed systems corresponding to the level outlined in Table 1, together with the reason for such correspondence.

- (1) Team introduction
- (2) Overview of entire system
- (3) Efforts for the task-board task and kitting task (hardware/software)
- (4) Efforts (hardware/software) for the assembly task (including surprise parts)
- (5) Summary: appeal points of the team in terms of agile and lean manufacturing and social implementation

The technical documents will be used in the scoring for each Society Award and may be used as references of technical points of some tasks.

### (B) Team introduction/system introduction videos

One video introduces the team and the team members, and another video introduces the robot system built by the team. Each video should be roughly two minutes long.

### (C) Risk assessment documents

See Chapter 7 for more information.

Table 12: Clothing and Protective Gear for Work Inside the Safety Fence

Hair	Make sure to bundle long hair
Work clothing	Make sure to wear long sleeves and long pants that are not baggy
Helmet	Make sure to wear the proper type of helmet considering the length of use to mitigate head injuries
Protective goggles	Always protect your eyes. Make sure to wear the proper goggles, such as those that protect the eyes from scattering objects and hazardous rays.
Proper use of proper gloves	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.
Ear plugs	Make sure to wear the proper ear plugs for impulsive sound and steady noise to protect your hearing ability.
Safety shoes	Always protect your feet. Make sure to wear the proper type of shoes as necessary.

Table 13: List of Materials to be Submitted

Must Item	Item	Format	Submission Deadline	Remarks
✓	Technical documents	PowerPoint	Beginning of October	
✓	Team introduction/system introduction videos	mpeg	Beginning of October	
✓	Risk assessment materials	pdf	Beginning of October	
	Demonstration videos of the laboratory system	mpeg	Beginning of October	
✓	Demonstration videos of the on-site system	mpeg	Day before each task of the competition is held	
	Exhibition presentation file	PowerPoint	After exhibition (only teams eligible for the exhibition)	Presentation file revised based on the technical documents
	Symposium presentation file	PowerPoint	After symposium (only teams participating in the symposium)	Presentation file revised based on the technical documents

#### (D) Demonstration videos of the laboratory system

This video introduces the robot system in operation taken at the team's development site or laboratory. The video should be taken separately for each task (task board, kitting and assembly). The video should be roughly one minute for each task. This video will be shown to the spectators in an event, e.g., when the robots are not functioning during the competition. The submission of this video is optional.

### **(E) Demonstration videos of the on-site system**

This video introduces the robot system in operation taken at the competition venue. The video should be taken separately for each task (task board, kitting and assembly). The video should be roughly one minute for each task. This video will be shown to the spectators in an event, e.g., when the robots are not functioning during the competition. Teams who have already submitted demonstration videos of the laboratory system do not need to submit the videos of the on-site system. Of course, they can update their demonstration videos by submitting new videos taken at the competition venue.

### **(F) Exhibition presentation file**

Teams instructed to hold an exhibition by the judging panel must submit the presentation file used for the exhibition by the end of the exhibition. The submitted presentation files will be saved as the record materials for the Competition Committee. Teams who hold an exhibition will be notified when all the points are finalized after the end of the competition task on Day 4. The presentation file for the exhibition may be prepared based on the technical documents in (A) and it is expected to be revised and modified by the team as necessary.

### **(G) Symposium presentation file**

The teams who give a presentation at the symposium must submit the presentation file after the presentation ends. The submitted presentation files will be saved as the record materials for the competition committee. The presentation file for the symposium may be prepared based on the technical documents in (A) and it is expected to be revised and modified by the team as necessary.

## **9 Symposium**

The symposium for the Industrial Robotics Category is scheduled on October 22<sup>nd</sup> (Monday), the day after the competition. The purpose of the symposium is to:

- provide an opportunity of technical exchange between teams;
- receive feedback from teams such as a review of the WRS 2018 competition;
- and discuss ideas about the competition design for the WRS 2020 by the team members and competition committee members.

Details about the symposium are scheduled to be announced at a later date, but as a general timetable, presentations from each team are planned in the morning and a review of the WRS 2018 and an exchange of ideas for the WRS 2020 are planned for the afternoon. The symposium is planned to be a closed event where only people related to the competition may attend.

Participation in the symposium is optional, but we ask for understanding about the purpose of holding the symposium and strongly recommend the participation of teams. Furthermore, presentations by high-rank award winning teams are also strongly recommended to joint this symposium.

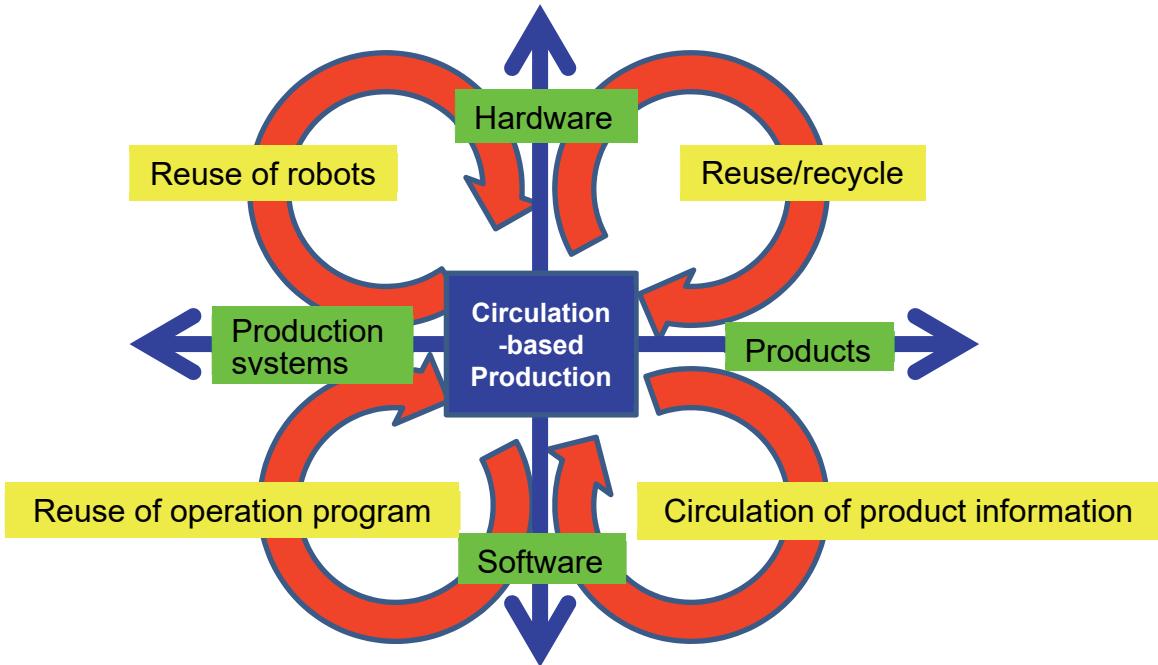


Figure 17: Circulation-based Production Society

## 10 Conclusion (Robotics for Happiness)

The basic theme of WRS is ‘Robotics for Happiness’. Therefore, in closing, we would like to think about what kind of ‘happiness’ will be brought about from 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’ being able to respond to different purposes. Ultimately, we, the Industrial Robotics Category, aims at realizing the circulation-based production society shown in Fig. 17. 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.

If such types of circulation-based production systems can be established, we would be able to realize a society where people can get the product they want at the right price and timing while lowering the environmental impact. This is the happiness that we hope to bring about from the WRS Industrial Robotics Category.

We are looking forward to seeing good performances by all the teams in the WRS 2018.

## References

- [1] Yu Sun et.al. 2ND ROBOTIC GRASPING AND MANIPULATION COMPETITION.  
[http://www.rhgm.org/activities/competition\\_iros2017/](http://www.rhgm.org/activities/competition_iros2017/). 2017.
- [2] The 2017 IEEE/RSJ International Conference on Intelligent Robots and Systems.  
<https://www.iros2017.org/>. 2017.

# Appendix A.

A1-TaskBoard\_Assembled  
Completion configuration of Task Board

A2-TaskBoard\_Setup  
Setup configuration of Task Board

A3-MainPlate  
Geometric feature, dimension and tolerance of the main plate

A4-MainPlate\_Drawing  
Mechanical drawing of the main plate of Task Board

A5-Taskboard\_Setup\_ContactSurface  
List of contact surfaces of target parts for setup configuration

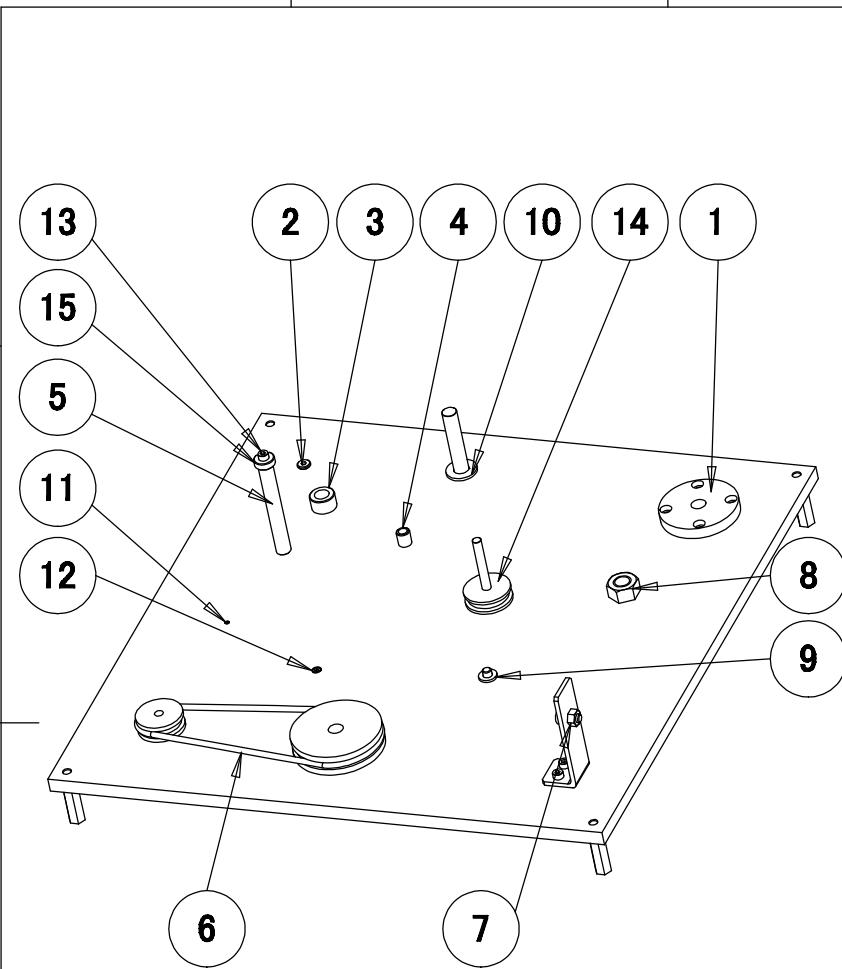
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Industrial Robotics Competition Committee  
World Robot Summit

\* 15th July, 2018  
Update A-1, A-2, and A-5.

\* 5th September, 2018  
Update A-1, A-2, A-3, A-4 and A-5.

\* 27th September, 2018  
Update A-5.

1	2	3	4	5	6
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No.	Model number *	Part name	Task
1	SBARB6200ZZ-30	Bearings with Housing	Insertion into a hole
2	BGPSL6-9-L30-F7	6mm Bearing retainer pin	Insertion into a hole
3	CLBPS10-17-50	17mm Spacer for bearings	Insertion into a hole
4	CLBPS6-9-50	9mm Spacer for bearings	Insertion into a hole
5**			
6	MBT4-400	4mm Round belt	Looping over pulleys
7	SLBNR6 & SCB6-10	M6 Nut & Bolt	Fasten a nut and bolt
8	SLBNR12	M12 Nut	Conjunction with a bolt
9	SPWF6	6mm washer	Placing onto a bolt
10	SPWF10	10mm washer	Placing onto a shaft
11	MSSFS3-12	M3 Setscrew	Screwing into a tapped hole
12	SCB3-6	M3 Bolt	Screwing into a tapped hole
13	SCB4-6	M4 Bolt	Screwing into a tapped hole
14	MBRFA30-2-P6	Pulley	Placing onto a shaft
15	EDCS10	10mm End cap	Placing onto a shaft

\* Products by MISUMI

\*\* This part is assembled on the main board in advance. See Appendix A.2.

Part No.	Part name	Last update 2018-Aug-18	
		Scale	Proj. method
010	TaskBoard_Assembled	0.200	3rd. angle projection
Designer M. Shibata		World Robot Challenge 2018	
010_TaskBoard			

1	2	3	4	5	6	
			No.	Model number *	Part name	QTY
			0	SLON10-30-M6	Hex Posts	4
			5,15	SCB4-15, SPWF4, SSFHRW10-75-M4-N4	Bolt & Washer & Rotary shaft	1
			6_1	MBGNA30-2, TWASS10-6-3	Pulley & Washer	1
			6_2	MBGNA60-2, TWASS14-10-1	Pulley & Washer	1
			7_1	FALBS-AMW-T3-A75-B25-L25-H50-N6-V12-S15-NA4	L Bracket	1
			7_2	SCB4-12, SPWF4	Bolt & Washer	2
			8	SCB12-25, SPWF12	Bolt & Washer	1
			9	SCB6-20, SPWF6	Bolt & Washer	1
			11	MSSFS3-12 **	Set screw	1
			10	PSSFAN10-50-F10-B8-P6	Shaft	1
			14	PSSFAN6-50-F10-B8-P4	Shaft	1

**\* Products by MISUMI**

**\*\* This part is screwed into the main board in advance (Offset 2mm).**

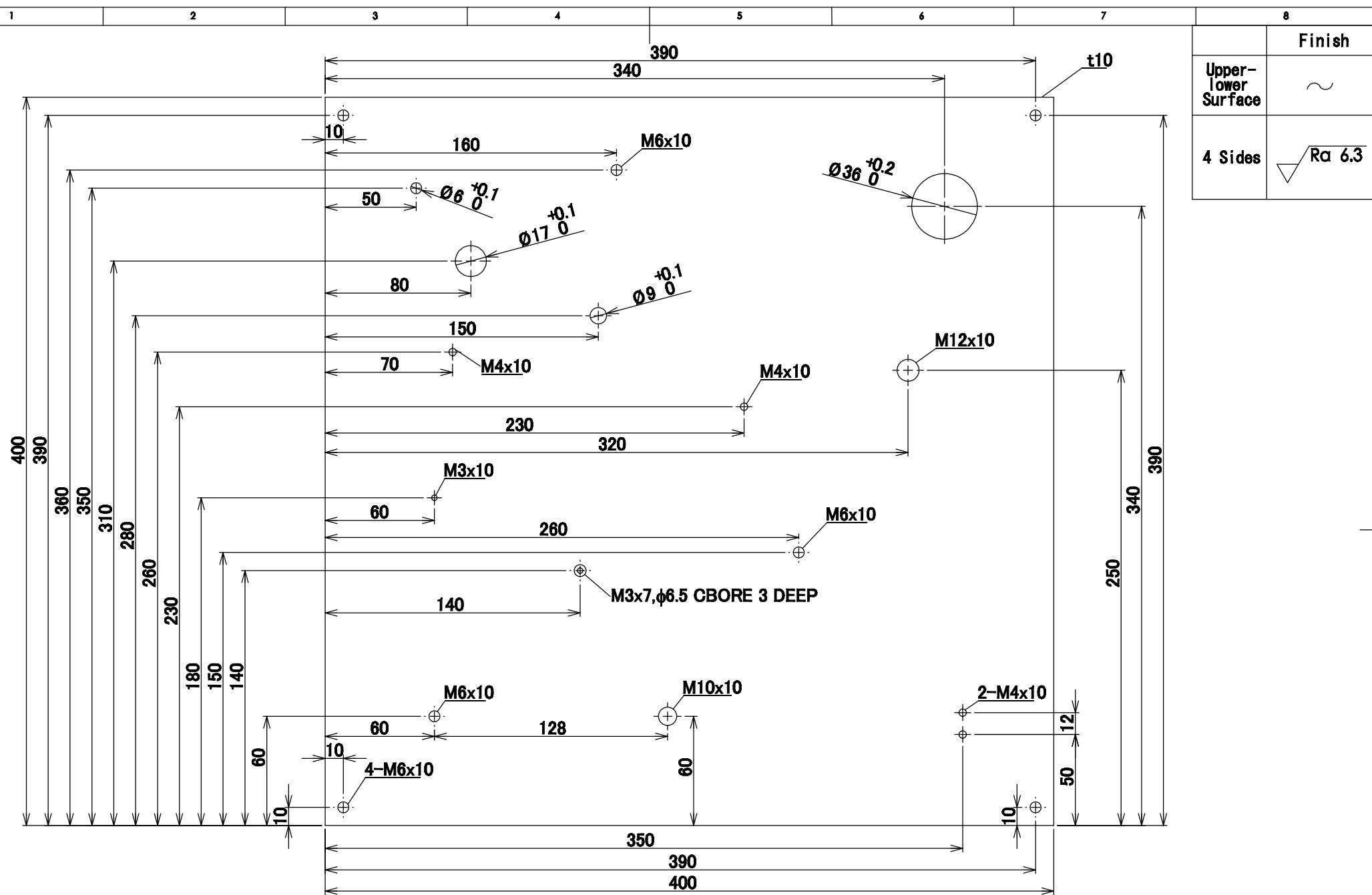
Part No.	Part name	Last update 2018-Aug-18	
011	TaskBoard_Setup	Scale	Proj. method
		0.200	3rd. angle projection

Designer M. Shibata

011\_TaskBoard

World Robot Challenge 2018

1	2	3	4	5	6
A			No.	X	Y
			0_1	10	10
B			0_2	10	390
			0_3	390	10
			0_4	390	390
C			1	340	340
			2	50	350
			3	80	310
			4	150	280
D			5	70	260
			6_1	60	60
			6_2	(188)	60
			7_1	350	50
			7_2	350	(62)
			8	320	250
			9	260	150
			10	160	360
			11	60	180
			12	140	140
			13		M3 x 7, Ø6.5 CBORE 3 DEEP
			14	230	M4 x 10
			* Polyacetal plate is used.		
			* Unless otherwise specified, dimensional tolerance is according to JIS B0405 medium grade.		
			Part No.	Part name	
			000	MainPlate	
				Last update 2018-Aug-18	
				Scale	Proj. method
				0.200	3rd. angle projection
			Designer M. Shibata	World Robot Challenge 2018	
			000_MAINPLATE		

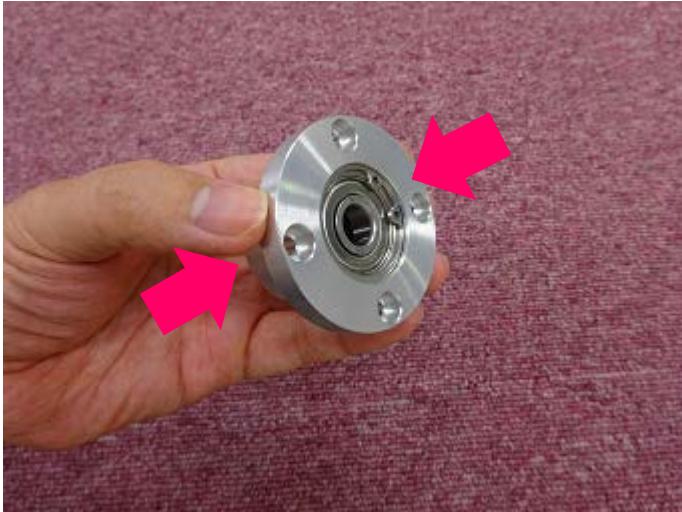


\* Unless otherwise specified, dimensional tolerance is according to JIS B0405 medium grade.

Proj. method:  
3rd.  
angle  
projection  
Date: 2018-Aug-18  
MATERIAL:  
Polyacetal(POM)  
Designer M. Shiba

World Robot Challenge 2018  
Name: MainPlate\_Drawing  
Size: A3  
SCALE: 1:12 SHEET 1 OF 1

# Contact surfaces for setup (1/4)



No.1  
Both surfaces are available.



No.2



No.3  
Both surfaces are available.

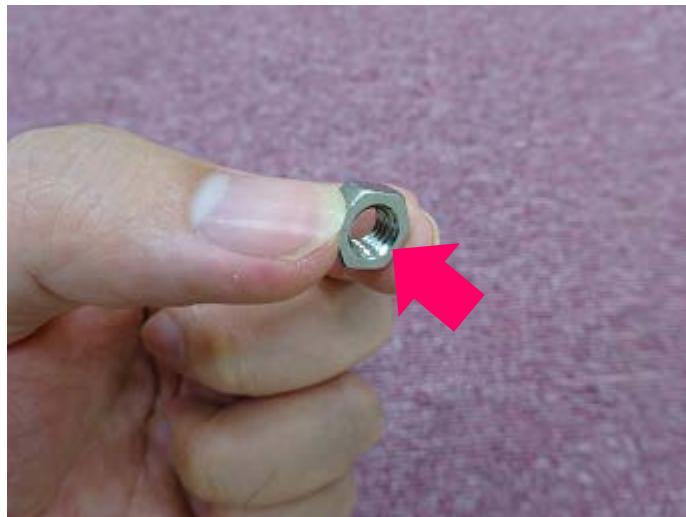


No.4  
Both surfaces are available.

# Contact surfaces for setup (2/4)

This part is assembled  
on the main board in advance.

No.5



No.7-1  
Back surface is available.



No.6



No.7-2

# Contact surfaces for setup (3/4)



No.8  
Back surface is available.



No.9  
Back surface is available.



No.10  
Back surface is available.

This part is screwed into the main board in advance (Offset 2mm).

No.11

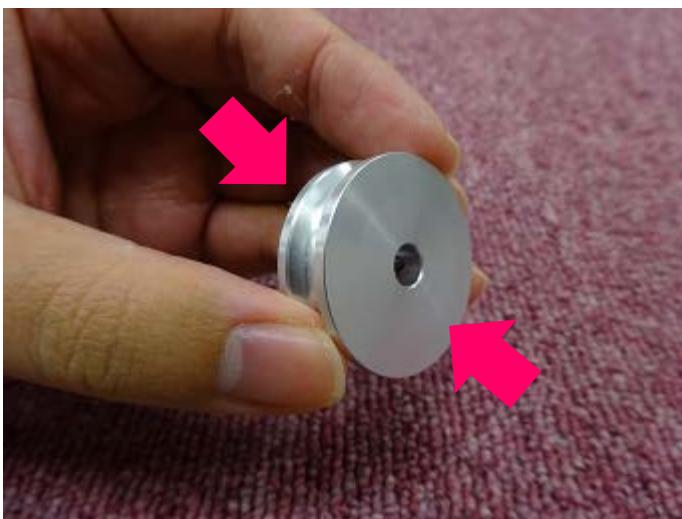
# Contact surfaces for setup (4/4)



No.12

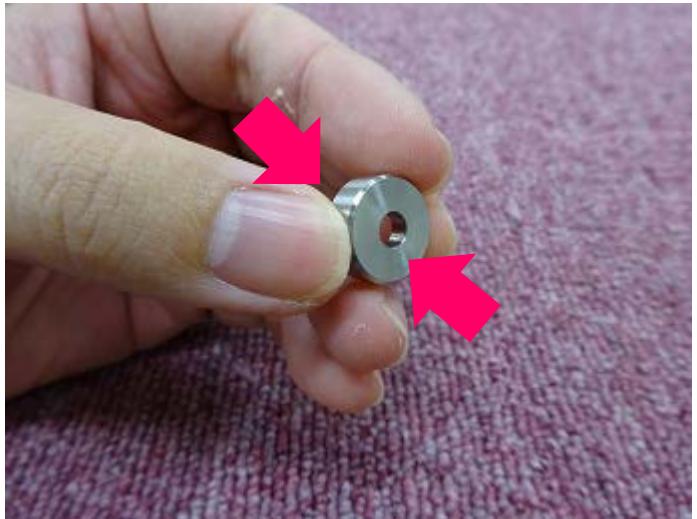


No.13



No.14

Both surfaces are available.



No.15

Both surfaces are available.

# Appendix B. :

## Detailed parts bin information, part-kitting tray information, and parts placement information

Appendix B has three sheets;

Parts bin information,

Relationship between parts and parts bins,

Part-kitting tray information,

Parts placement information, and

Example of set list.

Three kinds of parts bins and two part-kitting trays will be provided to each team.

If you need more, you can order through the MISUMI website.

The same parts as the assembly task are used in the kitting task.

---

10th July, 2018

Industrial Robotics Competition Committee

World Robot Summit

Change Log:

[7th Sep, 2018]

Relationship between parts and parts bins was added.

Part-kitting tray information was updated.

Parts placement information was updated.

Example of set list was added.

One part (No.8) was changed.

[25th Sep, 2018]

Point sheet was added.

Pictures of the tray were changed to the final specification.

### Parts bin

Product name	Part Number	Company	Color	Outside dimensions (mm)	Inside dimensions (mm)	Weight (g)	Required number	No. of Parts
1 Parts Tray	EA661CA-11	ESCO	Dark Blue	125(W)×133(D)×50(H)	112(W)×115(D)×45(H)	50	5	9, 10, 12, 14, 15, 16, 17, 18
2 Hanger Rack Container SK	SK-HL1-BL	SANKO Co., Ltd	Blue	112(W)×201(D)×75(H)	87(W)×162(D)×67(H)	120	4	4, 5, 7, 8, 11, 13
3 T-type Container Capacity	T3-YG	TRUSCO NAKAYAMA	Yellow Green	192(W)×285(D)×90(H)	158(W)×219(D)×82(H)	250	1	6
Total								10

You can order trough the MISUMI website.

2 <https://jp.misumi-ec.com/top/>

3	o	o	x	o	o
o	o	o	*	o	o

\* No Product Page (Available to Order)

JP

1 URL

2 <https://jp.misumi-ec.com/vona2/detail/223007343655/?HissuCode=EA661CA-11>

3 <https://jp.misumi-ec.com/vona2/detail/223000756791/?KWSearch=HL-1&searchFlow=results2products>

USA

1 URL

2 <https://us.misumi-ec.com/vona2/detail/223007343655/?HissuCode=EA661CA-11&PNSearch=EA661CA-11&KWSearch=EA661CA-11&searchFlow=results2typ>

3 <https://us.misumi-ec.com/vona2/detail/223000756791/?HissuCode=SK-HL1-BL&PNSearch=SK-HL1-BL&KWSearch=SK-HL1-BL&searchFlow=results2typ>

Europe

<https://us.misumi-ec.com/vona2/detail/223000756982/?HissuCode=T3-YG&PNSearch=T3-YG&KWSearch=T3-YG&searchFlow=results2product>

1 URL

2 <https://uk.misumi-ec.com/vona2/result/?Keyword=EA661CA-11&isReSearch=0>

3 <https://uk.misumi-ec.com/vona2/detail/223000756791/?HissuCode=SK-HL1-BL&PNSearch=SK-HL1-BL&KWSearch=SK-HL1-BL&searchFlow=results2typ>

China

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1 URL

2

3

Thailand

<https://th.misumi-ec.com/vona2/result/?Keyword=T3-YG+&isReSearch=1>

1 URL

2 <https://th.misumi-ec.com/vona2/detail/223007343655/?HissuCode=EA661CA-11&PNSearch=EA661CA-11&KWSearch=EA661CA-11&searchFlow=results2typ>

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SEA

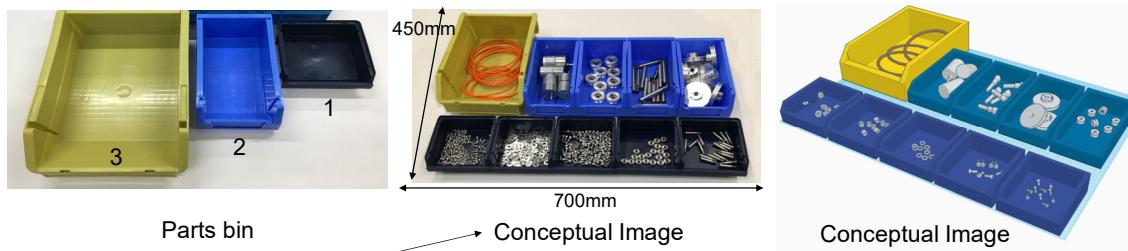
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1 URL

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3 <https://sq.misumi-ec.com/vona2/detail/223000756791/?HissuCode=SK-HL1-BL&PNSearch=SK-HL1-BL&KWSearch=SK-HL1-BL&searchFlow=results2typ>

<https://sq.misumi-ec.com/vona2/detail/223000756982/?HissuCode=T3-YG&PNSearch=T3-YG&KWSearch=T3-YG&searchFlow=results2typ>



Parts bin

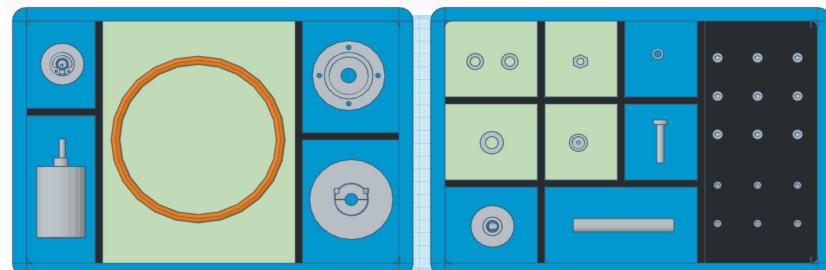
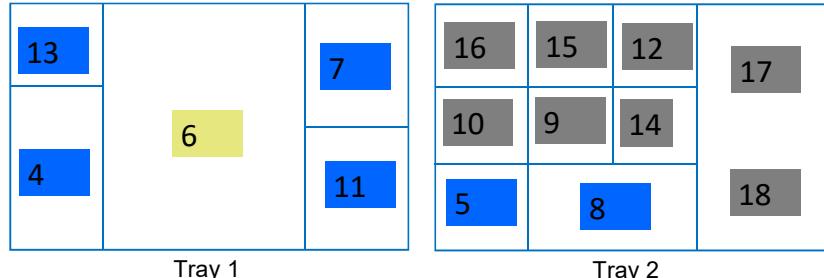
Conceptual Image

Conceptual Image

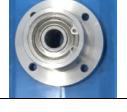


Tray 1

Tray 2



## Parts bins - Parts list

Parts bin					Parts			
No.	Name	Picture	Part Number	Company	No.	Name	Picture	Note
1	Parts Tray		EA661CA-11	ESCO	9	09_EDCS10		End Cap for Shaft
					10	10_CLBPS10_17_4		Bearing Spacers For Inner Ring (output pulley)
					12	12_CLBUS6-9-9.5		Bearing Spacers For Inner Ring (tension pulley)
					14	14_BGPSL6-9-L30-F7		Bearing Shaft Screw
					15	15_SLBNR6		M6 Hex Nut (Fixing for idler shaft)
					16	16_SPWF6		M6 Flat Washer (Fixing for idler shaft)
					17	17_SCB4-10		10mm M4 Socket Head Cap Screw (metric coarse thread)
					18	18_SCB3-10		10mm M3 Socket Head Cap Screw (metric coarse thread)
2	Hanger Rack Container SK		SK-HL1-BL	SANKO Co., Ltd	4	04_37D-GEARMOTOR-50-70		Geared motor (Gear ratio 1:70)
					5	05_MBRFA30-2-P6		Pulley for Round Belt (4mm) - Setscrew P.D. 30mm
					7	07_SBARB6200ZZ_30		Bearings with Housings (Double Bearings)
					8	08_SSFHRT10-75-M4-FC55-G20		Drive shaft (Straight) D10h7
					11	11_MBRAC60-2-10		Pulley for Round Belts Clamping Type P.D. 60mm
					13	13_MBGA30-2		Idler for Round Belt - Wide
3	T-type Container Capacity		T3-YG	TRUSCO NAKAYAMA	6	06_MBT4-400		Polyurethane round belt(welded joint product) P.D. 4mm L=400mm

## Part-kitting tray

	Product name	Part Number	Company	Color	Outside dimensions (mm)	Inside dimensions (mm)	Weight (g)	Required number
1	PZ Type Container	PZ-0006-B	SEKISUI CHEMICAL	Blue	300(W)×210(D)×22.5(H)	280(W)×190(D)×15(H)	170	=2x3
								Total 6

You can order through the MISUMI website.

<https://jp.misumi-ec.com/top/>

	Japan	USA	Europe	China	Thailand	South East Asia
1	o	o	o	x	o	*

\* No Product Page (Available to Order)

	URL
JP	<a href="https://jp.misumi-ec.com/vona2/detail/223000755936/?HissuCode=PZ-0006-B&amp;PNSearch=PZ-0006-B&amp;KWSearch=PZ-0006-B&amp;searchFlow=results2products">https://jp.misumi-ec.com/vona2/detail/223000755936/?HissuCode=PZ-0006-B&amp;PNSearch=PZ-0006-B&amp;KWSearch=PZ-0006-B&amp;searchFlow=results2products</a>
USA	<a href="https://us.misumi-ec.com/vona2/detail/223000755936/?HissuCode=PZ-0006-B&amp;PNSearch=PZ-0006-B&amp;KWSearch=PZ-0006-B&amp;searchFlow=results2type">https://us.misumi-ec.com/vona2/detail/223000755936/?HissuCode=PZ-0006-B&amp;PNSearch=PZ-0006-B&amp;KWSearch=PZ-0006-B&amp;searchFlow=results2type</a>
Europe	<a href="https://uk.misumi-ec.com/vona2/detail/223000755936/?PNSearch=PZ-0006-B&amp;HissuCode=PZ-0006-B&amp;searchFlow=suggest2products&amp;Keyword=PZ-0006-B">https://uk.misumi-ec.com/vona2/detail/223000755936/?PNSearch=PZ-0006-B&amp;HissuCode=PZ-0006-B&amp;searchFlow=suggest2products&amp;Keyword=PZ-0006-B</a>
China	<a href="https://th.misumi-ec.com/vona2/detail/223000755936/?PNSearch=PZ-0006-B&amp;HissuCode=PZ-0006-B&amp;searchFlow=suggest2products&amp;Keyword=PZ-0006-B">https://th.misumi-ec.com/vona2/detail/223000755936/?PNSearch=PZ-0006-B&amp;HissuCode=PZ-0006-B&amp;searchFlow=suggest2products&amp;Keyword=PZ-0006-B</a>
Thailand	<a href="https://sg.misumi-ec.com/vona2/result/?Keyword=PZ-0006-B&amp;isReSearch=0">https://sg.misumi-ec.com/vona2/result/?Keyword=PZ-0006-B&amp;isReSearch=0</a>
SEA	<a href="https://sg.misumi-ec.com/vona2/result/?Keyword=PZ-0006-B&amp;isReSearch=0">https://sg.misumi-ec.com/vona2/result/?Keyword=PZ-0006-B&amp;isReSearch=0</a>

Information (CAD data, etc.) on partitions, screw holder, cushionings will be released before long.

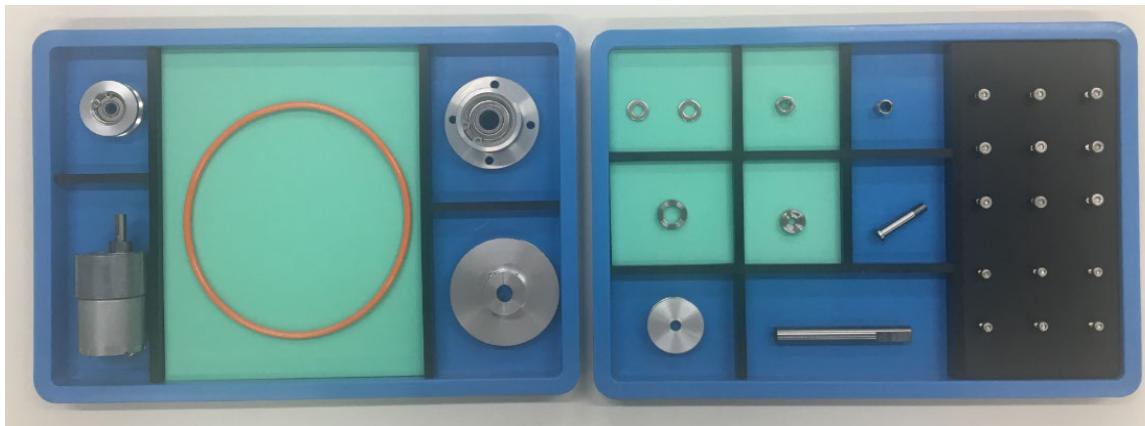


Part-kitting trays (Original)



Tray 1

Tray 2



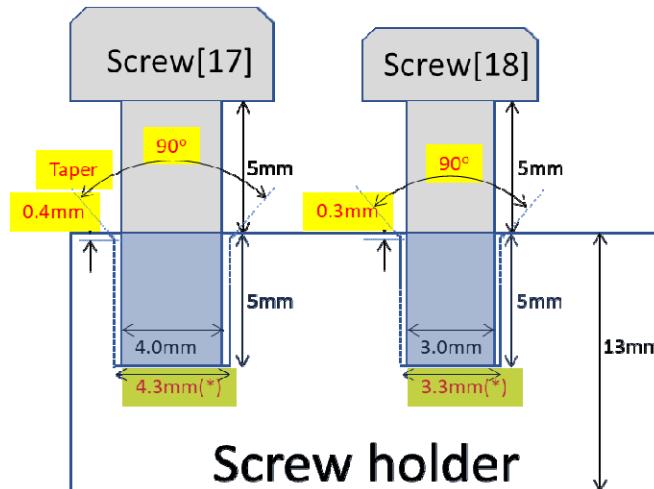
Tray 1

Tray 2

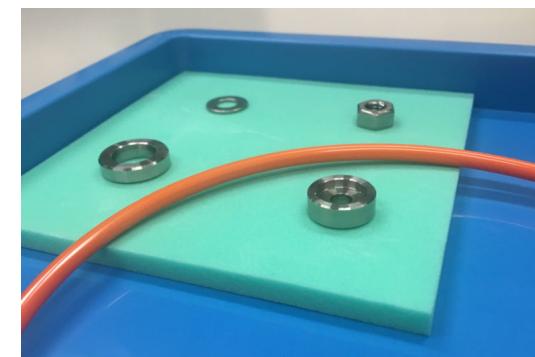
(Provisional) Part-kitting trays with partitions, cushionings, and a screw holder



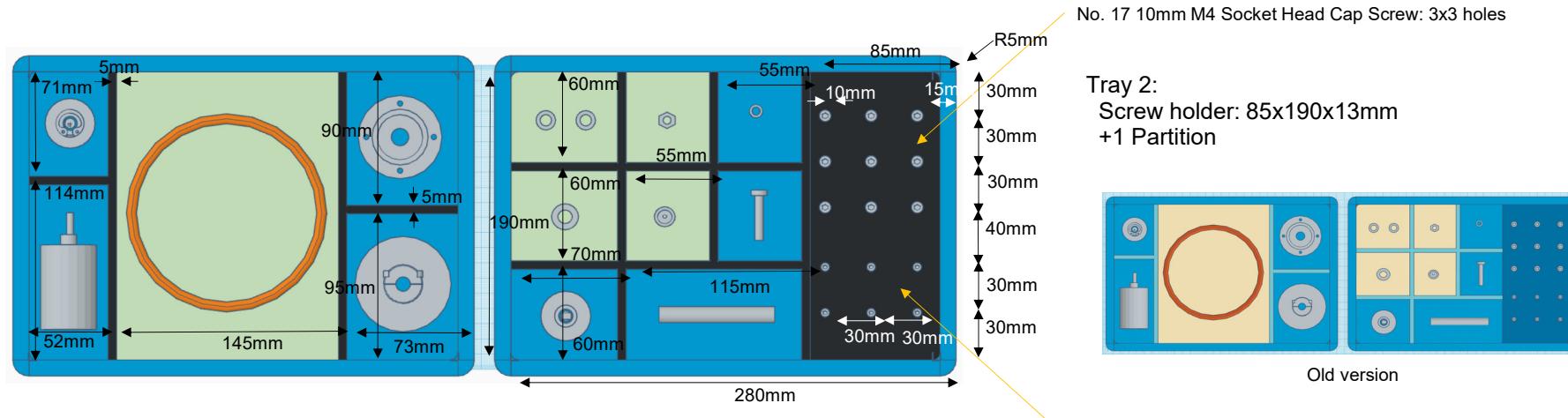
Screw holder



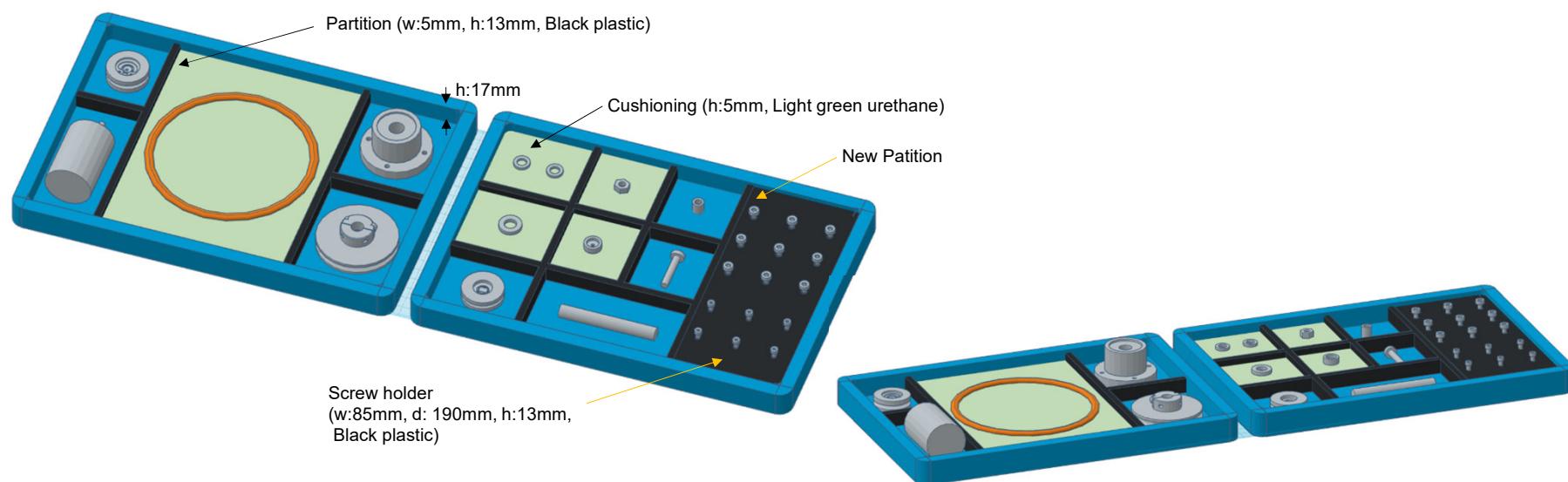
Screw holder



Cushioning



Old version



(Provisional) Size information

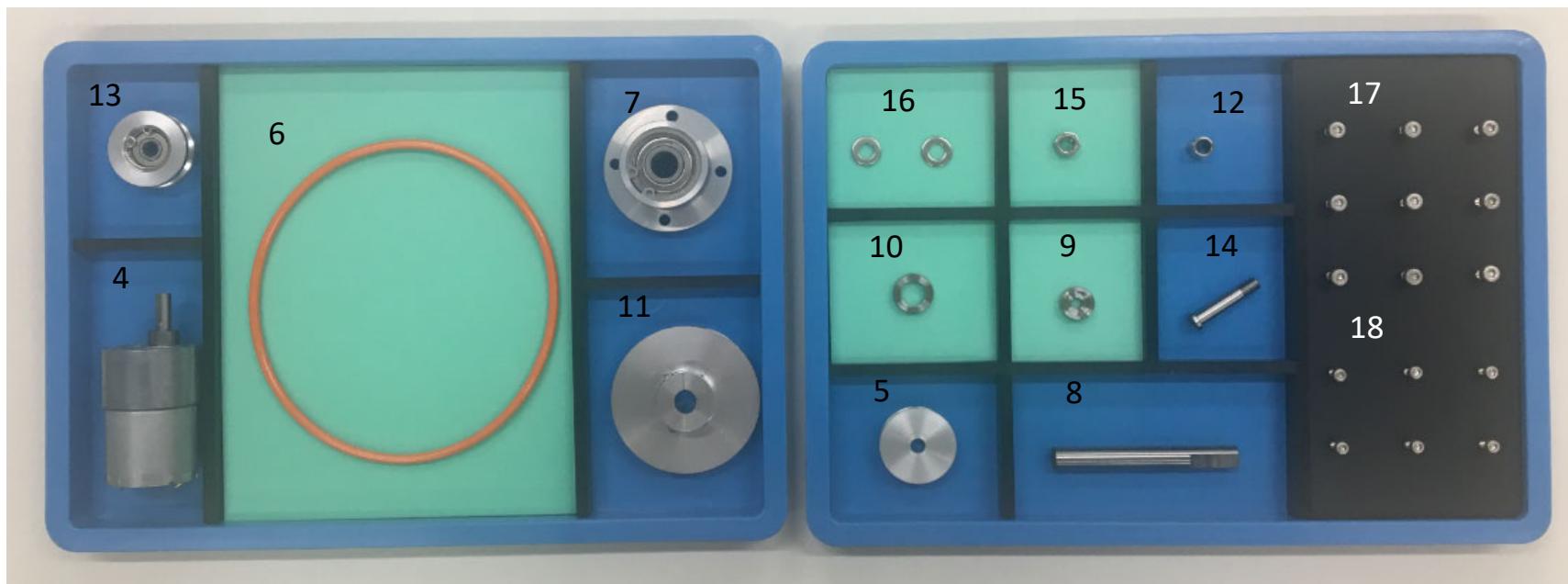
Parts placement information

Parts list (2018July06)

No.	Name of part	Note.
1	01-BASE	Base plate
2	02-PLATE	Output shaft fixing plate
3	03-PLATE2	Motor fixing plate
4	04_37D-GEARMOTOR-50-70	Geared motor (Gear ratio 1:70)
5	05_MBRFA30-2-P6	Pulley for Round Belt (4mm) - Setscrew P.D. 30mm
6	06_MB74-400	Polyurethane round belt (welded joint product) P.D. 4mm L=400mm
7	07_SBARB6200ZZ_30	Bearings with Housings (Double Bearings)
8	08_SSFHRT10-75-M4-FC55-G20	Drive shaft (Straight) D10h7
9	09_EDCS10	End Cap for Shaft
10	10_CLBPS10_17_4	Bearing Spacers For Inner Ring (output pulley)
11	11_MBRAC60-2-10	Pulley for Round Belts Clamping Type P.D. 60mm
12	12_CLBUS6-9-9.5	Bearing Spacers For Inner Ring (tension pulley)
13	13_MBGA30-2	Idler for Round Belt - Wide
14	14_BGPSL6-9-L30-F7	Bearing Shaft Screw
15	15_SLBNR6	M6 Hex Nut (Fixing for idler shaft)
16	16_SPWF6	M6 Flat Washer (Fixing for idler shaft)
17	17_SCB4-10	10mm M4 Socket Head Cap Screw (metric coarse thread)
18	18_SCB3-10	10mm M3 Socket Head Cap Screw (metric coarse thread)
19	19_MSSFS3-6	6mm M3 Hex Socket Set Screw (metric coarse thread)

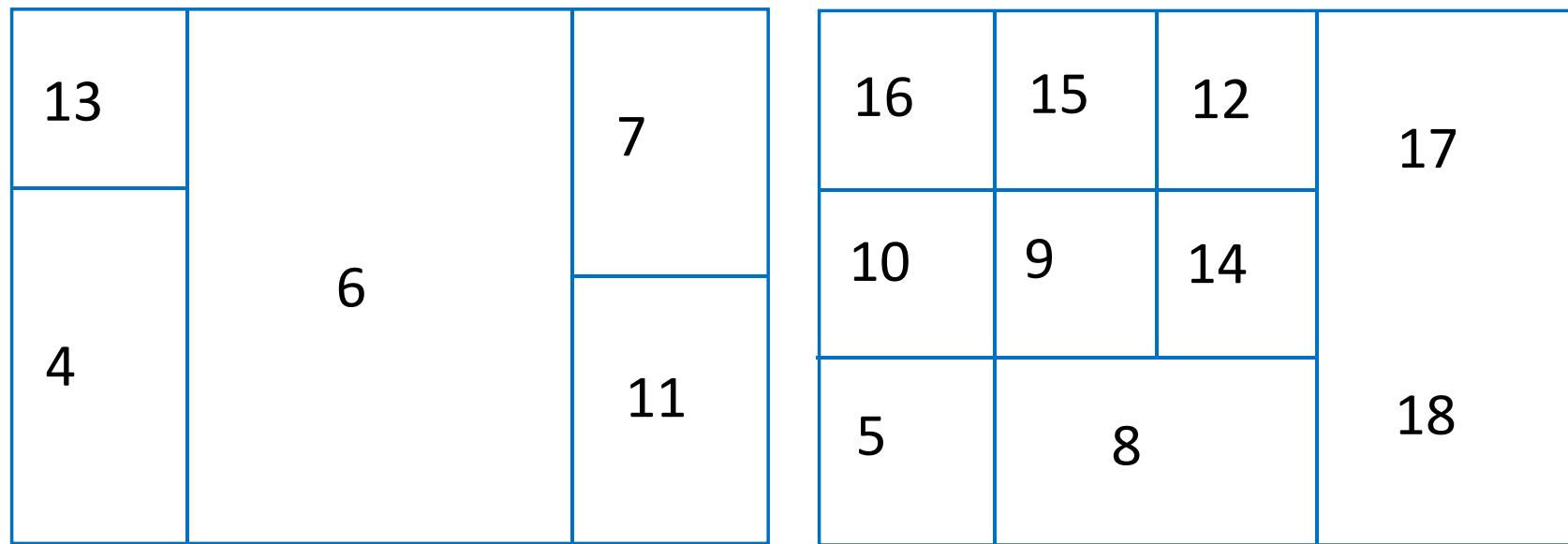
Update:2018July06

Unification of phrases (panel -> plate), Change PartNo.14



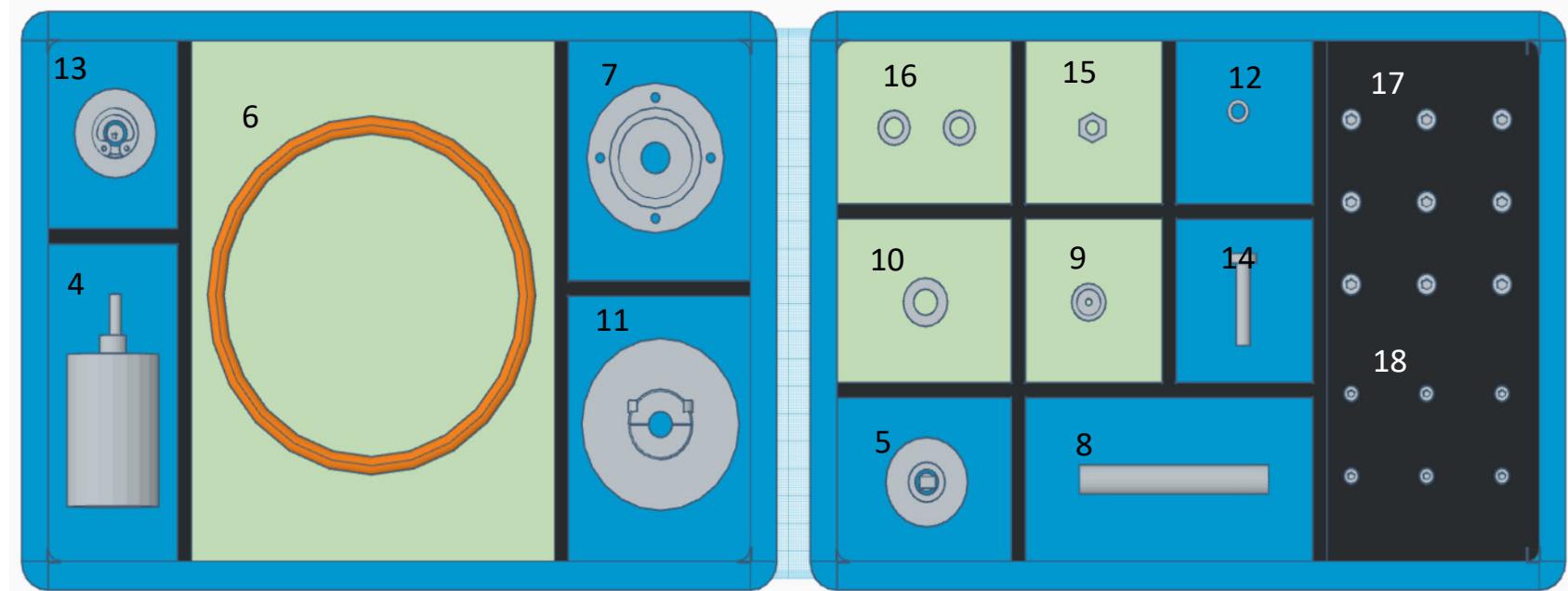
Tray 1

Tray 2



Tray 1

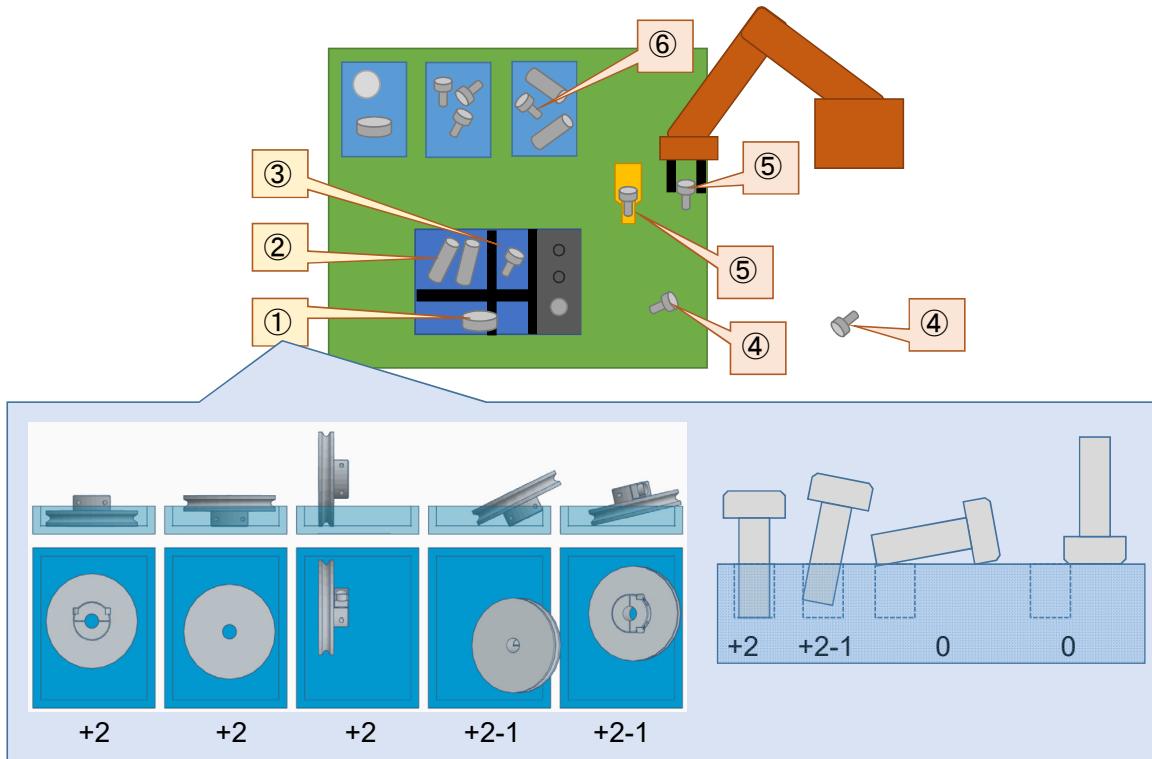
Tray 2



Point List for the Kitting Task		
	Items	Points
Points when parts are placed correctly in the designated area of the tray (2 points/part x 10 parts/set)		20 Points/set
Complete set points [Not applicable if any part for deduction included]		30 Points/set
Total points per set		50 Points/set

#### Deduction Point List for the Kitting Task

	Items	Point	
For each set list	① Parts protrude from the designated area of the tray	-1	Point/part
	② More parts than the designated number are in the designated area of the tray	-1	Point/part
	③ Parts are placed in the wrong area of the tray	-1	Point/part
At the task end	④ Parts are left on the work table ( including in the trays which were not carried out) / on the floor	-1	Point/part
	⑤ Parts are held by the robot system / jig	-1	Point/part
	⑥ Parts are left in the different parts bins	-1	Point/part
Parts dropped during the task have been returned to the original parts bins			No deduction
Parts dropped during the task have been placed in the designated area of the part-kitting tray			No deduction



# Appendix C. : Assembly Task

C1. 00\_assembly\_model.pdf:

Assembly drawing of the belt drive unit.

C2. 00\_assembly\_parts.pdf:

Parts list of the belt drive unit.

C3. 01-base-01.pdf:

Drawing of the base plate.

C4. 02-plate-01.pdf :

Drawing of the motor fixing plate.

C5. 03-plate2-01.pdf :

Drawing of the output shaft fixing plate.

C6. PartsList2018Aug28.xlsx

Detailed parts list.

C7. taskmodel\_backside.png:

Rear view of belt drive unit.

C8. taskmodel\_decomposition.png:

Exploded view of belt drive unit.

C9. taskmodel\_front.png:

Front view of belt drive unit.

C10. taskmodel\_topview.png:

Top view of belt drive unit.

---

18th May, 2018

Industrial Robotics Competition Committee

World Robot Summit

Change Log:

\* 9th July, 2018

(1) Fixed mixture of plate and panel

(2) Fine correction of parts with part number 14

\* 28th August, 2018

(1) Change: Part No. 14 (Drive Shaft) - The size of the shaft is exactly the same as before.

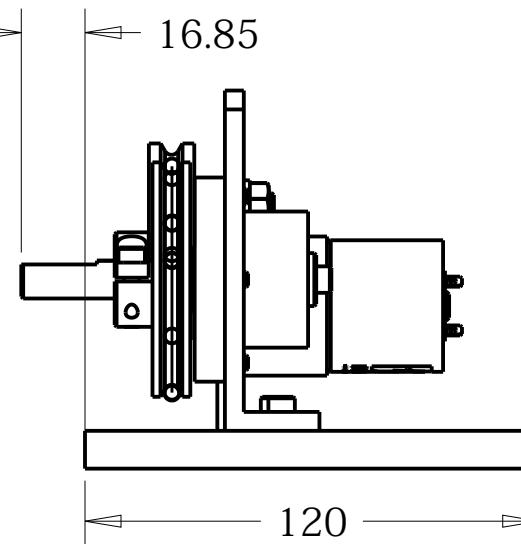
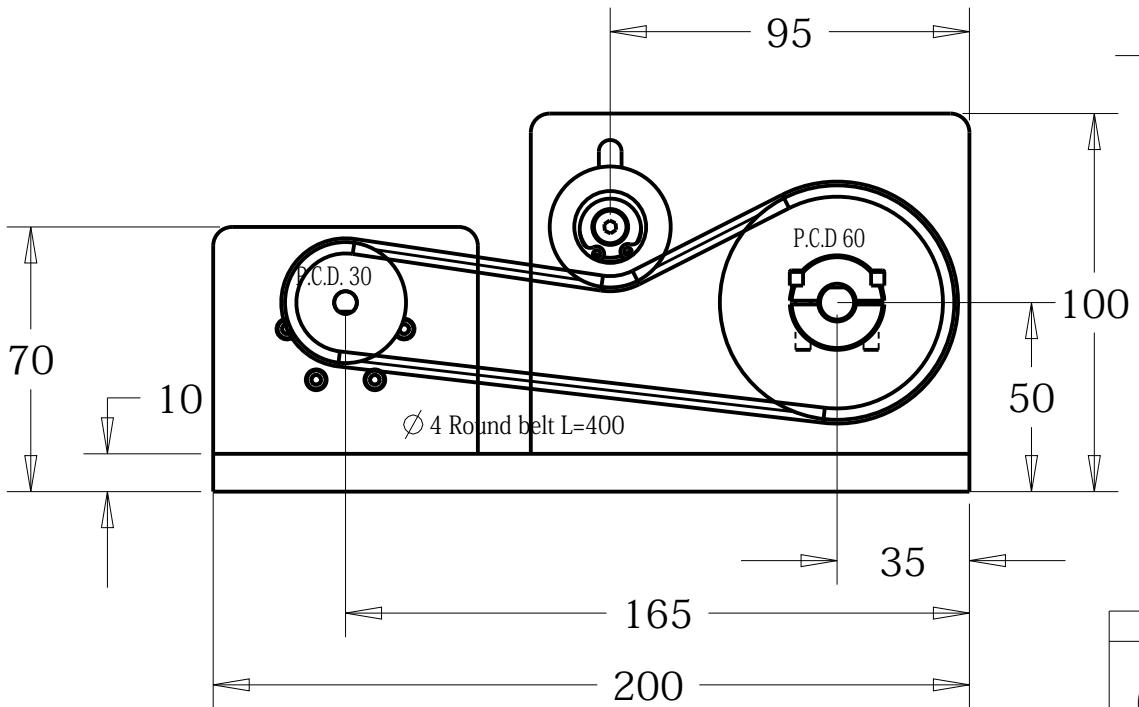
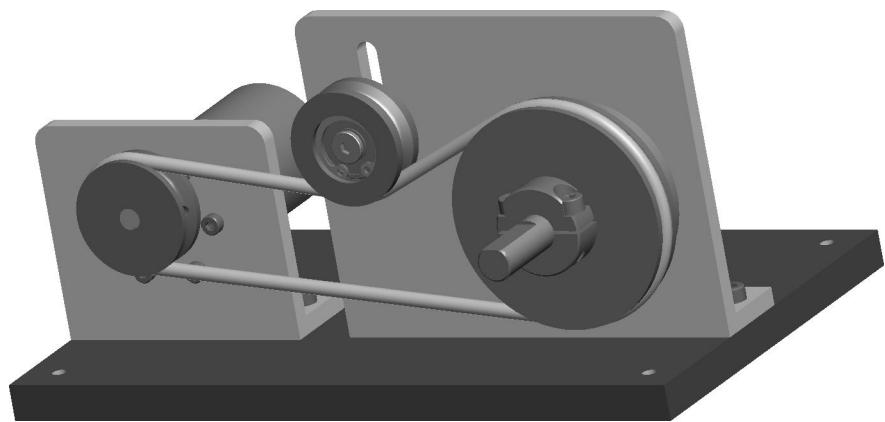
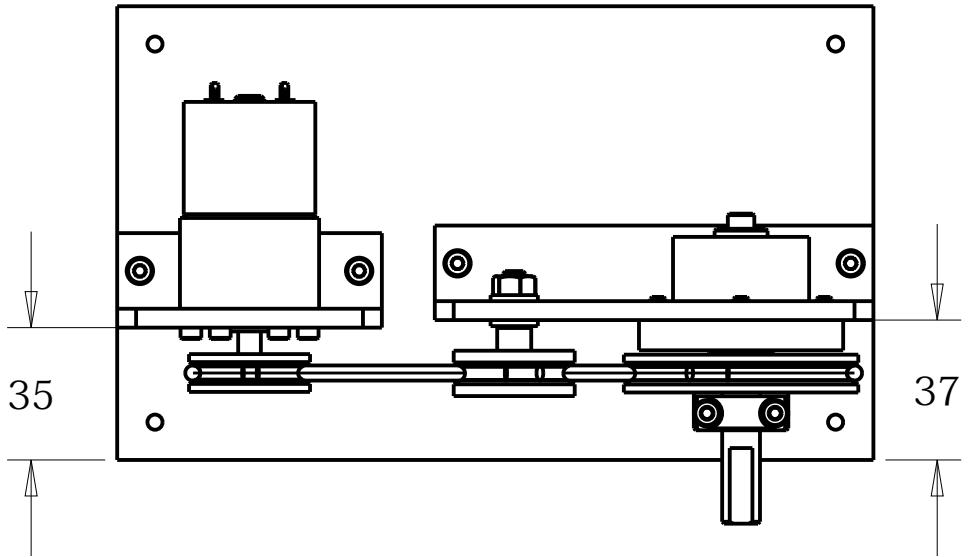
(2) Update: 00\_assembly\_parts.pdf

(3) Update: PartsList2018Aug28.xlsx

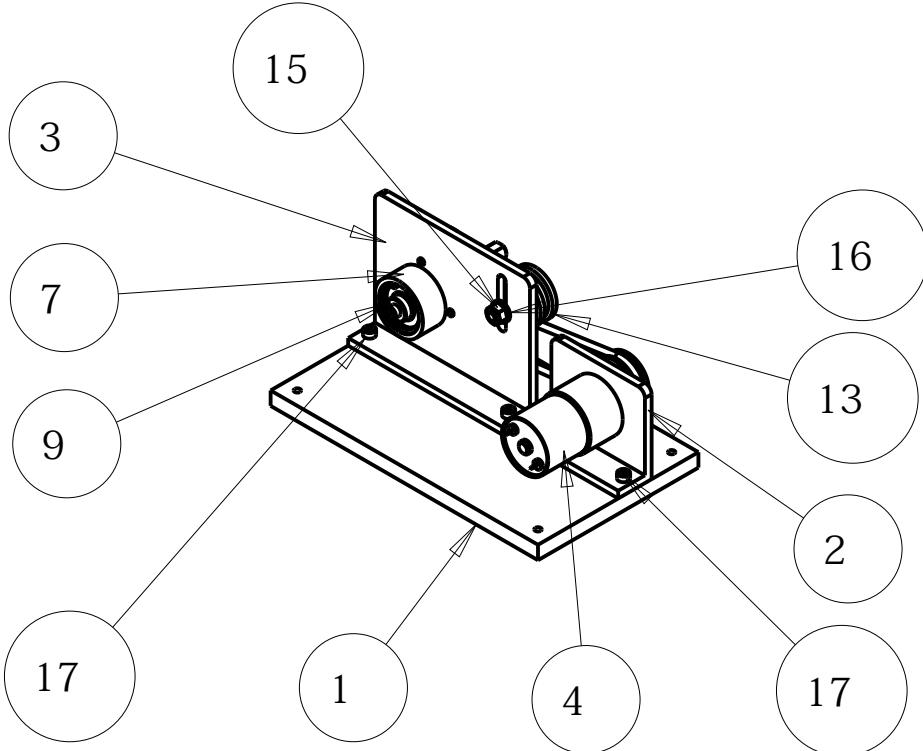
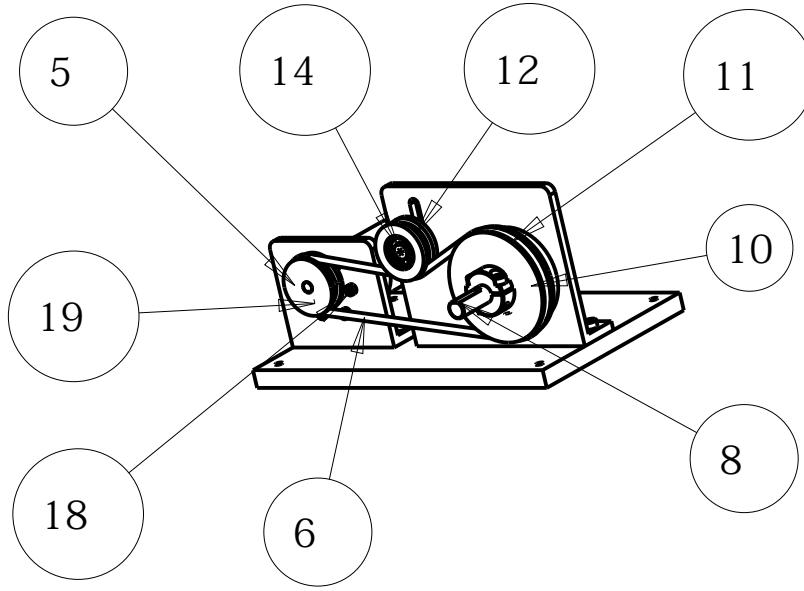
\* 17th September, 2018

(1) Fixed the mistake in the contents of the change log below.

Correctly, the part of no. 8 has been changed, not the part of no.14.

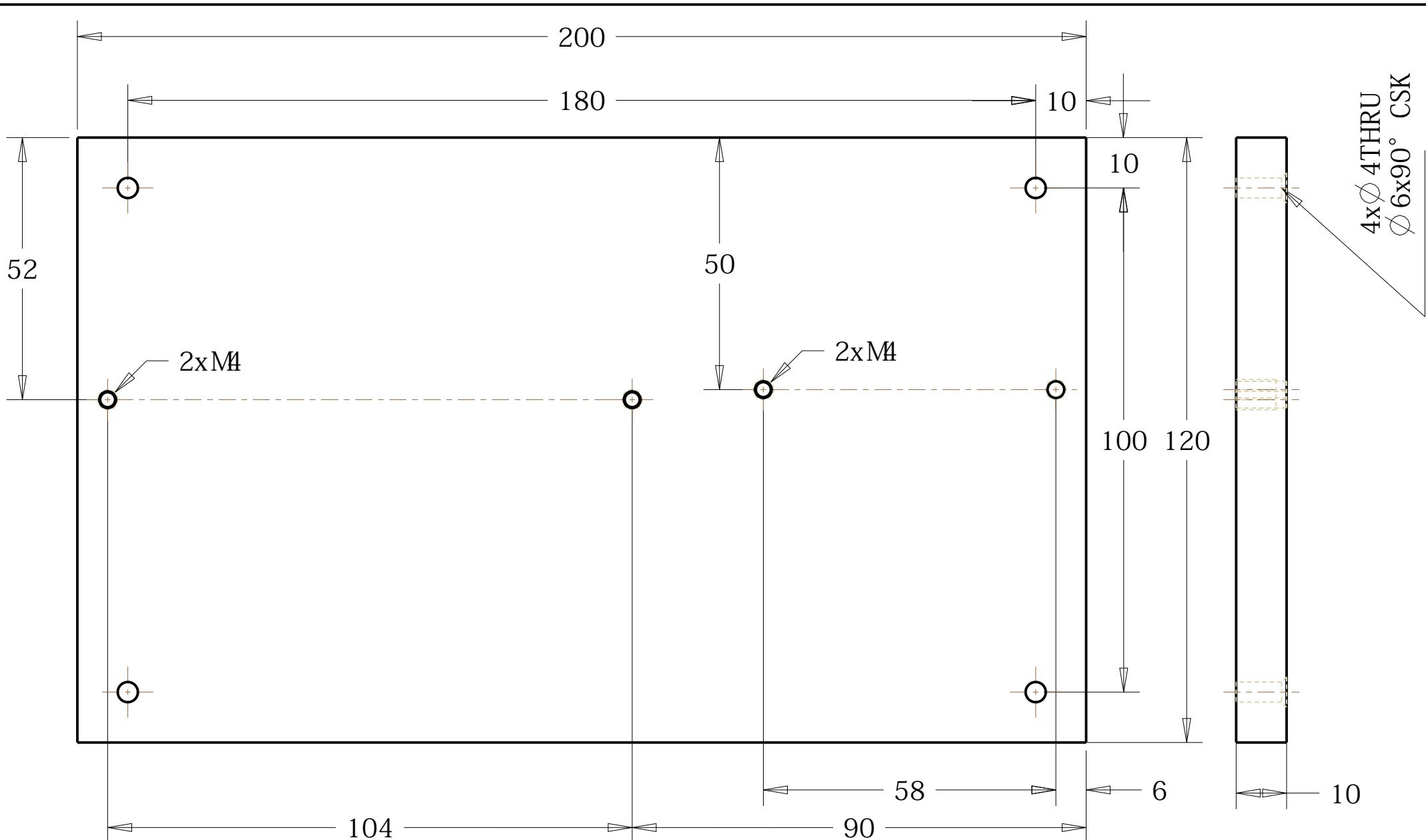


Part No.	Part name	Last update 2018.July.06	
		Scale	Proj. method
00	Task Model	0.500	3rd. angle projection
Designer S. Kotosaka		World Robot Challenge 2018	
Assembly task			

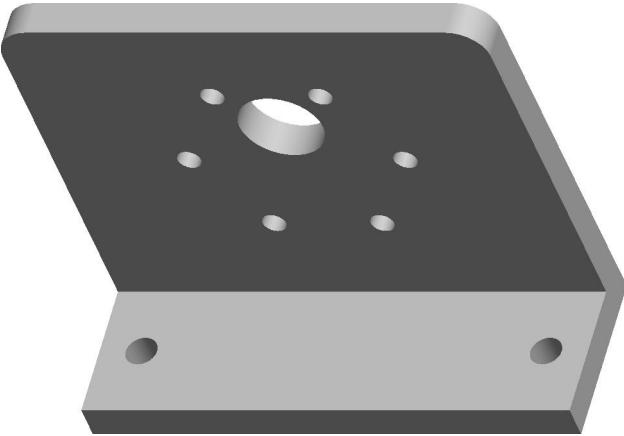
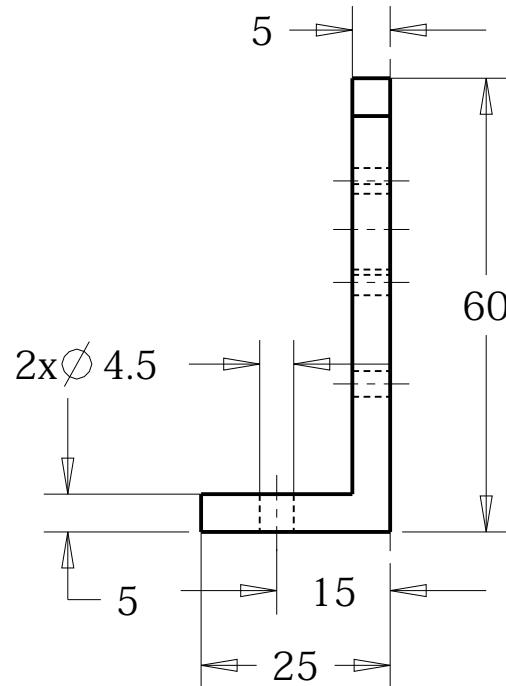
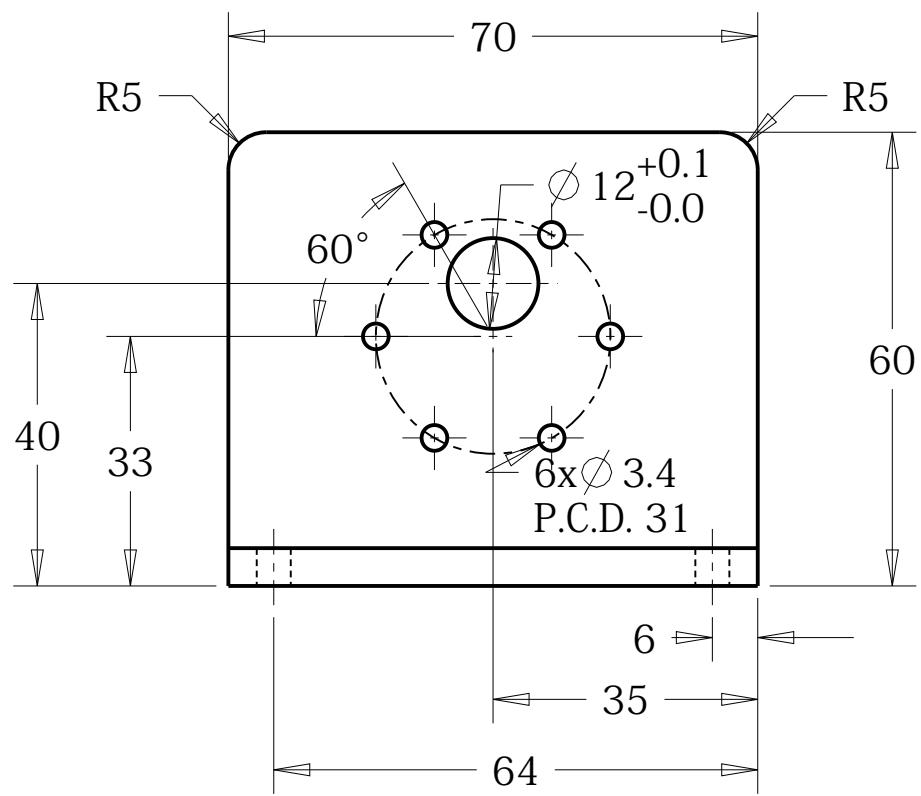


No.	Note	Part name	QTY
1	01-BASE	Base plate	1
2	02-PLATE	Motor fixing plate	1
3	03-PLATE2	Output shaft fixing plate	1
4	04_37D-GEARMOTOR-50-70	Geared motor (Gear ratio 1:70)	1
5	05_MBRAF30-2-P6	Pulley for Round Belt (4mm) - Setscrew P.D. 30mm	1
6	06-MBT4-400	Polyurethane round belt (welded joint product) P.D. 4mm L=400mm	1
7	07_SBARB6200ZZ_30	Bearings with Housings (Double Bearings)	1
8	08_SSFHRT10-75-M4-FC55-G20_s	Drive shaft D10 H7	1
9	09_EDCS10	End Cap for Shaft	1
10	10_CLBPS10_17_4	Bearing Spacers For Inner Ring (output pulley)	1
11	11_MBRAC60-2-10	Pulley for Round Belts Clamping Type P.D. 60mm	1
12	12_CLBUS6-9-9.5	Bearing Spacers For Inner Ring (tension pulley)	1
13	13_MBGA30-2	Idler for Round Belt - Wide	1
14	14_BGPSL6-9-L30-F7	Bearing Shaft Screw	1
15	15_SLBNR6	M6 Hex Nut (Fixing for idler shaft)	1
16	16_SPWF6	M6 Flat Washer (Fixing for idler shaft)	2
17	17_SCB4-10	10mm M4 Socket Head Cap Screw (metric coarse thread)	9
18	18_SCB3-10	10mm M3 Socket Head Cap Screw (metric coarse thread)	6
19	19_MSSFS3-6	6mm M3 Hex Socket Set Screw (metric coarse thread)	1

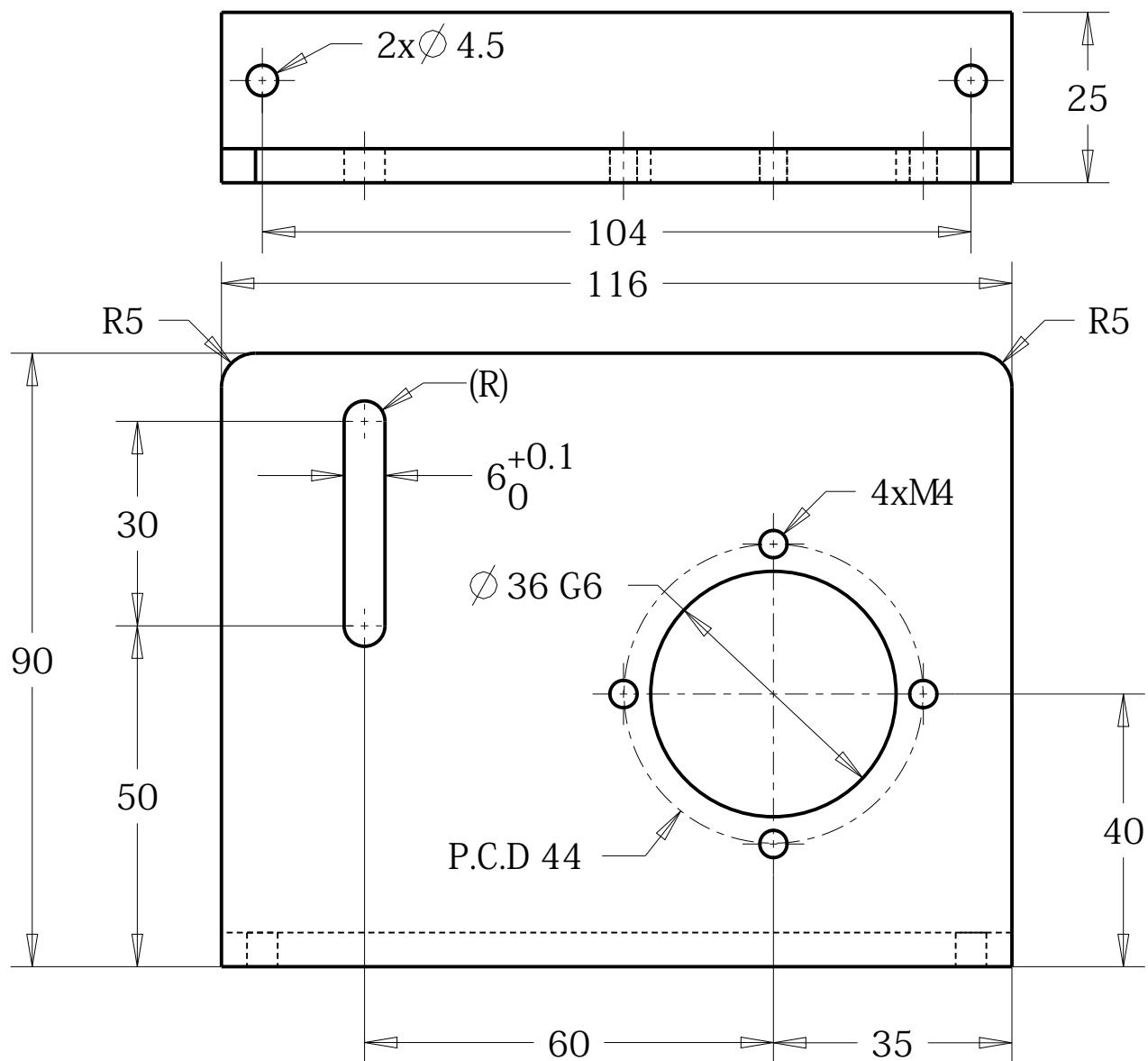
Part No.	Part name	Last update 2018.Aug.28	
		Scale	Proj. method
00	00-Assembly parts	0.250	3rd. angle projection
Designer S. Kotosaka		World Robot Challenge 2018	
00_ASSEMBLY_PARTS			



Part No.	Name of part	Last update 2018.March.06	
01	01-base-01	Scale	Proj. method
		1.000	3rd. angle projection
S. Kotosaka 01-base-01.prt	World Robot Challenge 2018		



Part No.	Part name	Last update 08-Jul-18	
		Scale	Proj. method
02	02-plate-01	1.000	3rd. angle projection
Designer S. Kotosaka		World Robot Challenge 2018	
02-PLATE-01			



Part No.	Part name	Last update 08-Jul-18	
		Scale	Proj. method
03	03-plate2-01	1.000	3rd. angle projection
Designer S. Kotosaka		World Robot Challenge 2018	
03-PLATE2-01			

Assembly Task

Parts list (2018Aug28)

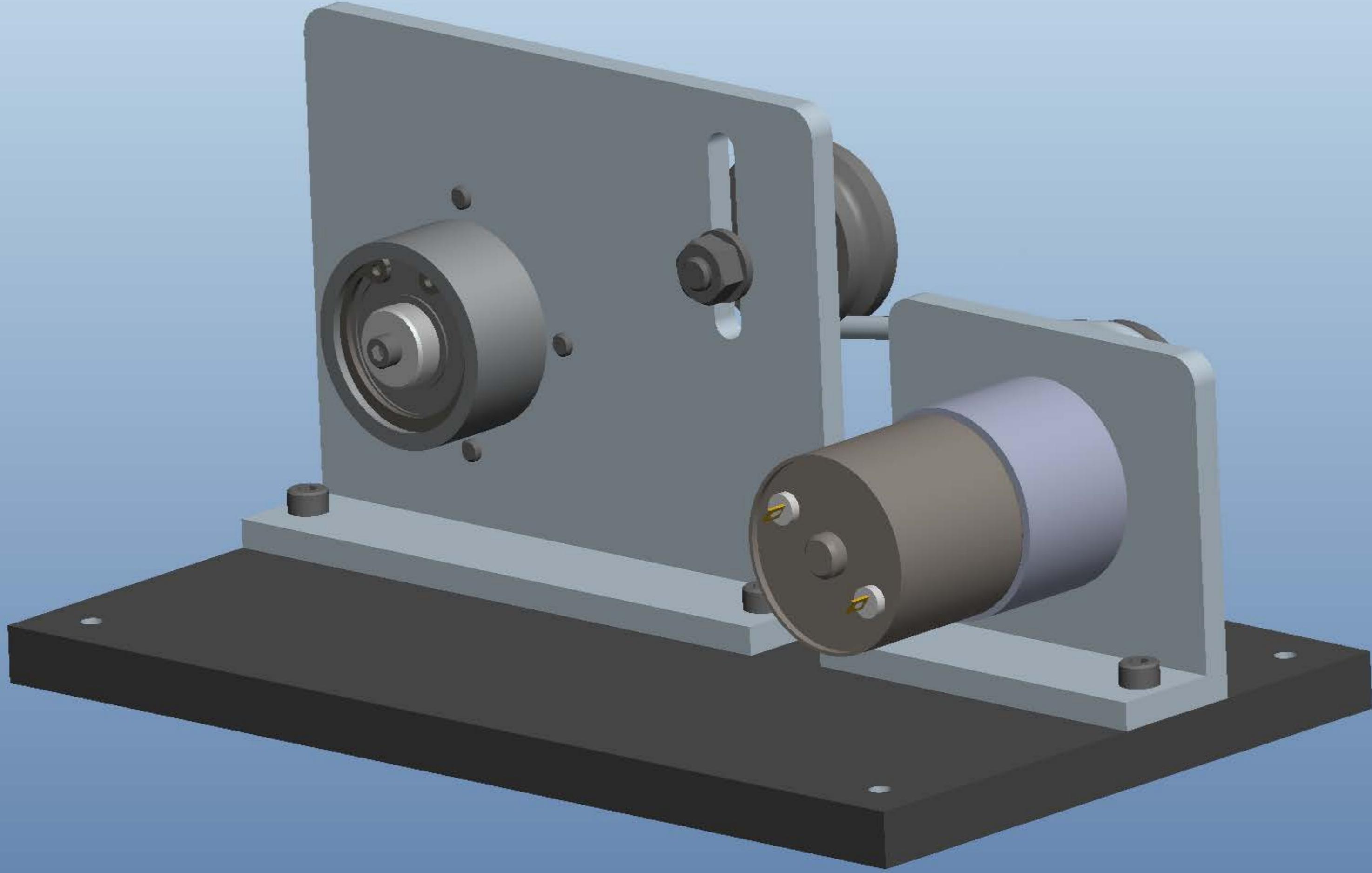
No.	Name of part	Note.	Qty.	Retailer	MISUMI order number
1	01-BASE	Base plate	1	manufactured	
2	02-PLATE	Output shaft fixing plate	1	manufactured	
3	03-PLATE2	Motor fixing plate	1	manufactured	
4	04_37D-GEARMOTOR-50-70	Geared motor (Gear ratio 1:70)	1	Pololu	<a href="https://www.pololu.com/product/1105">https://www.pololu.com/product/1105</a>
5	05_MBRFA30-2-P6	Pulley for Round Belt (4mm) - Setscrew P.D. 30mm	1	MISUMI	MBRFA30-2-P6
6	06_MBT4-400	Polyurethane round belt (welded joint product) P.D. 4mm L=400mm	1	MISUMI	MBT4-400
7	07_SBARB6200ZZ_30	Bearings with Housings (Double Bearings)	1	MISUMI	SBARB6200ZZ-30
8	08_SSFHRT10-75-M4-FC55-G20	Drive shaft (Straight) D10h7	1	MISUMI	SSFHRT10-75-M4-FC55-G20
9	09_EDCS10	End Cap for Shaft	1	MISUMI	EDCS10
10	10_CLBPS10_17_4	Bearing Spacers For Inner Ring (output pulley)	1	MISUMI	CLBPS10-17-4
11	11_MBRAC60-2-10	Pulley for Round Belts Clamping Type P.D. 60mm	1	MISUMI	MBRAC60-2-10
12	12_CLBUS6-9-9.5	Bearing Spacers For Inner Ring (tension pulley)	1	MISUMI	CLBUS6-9-9.5
13	13_MBGA30-2	Idler for Round Belt - Wide	1	MISUMI	MBGA30-2
14	14_BGPSL6-9-L30-F8	Bearing Shaft Screw	1	MISUMI	BGPSL6-9-L30-F8
15	15_SLBNR6	M6 Hex Nut (Fixing for idler shaft)	1	MISUMI	SLBNR6
16	16_SPWF6	M6 Flat Washer (Fixing for idler shaft)	2	MISUMI	SPWF6
17	17_SCB4-10	10mm M4 Socket Head Cap Screw (metric coarse thread)	9	MISUMI	SCB4-10
18	18_SCB3-10	10mm M3 Socket Head Cap Screw (metric coarse thread)	6	MISUMI	SCB3-10
19	19_MSSFS3-6	6mm M3 Hex Socket Set Screw (metric coarse thread)	1	MISUMI	MSSFS3-6

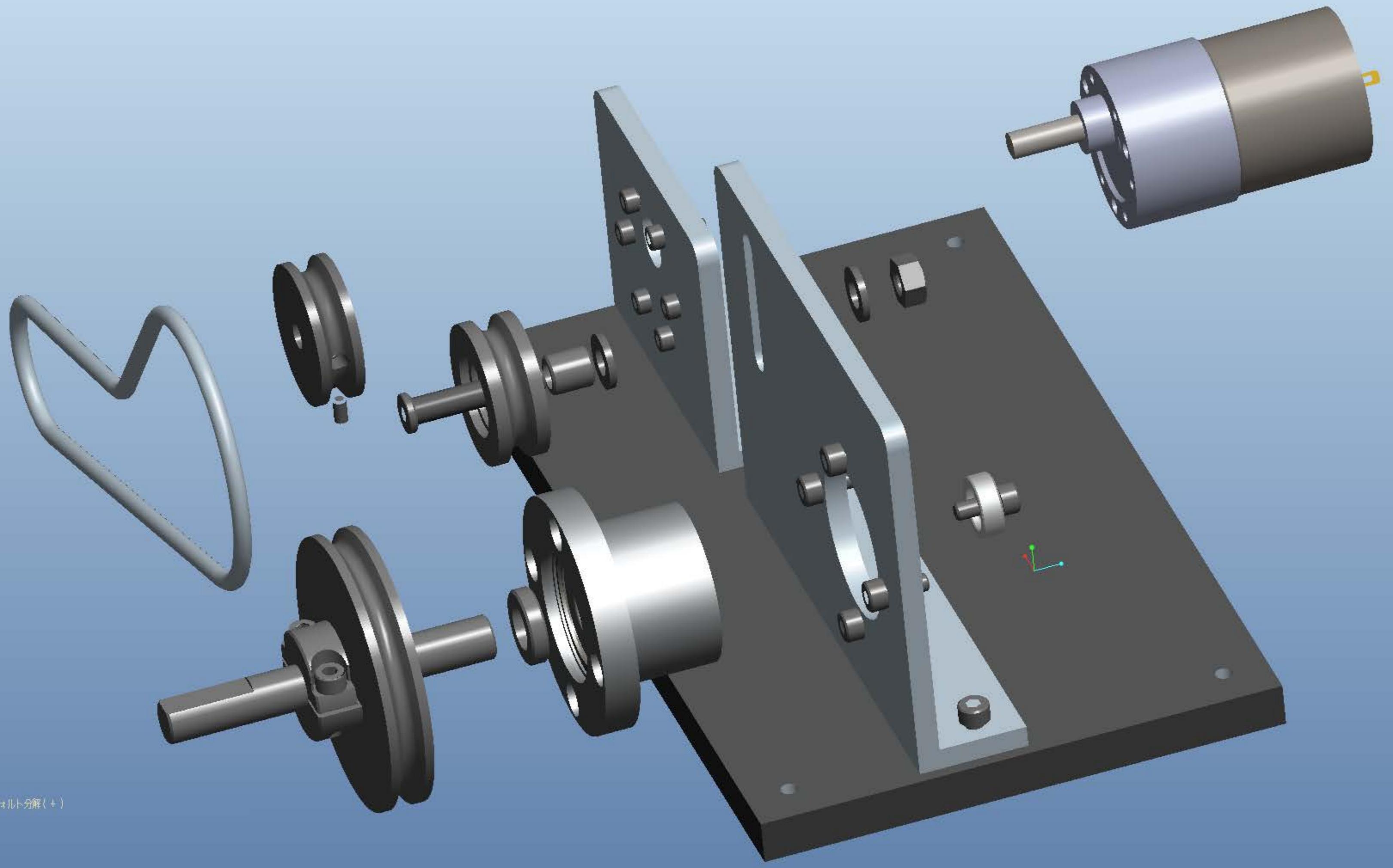
Update:2018July06

Unification of phrases (panel -> plate)

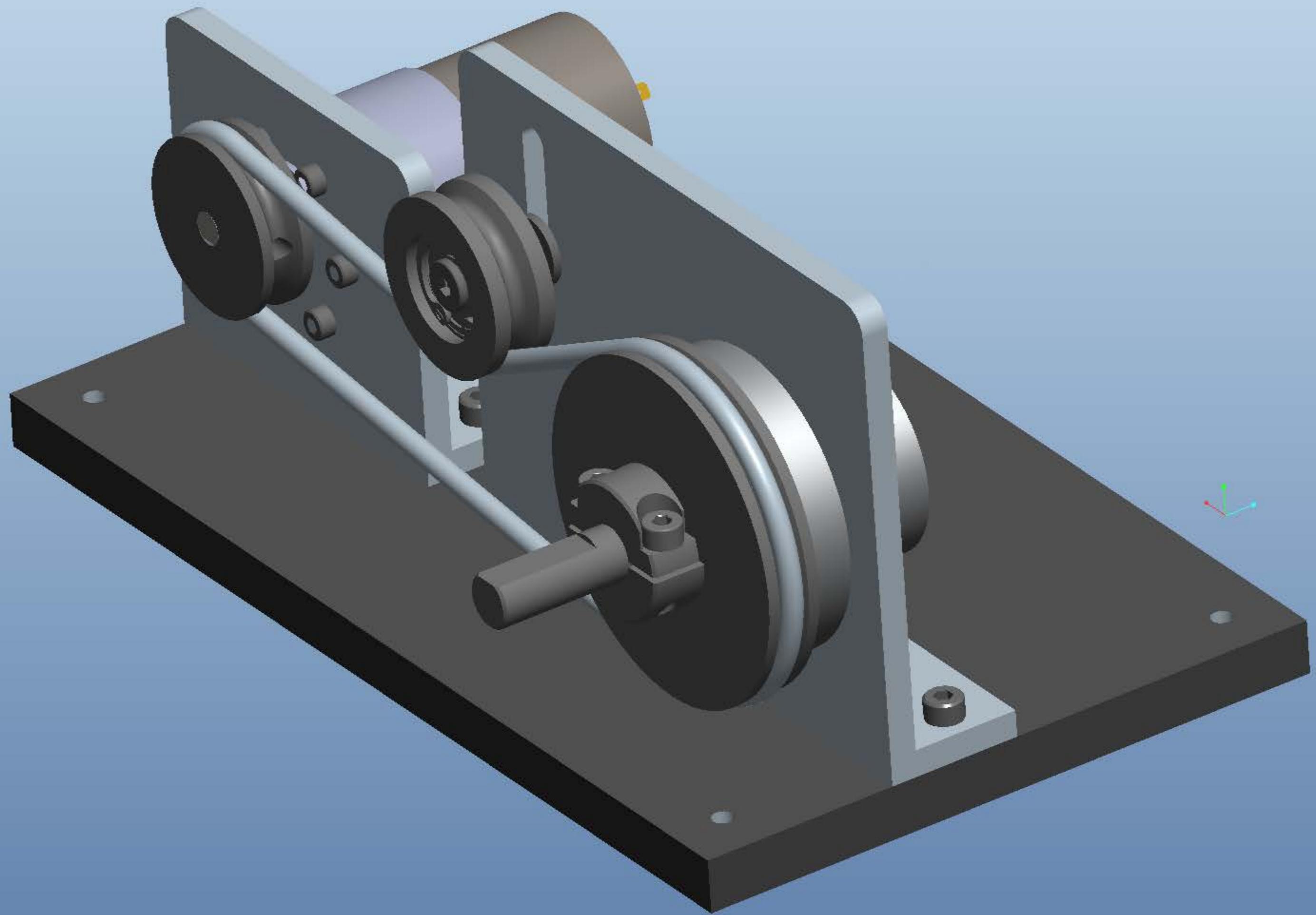
Update:2018Aug28

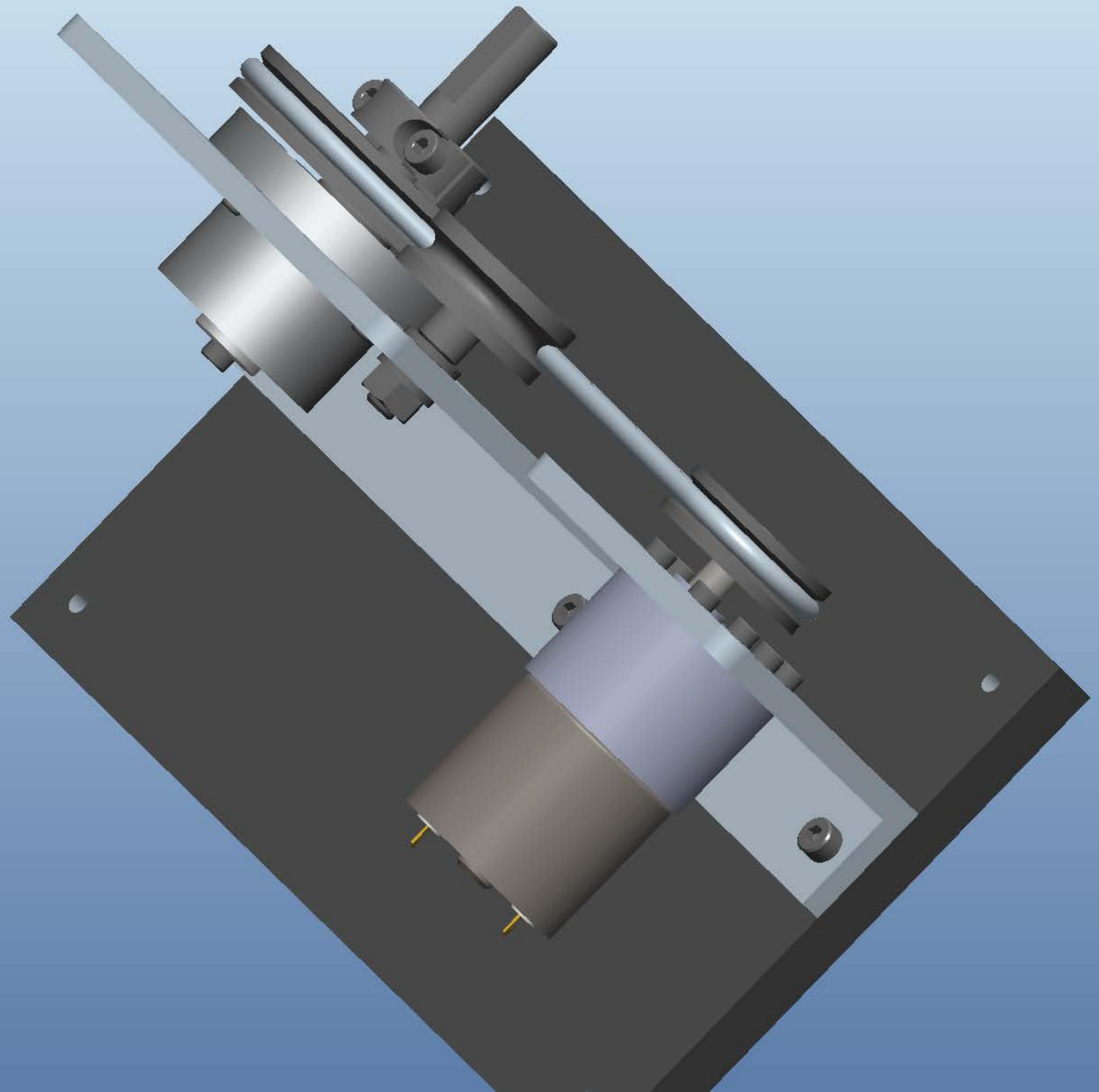
Change: No. 8 Drive shaft





分解スタート：デフォルト分解(+)





# Appendix D.

D1-Query @ Site Visits

Safety Fence? Robot System Fixing Method? Emissions? Risk Assessment Files?

D2-Inspection @ Competition

Documents and Implementation

D3-Equipment in System Running Area and Operation Area

- \* Overview of the field
- \* Safety Helmet
- \* Switches and Signal Towers
- \* Robot Operation Mode
- \* Task Phases
- \* Matching with modes defined in ISO
- \* Usage of switches / signal towers

D4-Relationship between game phases and team actions

Teams action's transition diagram.

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Industrial Robotics Competition Committee

World Robot Summit

\* 27th September, 2018

Files used for site visiting are opened.

# Query @ Site Visits

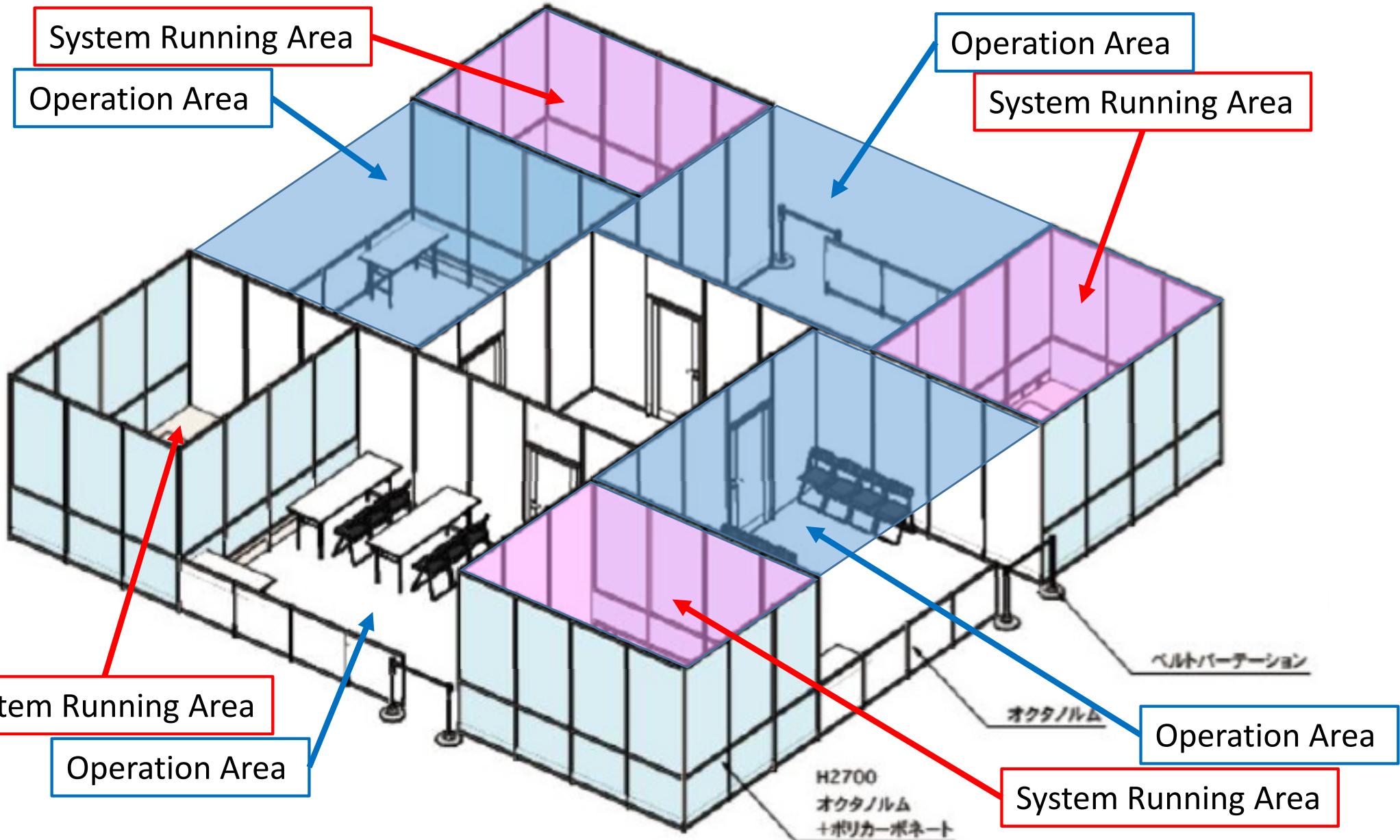
- Safety Fence?
  - YES!: Door Switch, Lights, Emergency Stop Buttons, Mode select Buttons?
  - NO!: Preparation planning to the competition?
- Robot System Fixing Method?
  - Anchor Bolts!: Iron Plates @System running area?
  - No needs!: Safety Problems?
  - Moving Robots!: Safety Problems?
- Emissions?
  - Gas/Liquid/Solid? Heat/Noise/Vibration?
  - YES! Countermeasures?
- Risk Assessment Files:
  - Ready! Show us?
  - No! Preparation planning to the competition?

	Major check items	Results
Documents		
Mode definition of the Team		
Risk Assesment Sheet		
Risk Assessment Conclusion (Risk List that remained)		
Operation Manuals for the team member		
Safty system checking routine		
ToDo/NotToDo list		
Team Implementation		
Mode definition of the Team		
Safty Circuits Implementation		
Robot System Fixing method for the robot motion		
Clearance between robots and fence		
Emissions		
Gas/Liquid/Noise/Heat/Vibration/Laser Beam		
Demonstration of the safty system checking routine		
Please open safety door under System running mode, etc		
Interview to team members for Risks of their system and their measures		
Electricity treatments especialy for high voltage power lines protection		
Preparation of safety breifing for the referees at the beginning of each game		
Preparation of protective equipments if needed. (also for referees)		
Cleanliness, especially securing passages in your own area		

## Appendix D.3

Equipment in  
System Running Area  
and Operation Area

# Overview of the field



## Work Table in System Running Area

SAKAE TKK6-127F

W1200 \* D750 \* H600-800 (Height Adjustable)

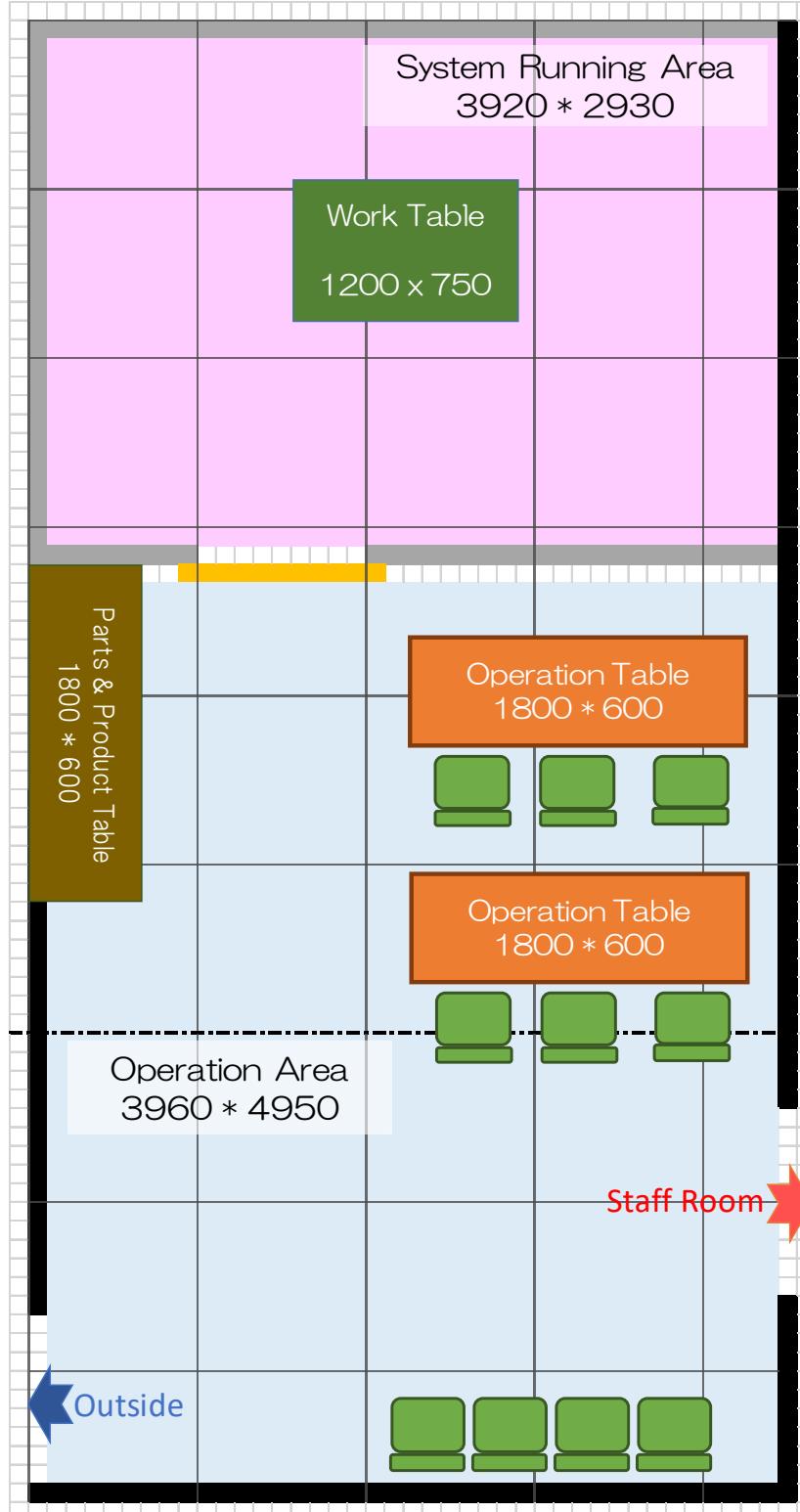
Average Load 200kg

Search “TKK6-127F” at <http://us.misumi-ec.com/>

[http://www.sts-sakae.co.jp/p\\_products/pdf\\_ZM/  
ZM\\_TKK6127.pdf](http://www.sts-sakae.co.jp/p_products/pdf_ZM/ZM_TKK6127.pdf) (Drawing w/ Japanese)



Each team can choose to use this table or to move it out of the area (not use the table)



## Tables in Operation Area

Tables for operators

W1800 \* D600 \* H700 (two tables)

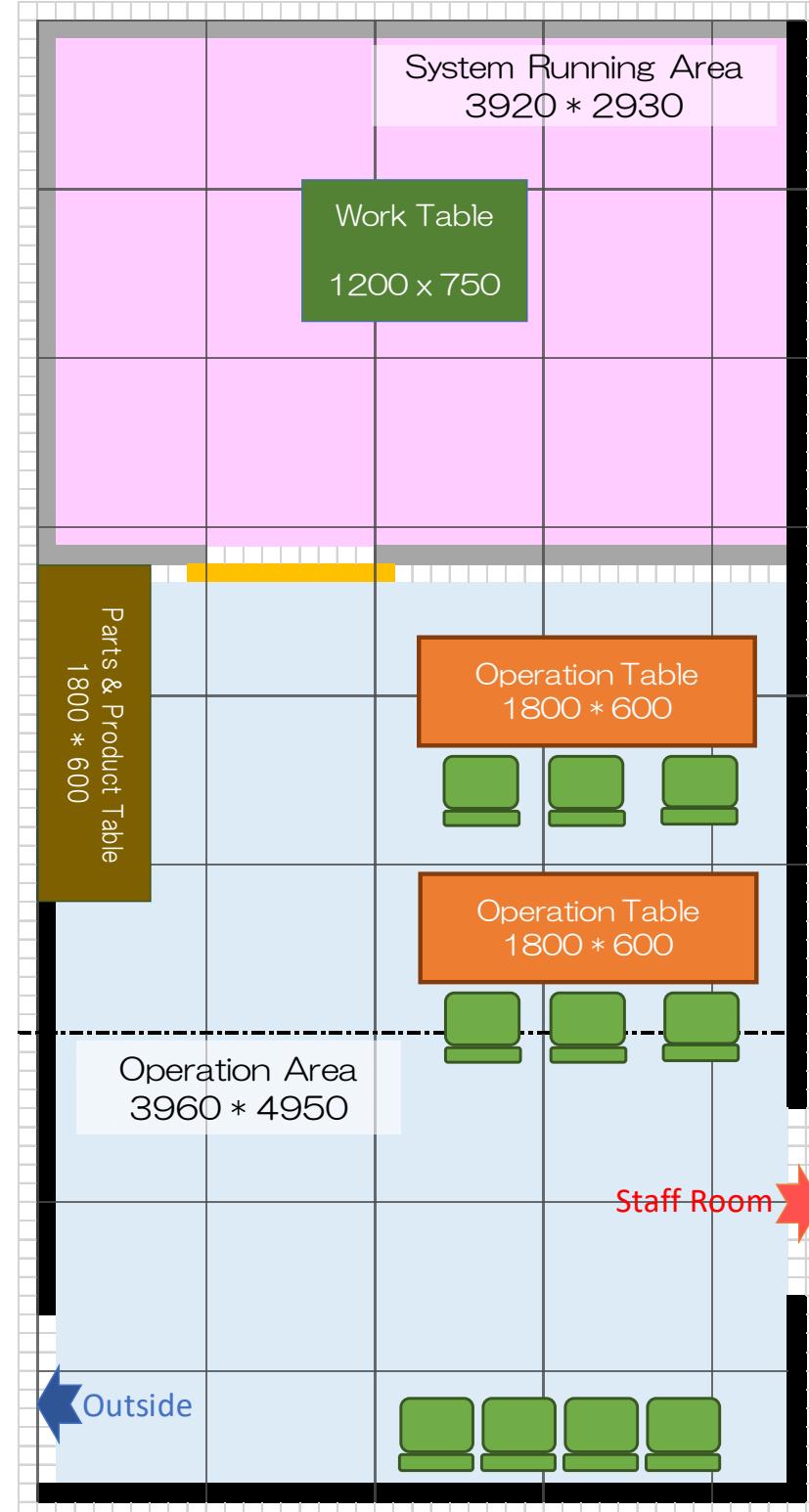
Chairs 10 chairs



Table for works

W1800 \* D600 \* H700

This table must not be moved



# Safety Helmet

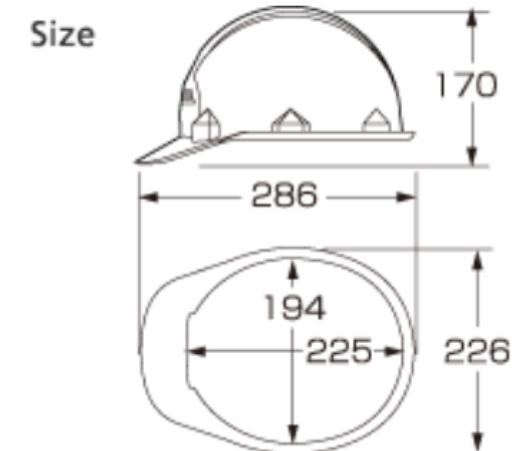
When someone enters to the system running area, he/she must wear safety helmet.

Committee will provide 5 helmets to each team.

Other safety equipment (such as safety boots, protective eyewear, etc.) should be prepared by the team according to its risk assessment result.



Material	ABS
Weight	371g
Headband	Type C / Type FB
interior fitting	FF-1 : FF / FF-3 : FC-S



Type FB Headband



# Switches and Signal Towers

Signal Tower



PATLITE

MPS-402-RYGB

LR6-402PJNW-RYGB

Mode Select Switch



IDECA

ABW111G

ABW111S

ABW111Y

Clear Switch / Servo ON



IDECA

ABW111W

\* Photos may not be correct type

Emergency Stop Switch



IDECA

HW1X-BV402R

HW1B-V302R



Safety Door Switch



IDECA

HS5D-02RN



Terminal Block

IDECA

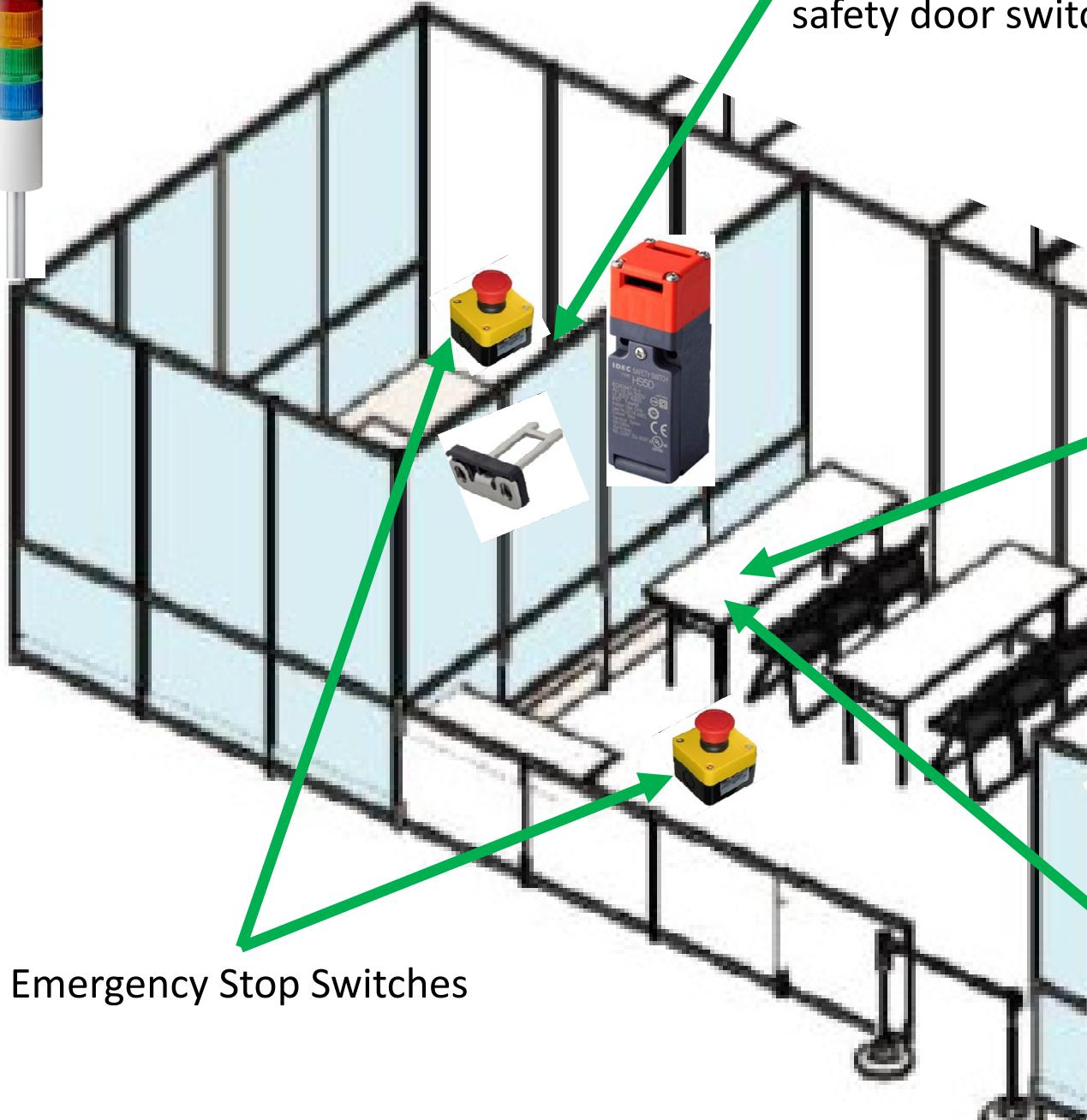
BTB15LC20

(three)



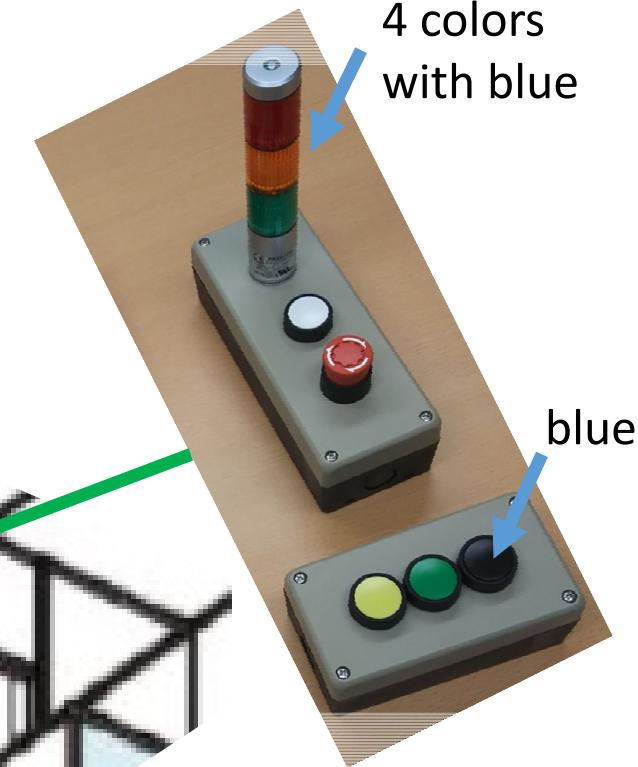


Signal tower for audience

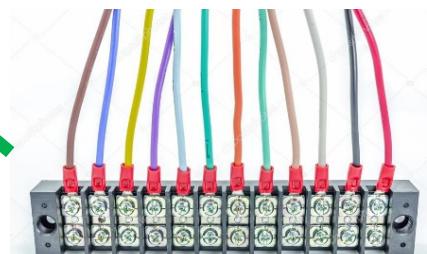


Emergency Stop Switches

Slide door with  
safety door switch

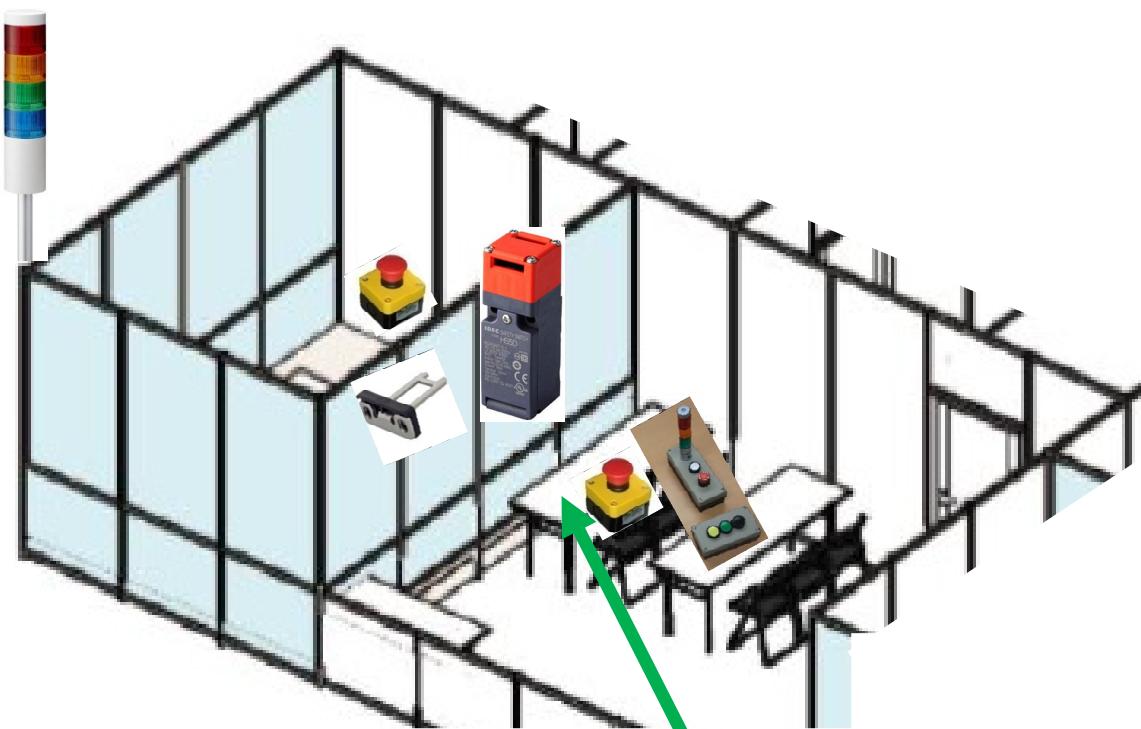


Operation switch box  
with emergency stop  
switch and signal tower

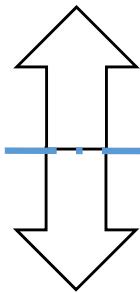


Signal lines will be provided  
by a terminal on the table

4 colors  
with blue



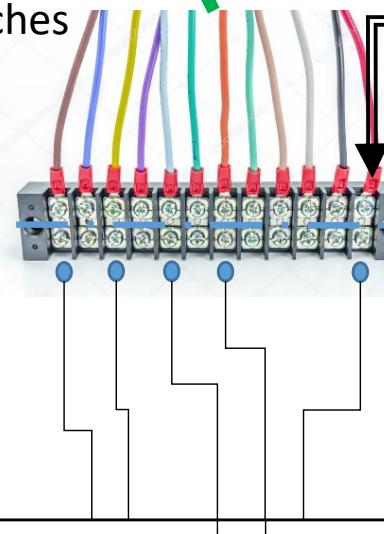
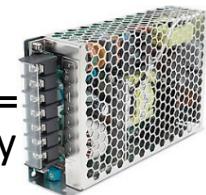
Prepared  
by Committee



Prepared  
by Team

Connected to switches  
and signal towers

+24V Power Supply



Your Robot System

# Usage of switches / signal towers

Must be used

- Signal tower for audience (LR6-402PJNW-RYGB)
- Safety door switch (HS5D-02RN)

Other switches / signal tower may be replaced with own equipment by each team.

But “Robot Operation Mode” and their transition operations must be safely implemented and must pass safety check on competition site by safety and health inspection at setup days.



# Signal Tower

PATLITE

LR6-402PJNW-RYGB

Model	Tiers	Rated Voltage	Mounting/Wiring	Flashing/Buzzer	Body Color	LED Unit Color	Globe Color
Assembly Model	LR 6 -	↓	↓	↓	↓	- RYGB	↓

Unit Model (Body Unit)	LR 6 -	↓	↓	↓	↓
	6 φ60	4	1 - 5 Tiers	B With Flashing/Buzzer <sup>※3</sup>	N No Flashing/Buzzer



※1 LR6- WJ•LJ•PJ W

※2 LR6- 02 W

※3 Assembly Model

※4 LR6- 02 WJ•LJ•PJ

WJ Direct Mount / Cable

LJ Pole Mount with L-bracket / Cable  
Pole Mount with Circular Bracket / Cable

PJ Pole Mount with Folding Bracket / Cable

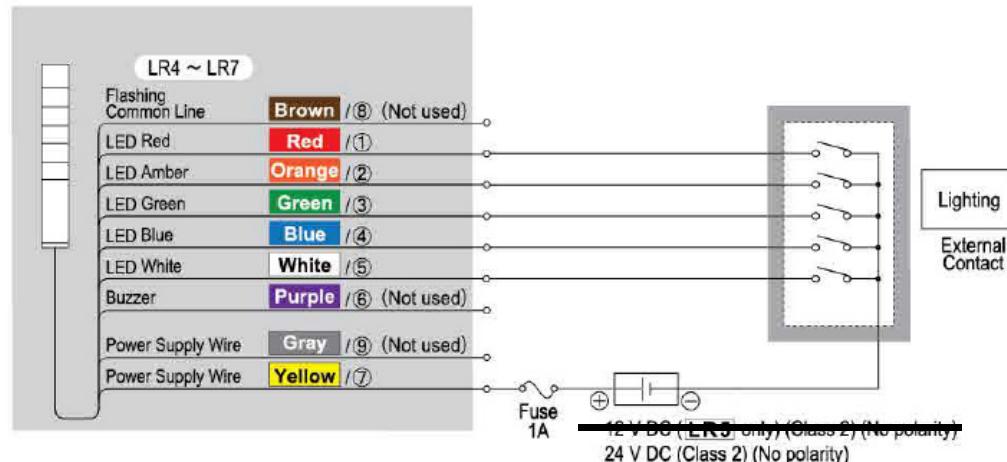
WC Direct Mount / M12 Connector<sup>※2</sup>

LED Color: R (Red)/Y (Amber)/G (Green)/B (Blue) /C (White)  
(From top to bottom)

(None) Color Globe  
Z Clear Globe

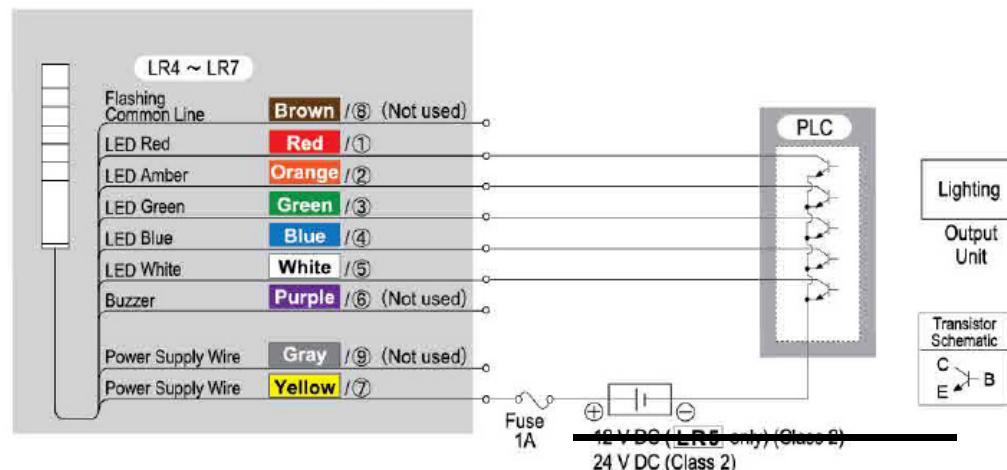
## External Contact Classification

### Voltage Contact Relay



## External Contact Classification

### PLC (NPN Transistor)

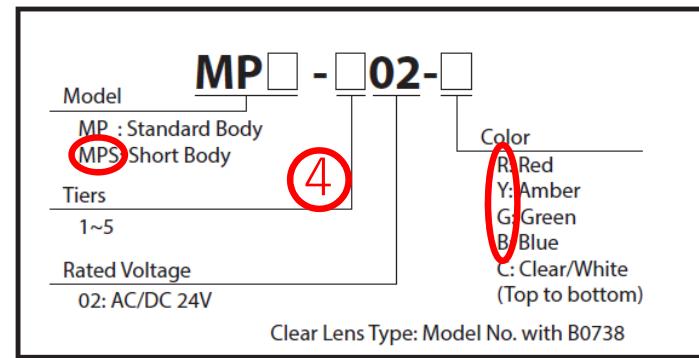




# Signal Tower

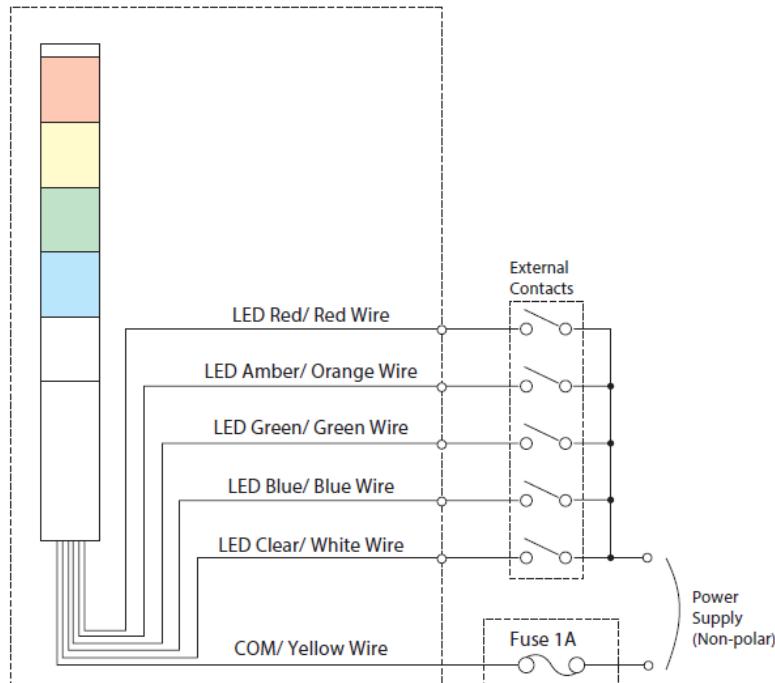
PATLITE

MPS-402-RYGB

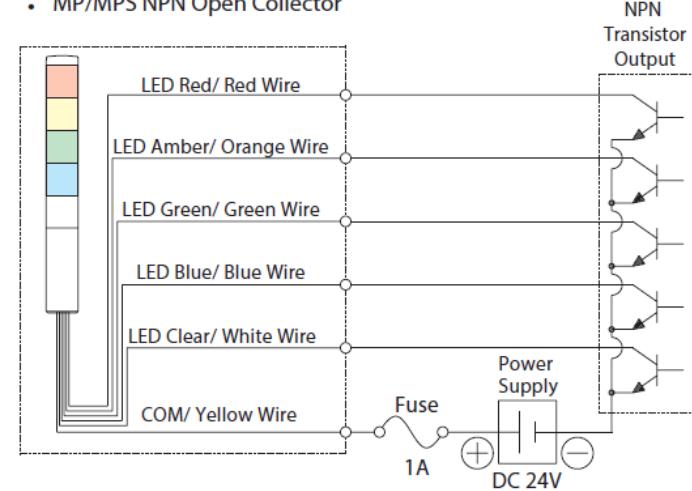


## Wiring

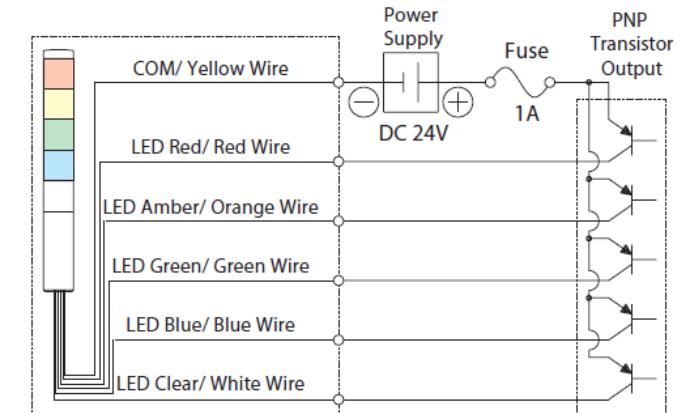
- MP/MPS Contact/ Switch



- MP/MPS NPN Open Collector



- MP/MPS PNP Open Collector



# Safety Door Switch



IDE  
HS5D-02RN

**HS5D-11 Z RN M**

Circuit Code

11: 1NO-1NC  
02: 2NC  
12: 1NO-2NC  
03: 3NC

Head Material

blank Plastic  
Z : Metal

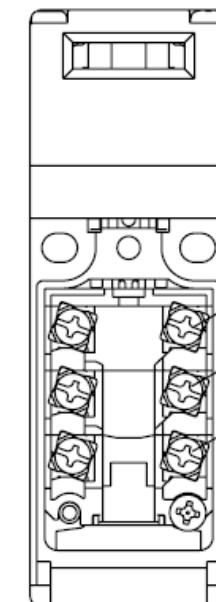
Gland Port

blank G1/2  
P: PG13.5  
M: M20

Head/Housing Color

RN: Red/Gray

Contact Configuration	Gland Port Size	Part No.	
		Plastic Head	Metal Head
1NC-1NO Main Circuit ⊕ 11- 12 Monitor Circuit 23- 24	G1/2	HS5D-11RN	HS5D-11ZRN
	PG13.5	HS5D-11RNP	HS5D-11ZRNP
	M20	HS5D-11RNM	HS5D-11ZRNFM
	G1/2	<b>HS5D-02RN</b>	HS5D-02ZRN
	PG13.5	HS5D-02RNP	HS5D-02ZRNP
	M20	HS5D-02RNM	HS5D-02ZRNFM
2NC Main Circuit ⊕ 11- 12 Monitor Circuit ⊕ 21- 22	G1/2	HS5D-12RN	HS5D-12ZRN
	PG13.5	HS5D-12RNP	HS5D-12ZRNP
	M20	HS5D-12RNM	HS5D-12ZRNFM
	G1/2	HS5D-03RN	HS5D-03ZRN
	PG13.5	HS5D-03RNP	HS5D-03ZRNP
	M20	HS5D-03RNM	HS5D-03ZRNFM



>Main Circuit: 11-12

>Main Circuit: 21-22

Monitor Circuit: 31-32 / Monitor Circuit: 33-34

## Emergency Stop Switch



IDE

HW1X-BV402R



IDE

HW1B-V302R

## Specifications (for both type)

Rated insulation voltage : 600V

Rated operating current :

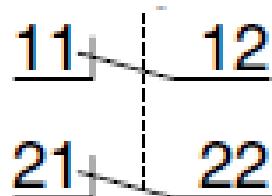
24V ... 5A

48V ... 2A

110V ... 1.1A

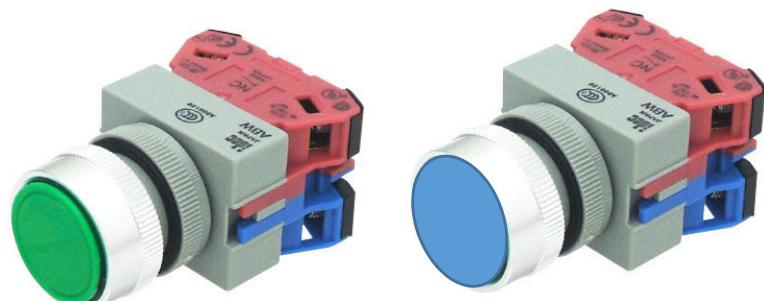
220V ... 0.6A

2NC contact type



Push-Lock - Turn-Reset type

## Mode Select Switch



## Specifications (for all)

Rated insulation voltage : 600V

Rated operating current :

24V ... 5A

48V ... 2A

110V ... 1.1A

220V ... 0.6A

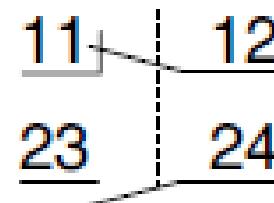
## Clear Switch / Servo ON



IDEC

ABW111W

1NC - 1NO contact type



Momentary switch

# Terminal Block

IDE

BTB15LC20  
(three)



## General Specifications

Dielectric Strength	2500V AC, 1 minute
Insulation Resistance	100 MΩ minimum
Operating Temperature	-25 to +55°C (no freezing)
Storage Temperature	-25 to +70°C (no freezing)
Operating Humidity	45 to 85% RH (no condensation)

## Material

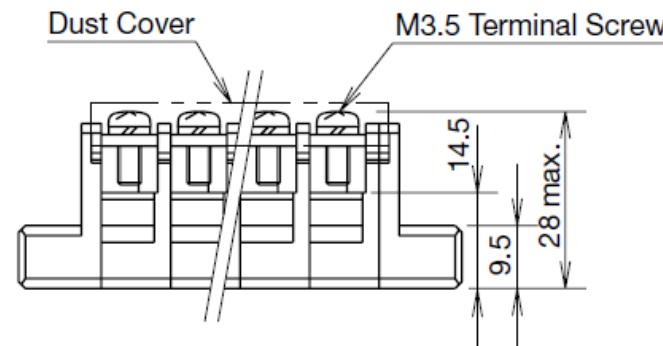
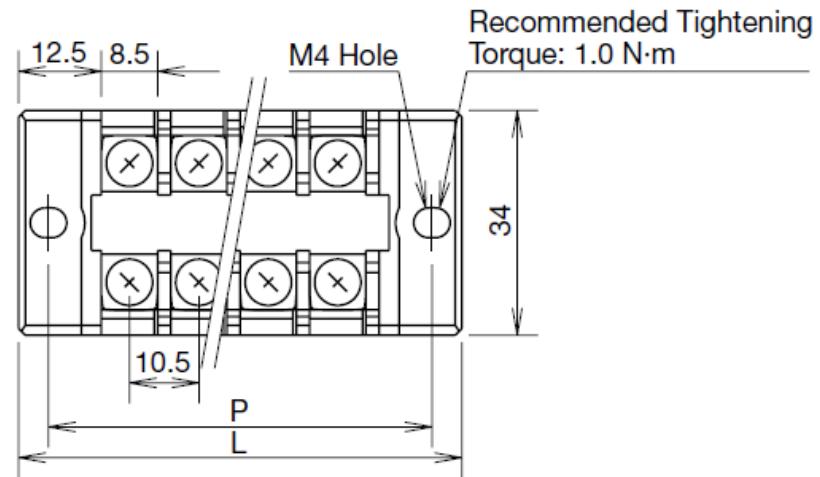
Parts Name	Material
Housing	Modified PPE
Bus Bar	Brass (nickel-plated)
Terminal Screw	Steel (zinc chrome-plated)
Connecting Rod/Nut	Steel (zinc chrome-plated)
Dust Cover	Polycarbonate

## Specifications

	BTB15LC/BTBH15LC		
Standards	UL/CSA	EN	JIS
Insulation Voltage	300V	500V	630V
Wire Size	22-14 AWG	2 mm <sup>2</sup> (18-14 AWG)	2 mm <sup>2</sup>
Rated Current	15A	22A	21A
Terminal screw		M3.5	
Crimping Terminal		2-3.5	
Max. No. of Crimping Terminals		2	
Tightening Torque		1.0 to 1.3 N·m	
Crimping Terminal Dimensions (mm)			
Accessory: Jumper	BNJ46, BNJ46B, BNJ46F, BNJ46FB (see page 43)		

# Terminal Block

IDECA  
BTB15LC20  
(three)



Power Supply (for signal tower)

MISUMI ESP10-15-24

Output : DC24V 15W  
(0.625A)

Dimensions L and P (mm)

No. of Poles	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
L	46	56.5	67	77.5	88	98.5	109	119.5	130	140.5	151	161.5	172	182.5	193
P	37	47.5	58	68.5	79	89.5	100	110.5	121	131.5	142	152.5	163	173.5	184

No. of Poles	17	18	19	20	21	22	23	24	25	26	27	28	29	30	—
L	203.5	214	224.5	235	245.5	256	266.5	277	287.5	298	308.5	319	329.5	340	—
P	194.5	205	215.5	226	236.5	247	257.5	268	278.5	289	299.5	310	320.5	331	—

Weight (per pole) BTB15L: Approx. 12g

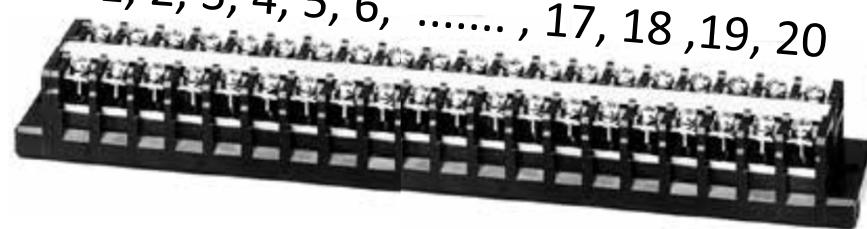
<http://jp.idec.com/ja/download/download.aspx?download=EP14510TerminalBlockBTBBTBH>

Search “ESP10-15-24” at <http://us.misumi-ec.com/>

# Terminal Block IDEC

## BTB15LC20 (three)

1, 2, 3, 4, 5, 6, ..... , 17, 18, 19, 20



Terminal Block 1 Signal Tower & Power Supply

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
LR6-Red	LR6-Orange	LR6-Green	LR6-Blue	LR6-Yellow		MPS-Red	MPS-Orange	MPS-Green	MPS-Blue	MPS-Yellow			+24V	+24V			0V	0V	

Terminal Block 2 Emergency Stop

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
HS5D-11	HS5D-12	HS5D-21	HS5D-22		HW1X(1)-11	HW1X(1)-12	HW1X(1)-21	HW1X(1)-22		HW1X(2)-11	HW1X(2)-12	HW1X(2)-21	HW1X(2)-22		HW1B-11	HW1B-12	HW1B-21	HW1B-22	

Terminal Block 3 Momentary Switch

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Green-11	Green-12	Green-23	Green-24		SkyB-11	SkyB-12	SkyB-23	SkyB-24		Yellow-11	Yellow-12	Yellow-23	Yellow-24		White-11	White-12	White-23	White-24	

### (enlarged) Terminal Block 1 Signal Tower & Power Supply

1	2	3	4	5	6	7	8	9	10
LR6-Red	LR6-Orange	LR6-Green	LR6-Blue	LR6-Yellow		MPS-Red	MPS-Orange	MPS-Green	MPS-Blue
11	12	13	14	15	16	17	18	19	20
MPS-Yellow			+24V	+24V			0V	0V	

Terminal Block 2 Emergency Stop

1	2	3	4	5	6	7	8	9	10
HS5D-11	HS5D-12	HS5D-21	HS5D-22		HW1X(1)-11	HW1X(1)-12	HW1X(1)-21	HW1X(1)-22	
11	12	13	14	15	16	17	18	19	20
HW1X(2)-11	HW1X(2)-12	HW1X(2)-21	HW1X(2)-22		HW1B-11	HW1B-12	HW1B-21	HW1B-22	

Terminal Block 3 Momentary Switch

1	2	3	4	5	6	7	8	9	10
Green-11	Green-12	Green-23	Green-24		SkyB-11	SkyB-12	SkyB-23	SkyB-24	
11	12	13	14	15	16	17	18	19	20
Yellow-11	Yellow-12	Yellow-23	Yellow-24		White-11	White-12	White-23	White-24	

# Robot Operation Mode

# Robot Operation Mode

## Must implemented

### **Running Mode** (servo on)

- no person in system running area
- no limit of robot motion speed
- door must be closed (safety door switch must be ON)
- **green** on signal towers

### **Emergency Stop Mode** (servo off)

- operator can be in system running area
- robot must be stopped (servo off)
- door may be opened / may be closed
- **red** on signal towers

Every team must implement these two robot operation modes.

It is checked on competition site by safety and health inspection at setup days.

# Robot Operation Mode

## Additional mode (recommended)

### Test Mode (servo on)

- operator can be in system running area
- robot speed is limited under 250mm/sec
- operator can control robots manually (for example, with teaching pendant)
- door may be opened / may be closed
- yellow on signal towers

## Additional mode (additionally)

### Pause Mode (servo on)

- operator can be in system running area
- robot must stop
- door may be opened / may be closed
- blue on signal towers

For easy understanding by referees and audiences, it is recommended to implement these two modes. **Test Mode** should be convenient to each team to deliver parts trays and products. It is checked on competition site by safety and health inspection at setup days.

# Task Phases

## Preparation Phase

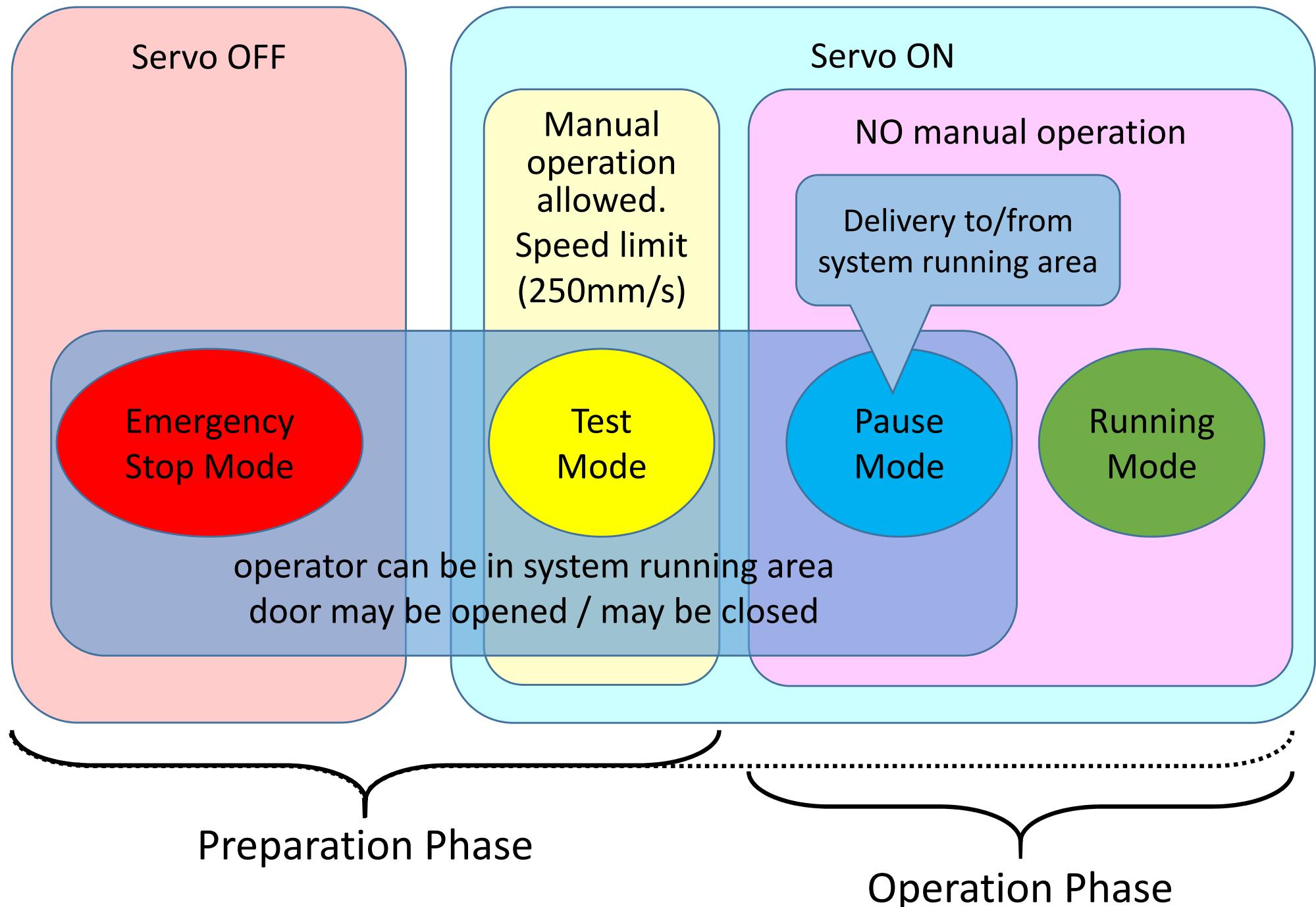
- normally in **Test Mode** or **Emergency Stop Mode**
- all modes are available
  - (motion test in **Running Mode** is also available)
  - (but during **Running Mode**, no one can be inside system running area even if only human collaborative robots are used in the system)

## Operation Phase

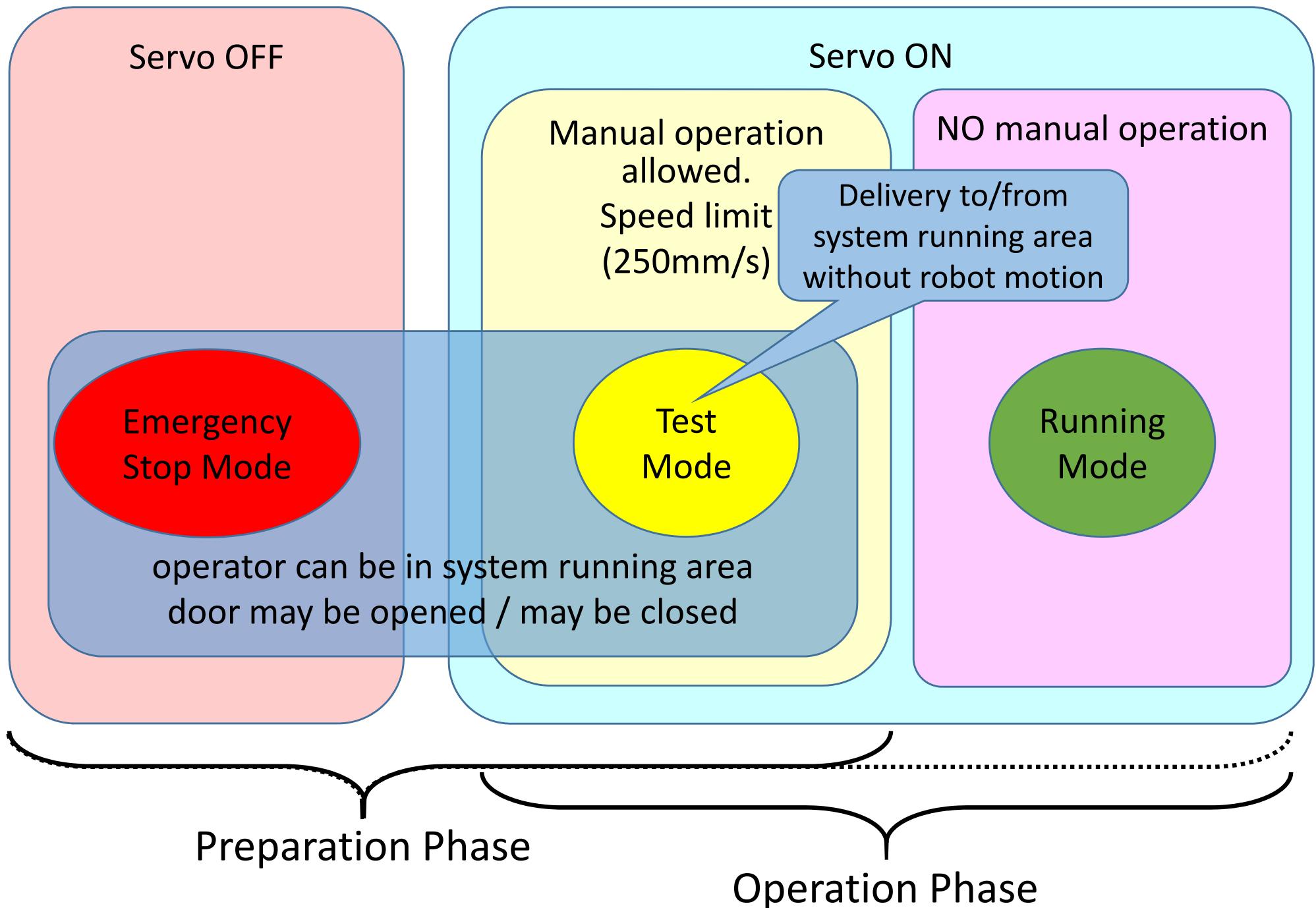
- **Running Mode** or **Pause Mode**
  - (operator goes in system running area to bring works during **Pause Mode**)
  - (if **Pause Mode** is not implemented, **Test Mode** or **Emergency Stop Mode** is used to deliver parts trays and products to/from system running area.
  - Running Mode** is not allowed for this delivery.)

By emergency stop switch or safety door switch during **Running Mode**, it must move to **Emergency Stop Mode**

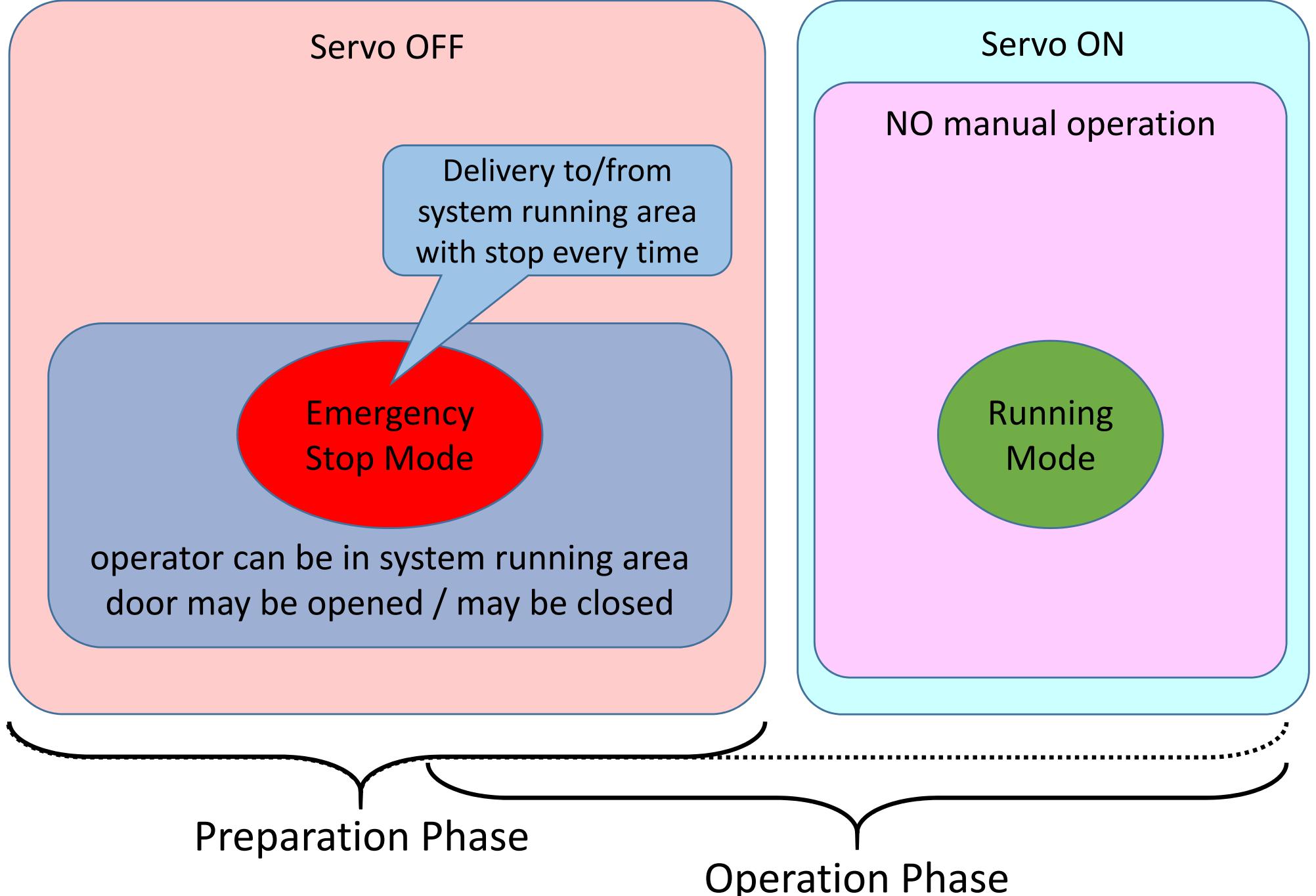
With four modes : **Running Mode**, **Pause Mode**, **Test Mode** and **Emergency Stop Mode**



With three modes : **Running Mode**, **Test Mode** and **Emergency Stop Mode**



With two modes : **Running Mode** and **Emergency Stop Mode**



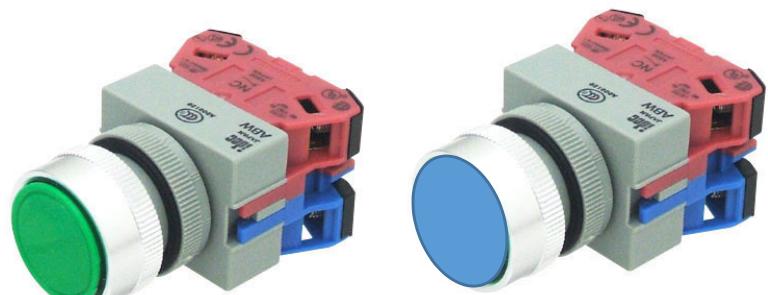
# Switches and Signal Towers

Signal Tower



PATLITE  
MPS-402-RYGB  
LR6-402PJNW-RYGB

Mode Select Switch



IDECA  
ABW111G  
ABW111S  
ABW111Y



Clear Switch / Servo ON



IDECA  
ABW111W

\* Photos may not be correct type

Emergency Stop Switch



IDECA  
HW1X-BV402R  
HW1B-V302R

Safety Door Switch



IDECA  
HS5D-02RN

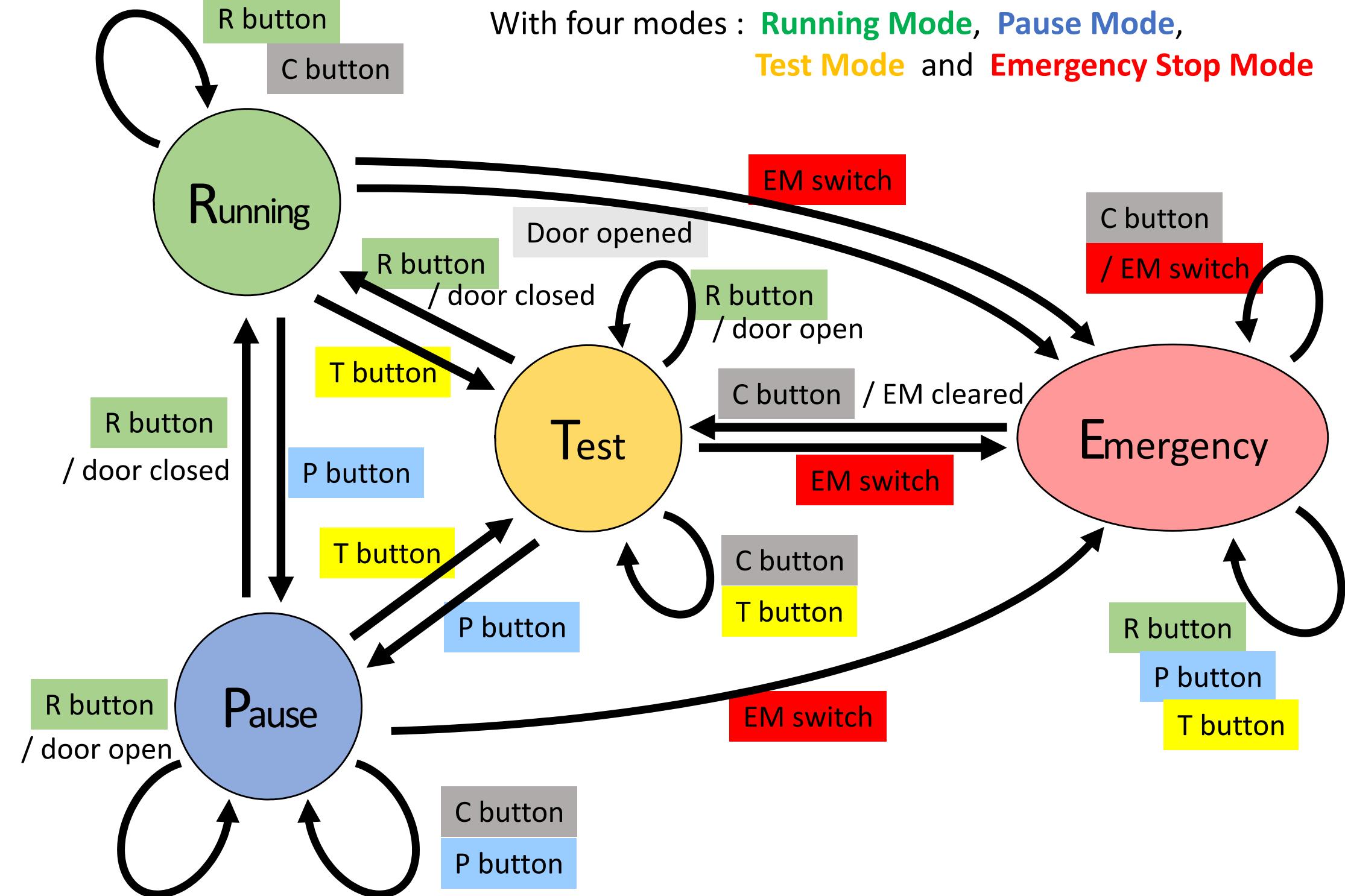


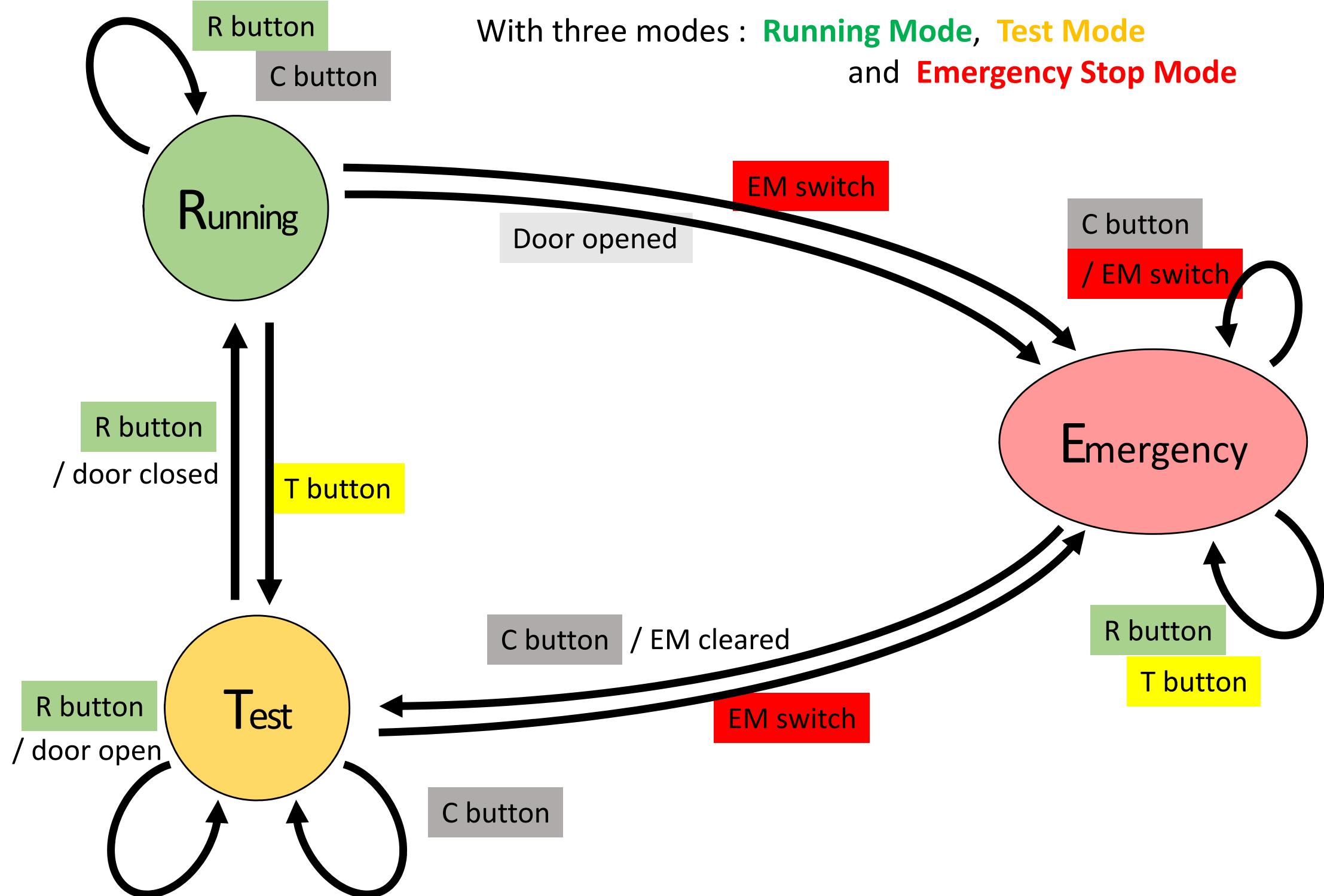
Terminal Block

IDECA  
BTB15LC20  
(three)

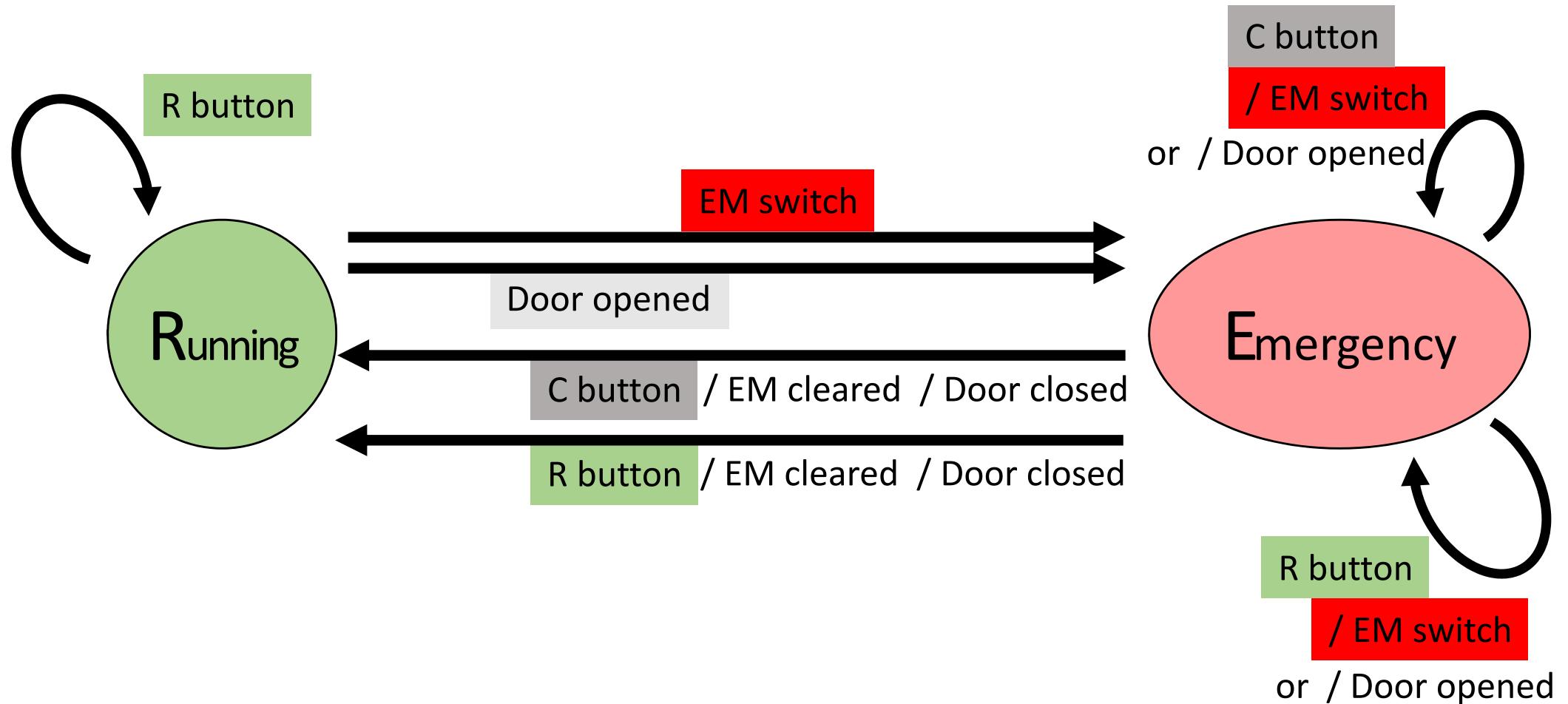


With four modes : **Running Mode**, **Pause Mode**,  
**Test Mode** and **Emergency Stop Mode**





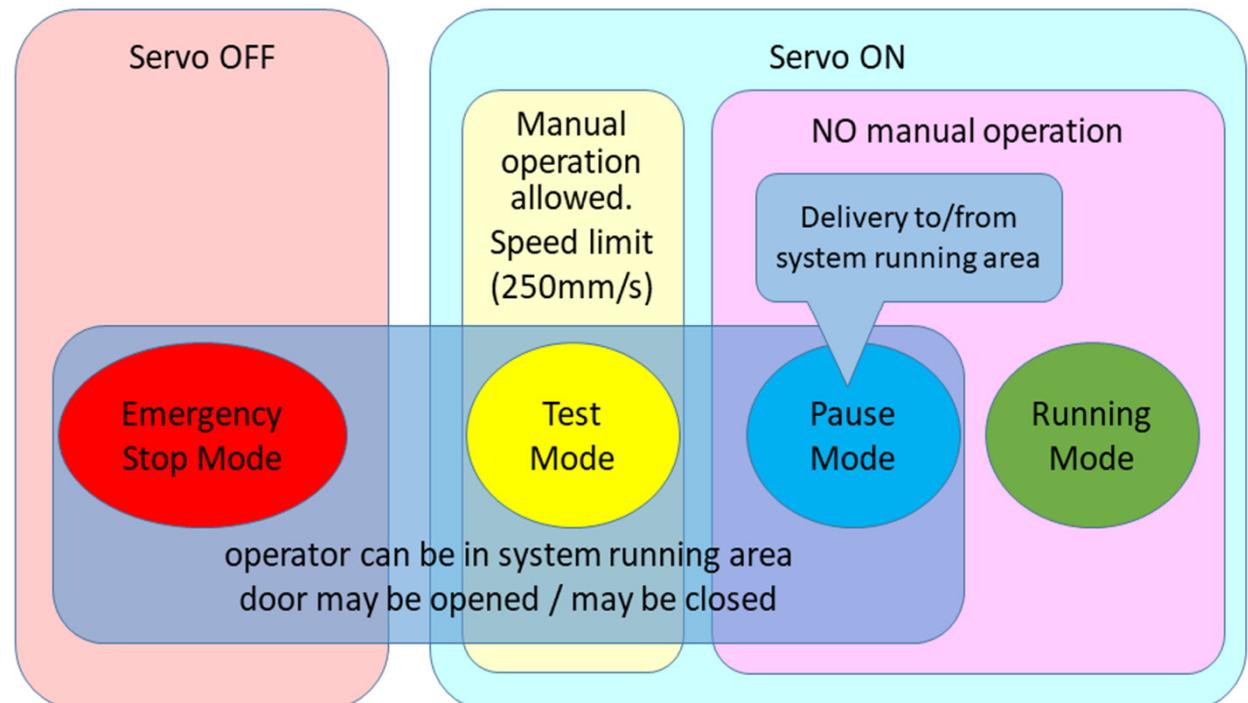
With two modes : **Running Mode**  
and **Emergency Stop Mode**



# Matching with modes defined in ISO

In this competition	ISO
Running Mode	Automatic Mode
Test Mode	Manual Mode: Reduced Speed Mode
(not allowed)	Manual Mode: High Speed Mode
Pause Mode	Emergency Stop: Category 2 Protectice Stop: Category 2
Emergency Stop Mode	Emergency Stop: Category 1 Protectice Stop: Category 1 Emergency Stop: Category 0 Protectice Stop: Category 0

With four modes : **Running Mode**, **Pause Mode**, **Test Mode** and **Emergency Stop Mode**



# Usage of switches / signal towers

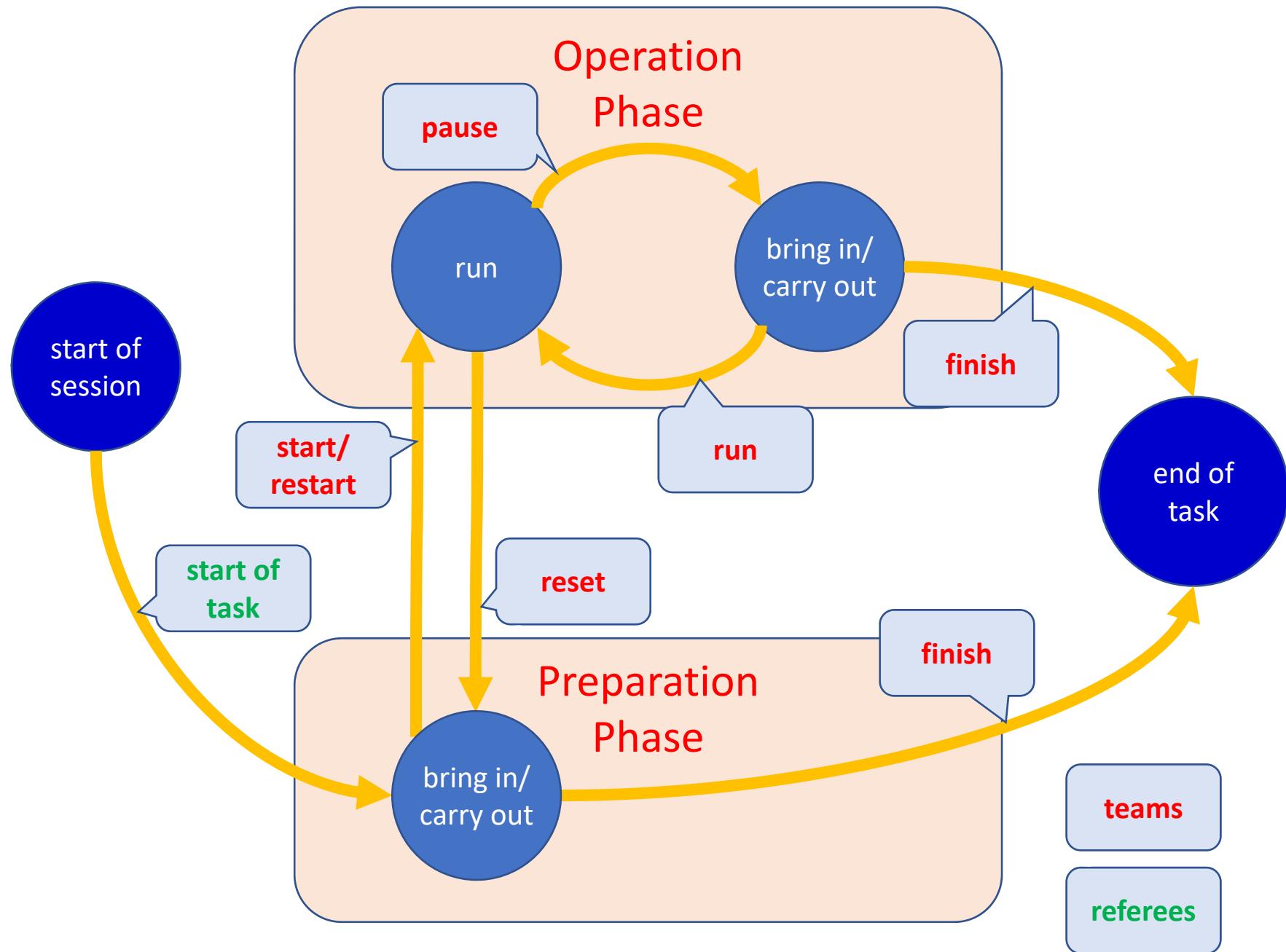
Must be used

- Signal tower for audience (LR6-402PJNW-RYGB)
- Safety door switch (HS5D-02RN)

Other switches / signal tower may be replaced with own equipment by each team.

But “Robot Operation Mode” and their transition operations must be safely implemented and must pass safety check on competition site by safety and health inspection at setup days.

# Relationship between game phases and team actions.



# Appendix E. :

## Assembly Task with Surprise

E1 - Part list and photos for each task with surprise

\* Surprise #0 : Bearing

- ✓ Bearings with Housings (Double Bearings) (Part No.7) is changed to longer one.
- ✓ Drive shaft (Straight) D10h7 (Part No.8) is changed to longer one.

\* Surprise #1 : Motor100

- ✓ Geared motor (Gear ratio 1:70) (Part No.4) is changed to Gear ration 1:100.
- ✓ Pulley for Round Belt (4mm) – Setscrew P.D. 30mm (Part No.5) is changed to P.D. 40mm.
- ✓ Polyurethane round belt (welded joint product) P.D. 4mm L=400mm (Part No.6) is changed to L=420mm.

\* Surprise #2 : Timing Belt

- ✓ Polyurethane round belt (welded joint product) P.D. 4mm L=400mm (Part No.6) is changed to Timing Belt P2M(6mm) 370mm.
- ✓ Pulley for Round Belt (4mm) – Setscrew P.D. 30mm (Part No.5) is changed to Pulley for Timing Belt (6mm) P.D. 30mm.
- ✓ Pulley for Round Belt (4mm) Clamping Type P.D. 60mm (Part No.11) is changed to Pulley for Timing Belt (6mm) P.D. 60mm with replacing its screw to SCB4-12.
- ✓ Idler for Round Belt – Wide (Part No.13) is changed to Idler for Timing Belt (6mm).
- ✓ Bearing Spacers For Inner Ring (output pulley) (Part No.10) is changed to shorter. (4mm --> 3mm)
- ✓ Shape of Drive shaft (Straight) D10h7 (Part No.8) is changed. (FC55 G20 --> FC40 G35)

\* Surprise #3 : Motor and Timing Belt

- ✓ Polyurethane round belt (welded joint product) P.D. 4mm L=400mm (Part No.6) is changed to Timing Belt P2M(6mm) 340mm.
- ✓ Geared motor (Gear ratio 1:70) (Part No.4) is changed to Gear ration 1:100.
- ✓ Pulley for Round Belt (4mm) – Setscrew P.D. 30mm (Part No.5) is changed to

Pulley for Timing Belt (6mm) P.D. 30mm.

- ✓ Pulley for Round Belt (4mm) Clamping Type P.D. 60mm (Part No.11) is changed to Pulley for Timing Belt (6mm) P.D. 42mm with replacing its screw to SCB4-6.
- ✓ Idler for Round Belt – Wide (Part No.13) is changed to Idler for Timing Belt (6mm).
- ✓ Bearing Spacers For Inner Ring (output pulley) (Part No.10) is changed to shorter. (4mm --> 3mm)
- ✓ Shape of Drive shaft (Straight) D10h7 (Part No.8) is changed. (FC55 G20 --> FC40 G35)

\* Surprise #4 : Chain

- ✓ Polyurethane round belt (welded joint product) P.D. 4mm L=400mm (Part No.6) is changed to Roller chain #25 1strand 420mm..
- ✓ Pulley for Round Belt (4mm) – Setscrew P.D. 30mm (Part No.5) is changed to Sprocket #25 11-tooth d=6mm with replacing its screw to SCB3-8.
- ✓ Pulley for Round Belt (4mm) Clamping Type P.D. 60mm (Part No.11) is changed to Sprocket #25 22-tooth d=10mm with replacing its screw to SCB4-14.
- ✓ Idler for Round Belt – Wide (Part No.13) is changed to Sprocket Idler for Chain #25 17-tooth d=6mm.
- ✓ Bearing Spacers For Inner Ring (output pulley) (Part No.10) is changed to longer. (4mm --> 11mm)
- ✓ Bearing Spacers For Inner Ring (tension pulley) (Part No.12) is changed to longer. (9.5mm --> 13mm)
- ✓ Bearing Shaft Screw (No.14) is changed to Roller Pin for Sprocket Idler.
- ✓ Shape of Drive shaft (Straight) D10h7 (Part No.8) is changed. (FC55 G20 --> FC40 G35)

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23rd Apr, 2020

Industrial Robotics Competition Committee

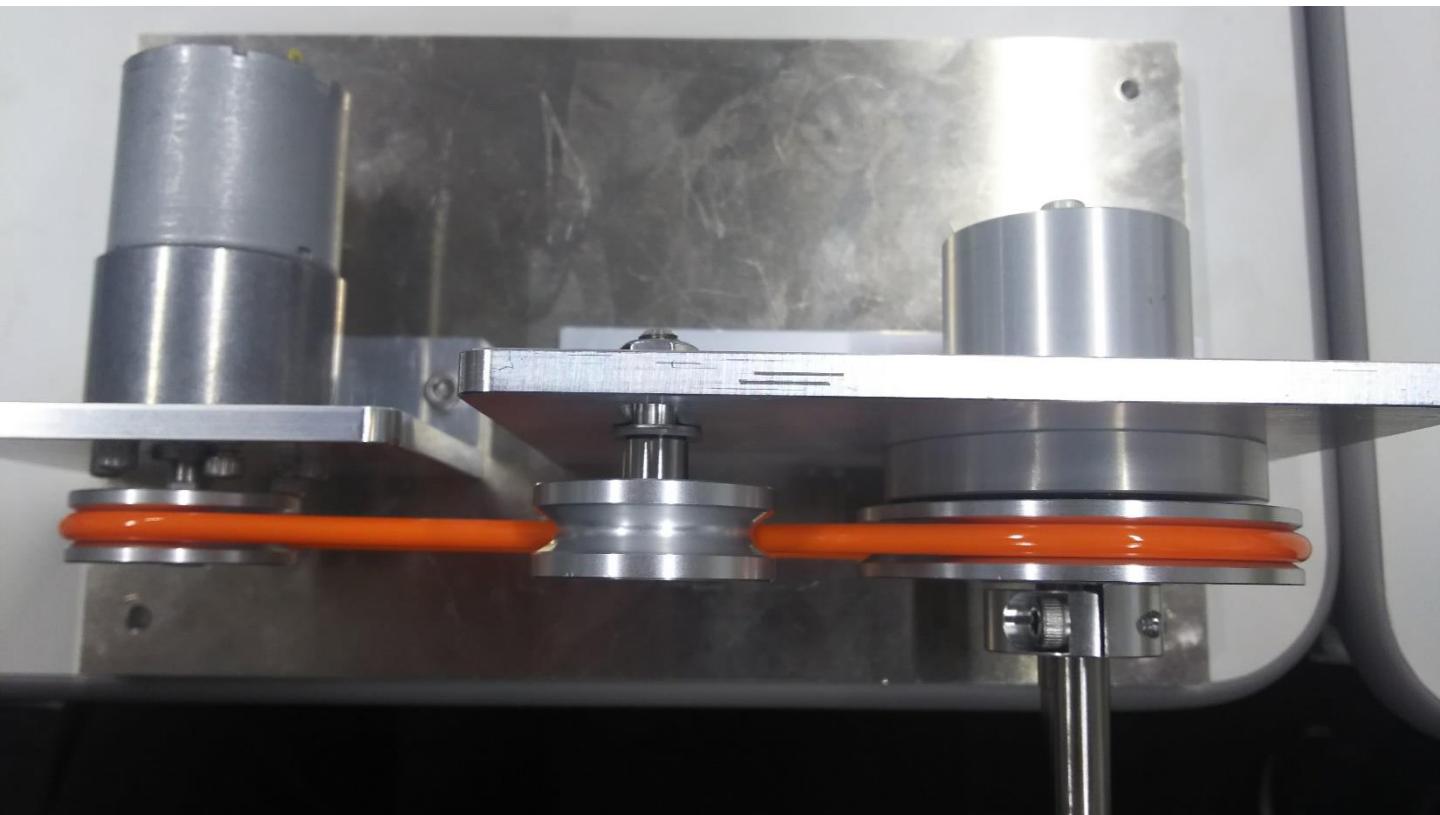
World Robot Summit

Assembly Task with Surprise Parts (#0 Bearing)

Parts list (#0 Bearing)

No.	Name of part	Note.	Qty.	Retailer	MISUMI order number
1	01-BASE	Base plate	1	manufactured	
2	02-PLATE	Output shaft fixing plate	1	manufactured	
3	03-PLATE2	Motor fixing plate	1	manufactured	
4	04_37D-GEARMOTOR-50-70	Geared motor (Gear ratio 1:70)	1	Pololu	<a href="https://www.pololu.com/product/1105">https://www.pololu.com/product/1105</a>
5	05_MBRFA30-2-P6	Pulley for Round Belt (4mm) - Setscrew P.D. 30mm	1	MISUMI	MBRFA30-2-P6
6	06_MBT4-400	Polyurethane round belt (welded joint product) P.D. 4mm L=400mm	1	MISUMI	MBT4-400
7	07_SBARTB6200ZZ_30	Bearings with Housings (Double Bearings)	4	MISUMI	SBARTB6200ZZ_30
7	07_SBARTB6200ZZ_40	Bearings with Housings (Double Bearings)	1	MISUMI	SBARTB6200ZZ_40
8	08_SSFHRT10-75-M4-FC55-G20	Drive shaft (Straight) D10h7	4	MISUMI	SSFHRT10-75-M4-FC55-G20
8	08_SSFHRT10-85-M4-FC65-G20	Drive shaft (Straight) D10h7	1	MISUMI	SSFHRT10-85-M4-FC65-G20
9	09_EDCS10	End Cap for Shaft	1	MISUMI	EDCS10
10	10_CLBPS10_17_4	Bearing Spacers For Inner Ring (output pulley)	1	MISUMI	CLBPS10-17-4
11	11_MBRAC60-2-10	Pulley for Round Belts Clamping Type P.D. 60mm	1	MISUMI	MBRAC60-2-10
12	12_CLBUS6-9-9.5	Bearing Spacers For Inner Ring (tension pulley)	1	MISUMI	CLBUS6-9-9.5
13	13_MBGA30-2	Idler for Round Belt - Wide	1	MISUMI	MBGA30-2
14	14_BGPSL6-9-L30-F8	Bearing Shaft Screw	1	MISUMI	BGPSL6-9-L30-F8
15	15_SLBNR6	M6 Hex Nut (Fixing for idler shaft)	1	MISUMI	SLBNR6
16	16_SPWF6	M6 Flat Washer (Fixing for idler shaft)	2	MISUMI	SPWF6
17	17_SCB4-10	10mm M4 Socket Head Cap Screw (metric coarse thread)	9	MISUMI	SCB4-10
18	18_SCB3-10	10mm M3 Socket Head Cap Screw (metric coarse thread)	6	MISUMI	SCB3-10
19	19_MSSFS3-6	6mm M3 Hex Socket Set Screw (metric coarse thread)	1	MISUMI	MSSFS3-6

## Assembly Task with Surprise Parts (#0 Bearing)

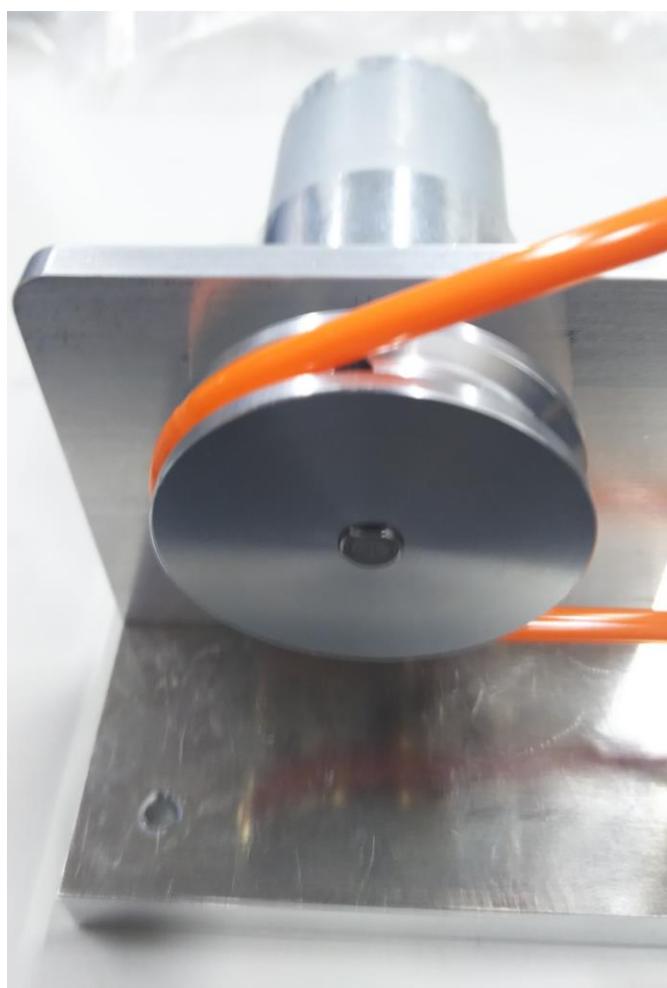
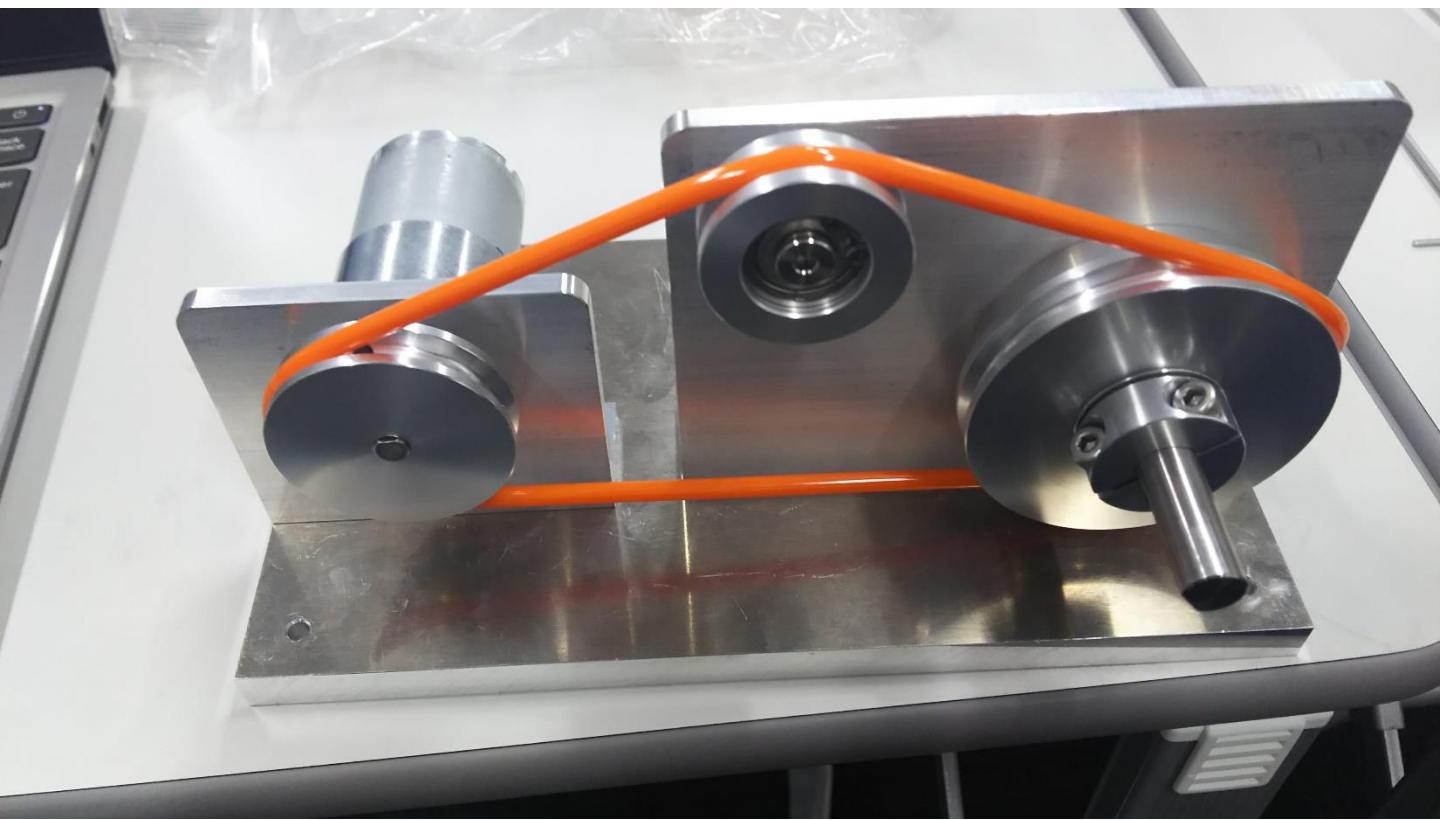


Assembly Task with Surprise Parts (#1 Motor100)

Parts list (#1 Motor100)

No.	Name of part	Note.	Qty.	Retailer	MISUMI order number
1	01-BASE	Base plate	1	manufactured	
2	02-PLATE	Output shaft fixing plate	1	manufactured	
3	03-PLATE2	Motor fixing plate	1	manufactured	
4	04_37D_GEARMOTOR-50-70	Geared motor (Gear ratio 1:70)	1	Pololu	<a href="https://www.pololu.com/product/1105">https://www.pololu.com/product/1105</a>
4	04_37D-GEARMOTOR-100	Geared motor (Gear ratio 1:100)	1	Pololu	<a href="https://www.pololu.com/product/1105">https://www.pololu.com/product/1105</a>
5	05_MBRFA30-2-P6	Pulley for Round Belt (4mm) - Setscrew P.D. 30mm	1	MISUMI	MBRFA30-2-P6
5	05_MBRFA40-2-P6	Pulley for Round Belt (4mm) - Setscrew P.D. 40mm	1	MISUMI	MBRFA40-2-P6
6	06_MBTA4-400	Polyurethane round belt (welded joint product) P.D. 4mm L=400mm	1	MISUMI	MBT4-400
6	06_MBTA4-420	Polyurethane round belt (welded joint product) P.D. 4mm L=420mm	1	MISUMI	MBT4-420
7	07_SBART6200ZZ_30	Bearings with Housings (Double Bearings)	1	MISUMI	SBART6200ZZ-30
8	08_SSFHRT10-75-M4-FC55-G20	Drive shaft (Straight) D10h7	1	MISUMI	SSFHRT10-75-M4-FC55-G20
9	09_EDCS10	End Cap for Shaft	1	MISUMI	EDCS10
10	10_CLBPS10_17_4	Bearing Spacers For Inner Ring (output pulley)	1	MISUMI	CLBPS10-17-4
11	11_MBRAC60-2-10	Pulley for Round Belts Clamping Type P.D. 60mm	1	MISUMI	MBRAC60-2-10
12	12_CLBUS6-9-9.5	Bearing Spacers For Inner Ring (tension pulley)	1	MISUMI	CLBUS6-9-9.5
13	13_MBGA30-2	Idler for Round Belt - Wide	1	MISUMI	MBGA30-2
14	14_BGPSL6-9-L30-F8	Bearing Shaft Screw	1	MISUMI	BGPSL6-9-L30-F8
15	15_SLBNR6	M6 Hex Nut (Fixing for idler shaft)	1	MISUMI	SLBNR6
16	16_SPWF6	M6 Flat Washer (Fixing for idler shaft)	2	MISUMI	SPWF6
17	17_SCB4-10	10mm M4 Socket Head Cap Screw (metric coarse thread)	9	MISUMI	SCB4-10
18	18_SCB3-10	10mm M3 Socket Head Cap Screw (metric coarse thread)	6	MISUMI	SCB3-10
19	19_MSSFS3-6	6mm M3 Hex Socket Set Screw (metric coarse thread)	1	MISUMI	MSSFS3-6

## Assembly Task with Surprise Parts (#1 Motor100)

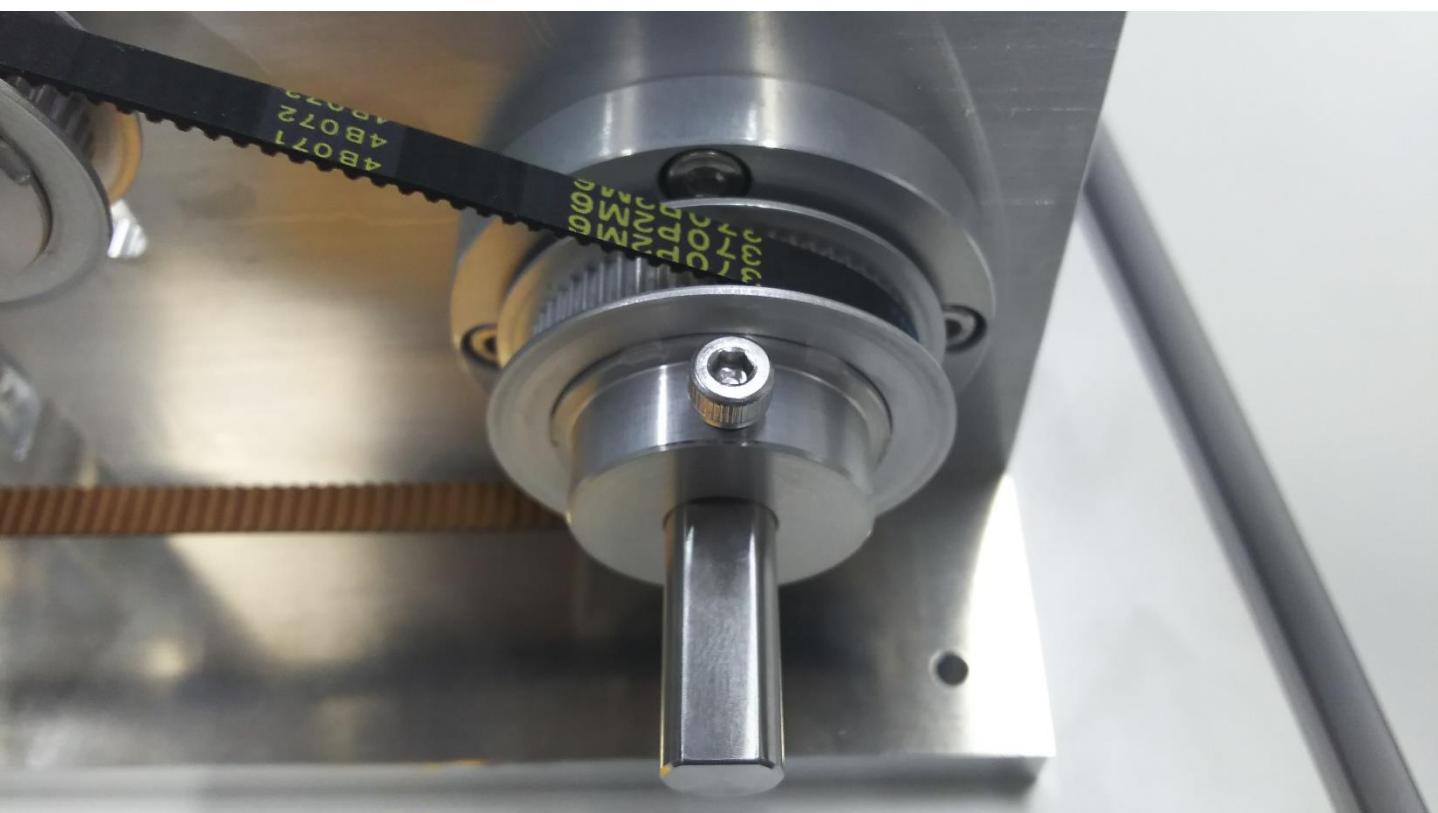
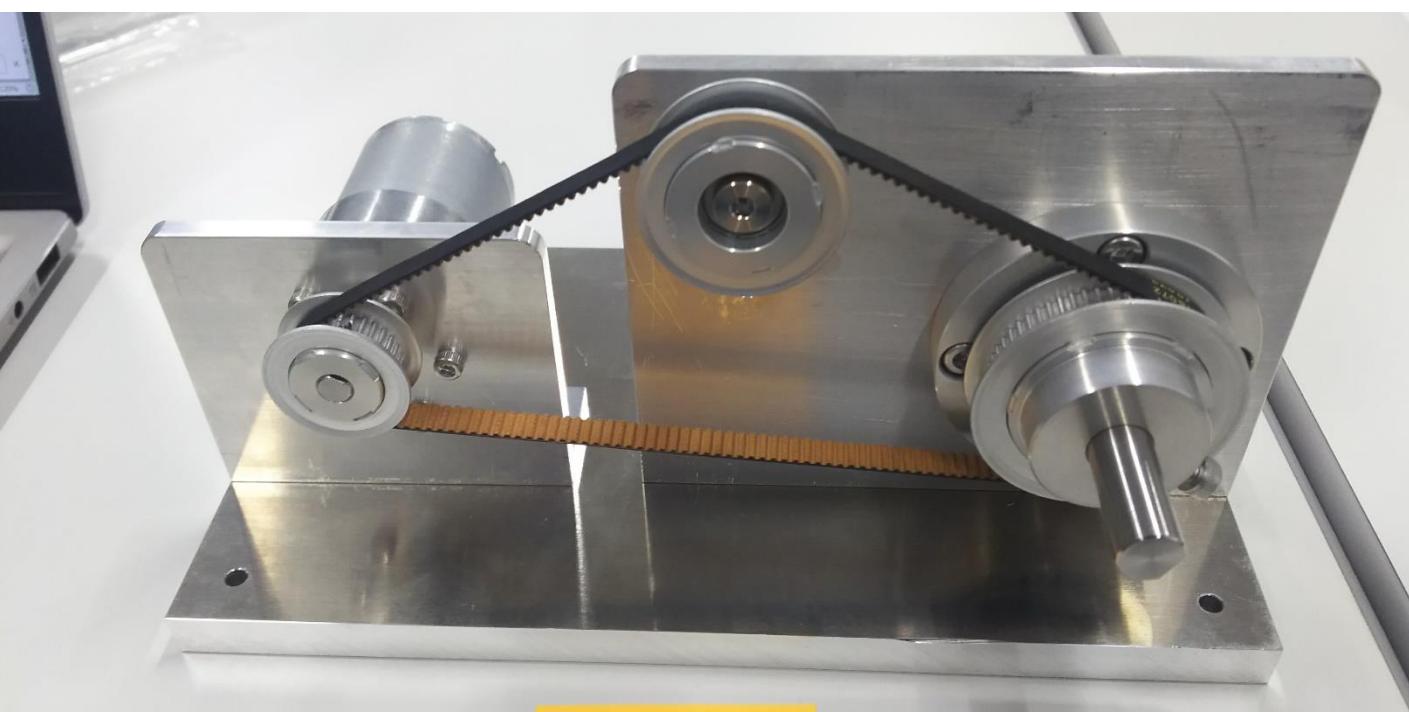


Assembly Task with Surprise Parts (#2 Timing Belt)

Parts list (#2 Belt)

No.	Name of part	Note.	Qty.	Retailer	MISUMI order number
1	01-BASE	Base plate	1	manufactured	
2	02-PLATE	Output shaft fixing plate	1	manufactured	
3	03-PLATE2	Motor fixing plate	1	manufactured	
4	04_37D-GEARMOTOR-50-70	Geared motor (Gear ratio 1:70)	1	Pololu	<a href="https://www.pololu.com/product/1105">https://www.pololu.com/product/1105</a>
5	05_MBRFA30-2-P6	Pulley for Round Belt (4mm) - Setscrew P.D. 30mm	4	MISUMI	MBRFA30-2-P6
5'	05_TimingBeltPulley30mm	Pulley for Timing Belt (6mm) P.D. 30mm	1	MISUMI	PTPA30P2M060-A-P6
6	06_MBT4-400	Polyurethane round belt (welded joint product) P.D. 4mm L=400mm	1	MISUMI	MBT4-400
6'	06_TimingBelt6mm	Timing Belt P2M(6mm) 370mm	1	MISUMI	PTBN370P2M-060
7'	07_SBART6200ZZ_30	Bearings with Housings (Double Bearings)	1	MISUMI	SBART6200ZZ-30
8	08_SSFHRT10-75-M4-FC55-G20	Drive shaft (Straight) D10h7	1	MISUMI	SSFHRT10-75-M4-FC55-G20
8'	08_SSFHRT10-75-M4-FC40-G35	Drive shaft (Straight) D10h7	1	MISUMI	SSFHRT10-75-M4-FC40-G35
9	09_EDCS10	End Cap for Shaft	1	MISUMI	EDCS10
10	10_CLBPS10_17_4	Bearing Spacers For Inner Ring (output pulley)	4	MISUMI	CLBPS10-17-4
10'	10_CLBPS10_17_3	Bearing Spacers For Inner Ring (output pulley)	1	MISUMI	CLBPS10-17-3
11	11_MBRAC60-2-10	Pulley for Round Belts Clamping Type P.D. 60mm	4	MISUMI	MBRAC60-2-10
11'	11_TimingBeltPulley60mm	Pulley for Timing Belt (6mm) P.D. 60mm	1	MISUMI	PTPA60P2M060-B-P10
11'a	11a_screwM4-12	Screw(M4) for Pulley	1	MISUMI	SCB4-12
12	12_CLBUS6-9-9.5	Bearing Spacers For Inner Ring (tension pulley)	1	MISUMI	CLBUS6-9-9.5
13	13_MBGA30-2	Idler for Round Belt - Wide	4	MISUMI	MBGA30-2
13'	13_TimingBeltIdler	Idler for Timing Belt (6mm)	1	MISUMI	APTF40P2M060
14	14_BGPSL6-9-L30-F8	Bearing Shaft Screw	1	MISUMI	BGPSL6-9-L30-F8
15	15_SLBNR6	M6 Hex Nut (Fixing for idler shaft)	1	MISUMI	SLBNR6
16	16_SPWF6	M6 Flat Washer (Fixing for idler shaft)	2	MISUMI	SPWF6
17	17_SCB4-10	10mm M4 Socket Head Cap Screw (metric coarse thread)	9	MISUMI	SCB4-10
18	18_SCB3-10	10mm M3 Socket Head Cap Screw (metric coarse thread)	6	MISUMI	SCB3-10
19	19_MSSFS3-6	6mm M3 Hex Socket Set Screw (metric coarse thread)	1	MISUMI	MSSFS3-6

## Assembly Task with Surprise Parts (#2 Timing Belt)

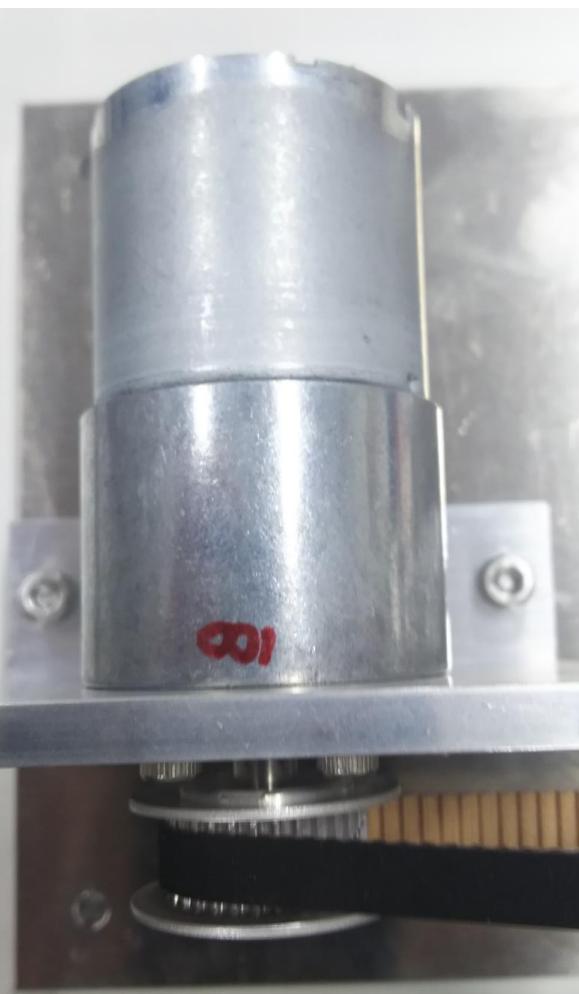
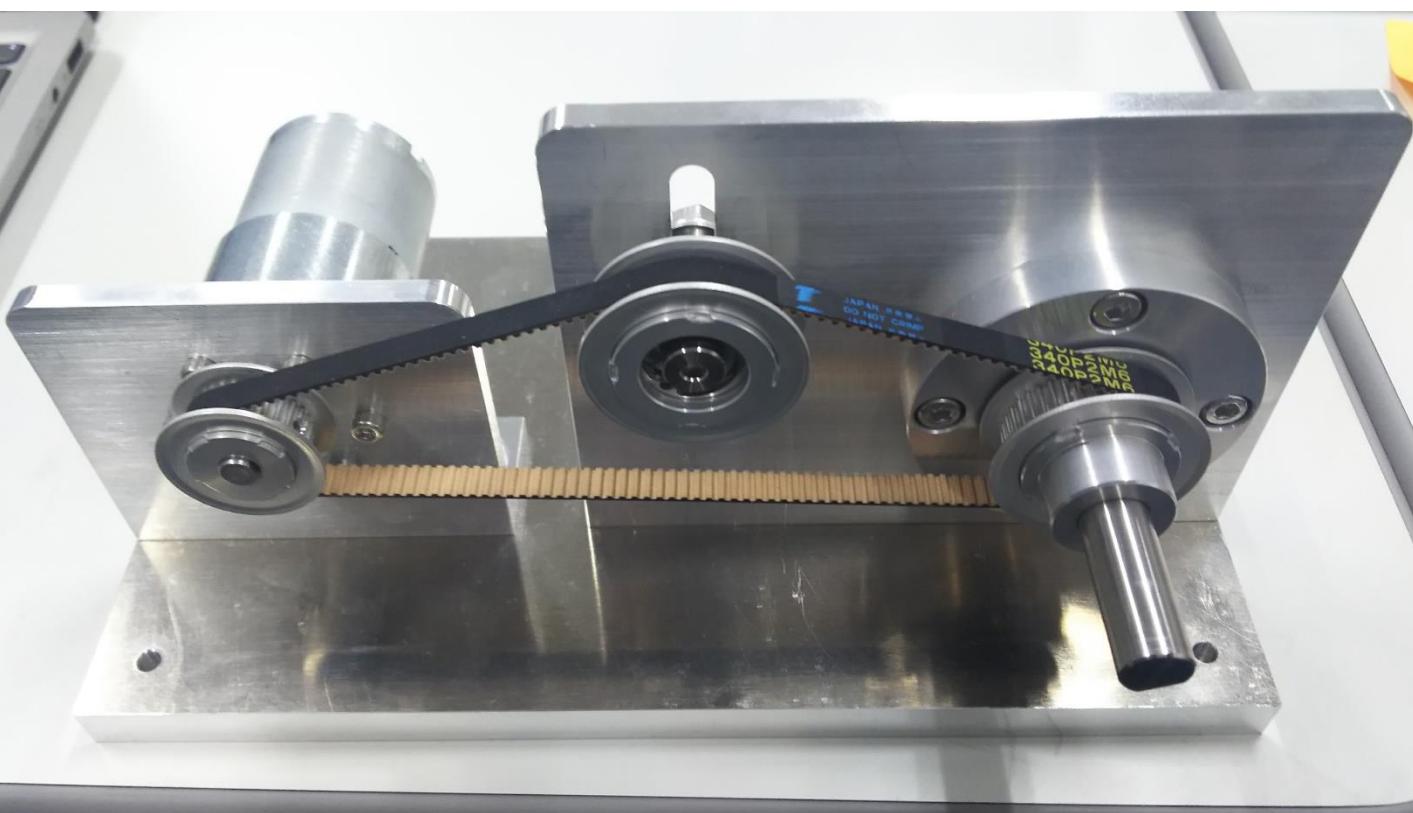


Assembly Task with Surprise Parts (#3 Motor & TimingBelt)

Parts list (#3 Motor & Timing Belt)

No.	Name of part	Note.	Qty.	Retailer	MISUMI order number
1	01-BASE	Base plate	1	manufactured	
2	02-PLATE	Output shaft fixing plate	1	manufactured	
3	03-PLATE2	Motor fixing plate	1	manufactured	
4	04_37D_GEARMOTOR-50-70	Geared motor (Gear ratio 1:70)	1	Pololu	<a href="https://www.pololu.com/product/1105">https://www.pololu.com/product/1105</a>
4'	04_37D-GEARMOTOR-100	Geared motor (Gear ratio 1:100)	1	Pololu	<a href="https://www.pololu.com/product/1105">https://www.pololu.com/product/1105</a>
5	05_MBRFA30-2-P6	Pulley for Round Belt (4mm) Setscrew P.D. 30mm	1	MISUMI	MBRFA30-2-P6
5'	05_TimingBeltPulley30mm	Pulley for Timing Belt (6mm) P.D. 30mm	1	MISUMI	PTPA30P2M060-A-P6
6	06_MBT4-400	Polyurethane round belt (welded joint product) P.D. 4mm L=400mm	1	MISUMI	MBT4-400
6'	06_TimingBelt6mm	Timing Belt P2M(6mm) 340mm	1	MISUMI	PTBN340P2M-060
7	07_SBARB6200ZZ_30	Bearings with Housings (Double Bearings)	1	MISUMI	SBARB6200ZZ-30
8	08_SSFHRT10-75-M4-FC55-G20	Drive shaft (Straight) D10h7	1	MISUMI	SSFHRT10-75-M4-FC55-G20
8'	08_SSFHRT10-75-M4-FC40-G35	Drive shaft (Straight) D10h7	1	MISUMI	SSFHRT10-75-M4-FC40-G35
9	09_EDCS10	End Cap for Shaft	1	MISUMI	EDCS10
10	10_CLBPS10_17_4	Bearing Spacers For Inner Ring (output pulley)	1	MISUMI	CLBPS10-17-4
10'	10_CLBPS10_17_3	Bearing Spacers For Inner Ring (output pulley)	1	MISUMI	CLBPS10-17-3
11	11_MBRAC60-2-10	Pulley for Round Belts Clamping Type P.D. 60mm	1	MISUMI	MBRAC60-2-10
11'	11_TimingBeltPulley42mm	Pulley for Timing Belt (6mm) P.D. 42mm	1	MISUMI	PTPA42P2M060-B-P10
11'a	11a_screwM4-6	Screw(M4) for Pulley	1	MISUMI	SCB4-6
12	12_CLBUS6-9-9.5	Bearing Spacers For Inner Ring (tension pulley)	1	MISUMI	CLBUS6-9-9.5
13	13_MBGA30-2	Idler for Round Belt Wide	1	MISUMI	MBGA30-2
13'	13_TimingBeltIdler	Idler for Timing Belt (6mm)	1	MISUMI	APTF40P2M060
14	14_BGPSL6-9-L30-F8	Bearing Shaft Screw	1	MISUMI	BGPSL6-9-L30-F8
15	15_SLBNR6	M6 Hex Nut (Fixing for idler shaft)	1	MISUMI	SLBNR6
16	16_SPWF6	M6 Flat Washer (Fixing for idler shaft)	2	MISUMI	SPWF6
17	17_SCB4-10	10mm M4 Socket Head Cap Screw (metric coarse thread)	9	MISUMI	SCB4-10
18	18_SCB3-10	10mm M3 Socket Head Cap Screw (metric coarse thread)	6	MISUMI	SCB3-10
19	19_MSSFS3-6	6mm M3 Hex Socket Set Screw (metric coarse thread)	1	MISUMI	MSSFS3-6

## Assembly Task with Surprise Parts (#3 Motor & TimingBelt)



Assembly Task with Surprise Parts (#4 Chain)

Parts list (#4 Chain)

No.	Name of part	Note.	Qty.	Retailer	MISUMI order number
1	01-BASE	Base plate	1	manufactured	
2	02-PLATE	Output shaft fixing plate	1	manufactured	
3	03-PLATE2	Motor fixing plate	1	manufactured	
4	04_37D-GEARMOTOR-50-70	Geared motor (Gear ratio 1:70)	1	Pololu	<a href="https://www.pololu.com/product/1105">https://www.pololu.com/product/1105</a>
5	05_MBRFA30-2-P6	Pulley for Round Belt (4mm) - Setscrew P.D. 30mm	1	MISUMI	MBRFA30-2-P6
5'	05_Sprocket#25-11-d6	Sprocket #25 11-tooth d=6mm	1	Tsubakimoto	RS25-1B11T-6 without screw
5'a	05a_screwM3-8	Screw(M3) for Sprocket	1	MISUMI	SCB3-8
6	06_MBT4-400	Polyurethane round belt (welded joint product) P.D. 4mm L=400mm	1	MISUMI	MBT4-400
6'	06_Chain#25-420	Roller chain #25 1strand 420mm	1	Tsubakimoto	RS25-1-RP
7	07_SBART6200ZZ_30	Bearings with Housings (Double Bearings)	1	MISUMI	SBART6200ZZ-30
8	08_SSFHRT10-75-M4-FC55-G20	Drive shaft (Straight) D10h7	1	MISUMI	SSFHRT10-75-M4-FC55-G20
8'	08_SSFHRT10-75-M4-FC40-G35	Drive shaft (Straight) D10h7	1	MISUMI	SSFHRT10-75-M4-FC40-G35
9	09_EDCS10	End Cap for Shaft	1	MISUMI	EDCS10
10	10_CLBPS10_17_4	Bearing Spacers For Inner Ring (output pulley)	1	MISUMI	CLBPS10-17-4
10'	10_CLBPS10_17_11	Bearing Spacers For Inner Ring (output pulley)	1	MISUMI	CLBPS10-17-11
11	11_MBRAC60-2-10	Pulley for Round Belts Clamping Type P.D. 60mm	1	MISUMI	MBRAC60-2-10
11'	11_Sprocket#25-22-d10	Sprocket #25 22-tooth d=10mm	1	Tsubakimoto	RS25-1B22T-10 without screw
11'a	11a_screwM4-14	Screw(M4) for Sprocket	1	MISUMI	SCB4-14
12	12_CLBUS6-9-9.5	Bearing Spacers For Inner Ring (tension pulley)	1	MISUMI	CLBUS6-9-9.5
12'	12_CLBUS6-9-13	Bearing Spacers For Inner Ring (tension pulley)	1	MISUMI	CLBUS6-9-13
13	13_MBGA30-2	Idler for Round Belt -Wide	1	MISUMI	MBGA30-2
13'	13_Sprocket_Idler#25-17-d6	Sprocket Idler for Chain #25 17-tooth d=6mm	1	MISUMI	DRC25-17-6
14	14_BGPSL6-9-L30-F8	Bearing Shaft Screw	1	MISUMI	BGPSL6-9-L30-F8
14'	14_RollerPin_d=6mm	Roller Pin for Sprocket Idler	1	MISUMI	FSRFN6-35-F8
15	15_SLBNR6	M6 Hex Nut (Fixing for idler shaft)	1	MISUMI	SLBNR6
16	16_SPWF6	M6 Flat Washer (Fixing for idler shaft)	2	MISUMI	SPWF6
17	17_SCB4-10	10mm M4 Socket Head Cap Screw (metric coarse thread)	9	MISUMI	SCB4-10
18	18_SCB3-10	10mm M3 Socket Head Cap Screw (metric coarse thread)	6	MISUMI	SCB3-10
19	19_MSSFS3-6	6mm M3 Hex Socket Set Screw (metric coarse thread)	4	MISUMI	MSSFS3-6

## Assembly Task with Surprise Parts (#4 Chain)

