Manufacturing Robotics Challenge

Rules and Regulations for WRS 2025

The Industrial Robotics Competition Committee

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Table of contents

1 Background

1.1 Toward the World Robot Summit 2025

The trends of industrial globalization, low birth rates, and aging populations in developed countries are leading to rapid changes in the industrial structure. Some of these changes, such as the automation of the manufacturing industry and improved productivity, are inevitable. To prepare for these upcoming situations, various robot competitions have been organized to drive technological advancements, share technologies, and develop skilled individuals. In Japan, a competition titled “Toward agile one-off manufacturing” focused on product assembly systems that could quickly, efficiently, and effectively respond to changing production requirements. The pre-tournament in 2018 and the main tournament in 2021 highlighted a competition on the automatic assembly of belt drive units, which encompass the essential technologies for assembling industrial products.

The WRS2020 competition experienced limited success in complete assembly by participating teams; however, it demonstrated that modern robots excelled in tasks requiring high-precision fitting. The ability to handle multiple diverse parts was determined by hand performance and function, while creating a versatile hand proved to be a challenging task. Furthermore, managing a belt as a flexible object was easily resolved. The low success rate in assembly was primarily attributed to time constraints; nevertheless, it also indicated the unattained goal of rapid manufacturing.

Given the awareness of the current scenario detailed above, the objective for WRS2025 has been determined to introduce a novel competition task that highlighted hand design, agility, and leanness (henceforth referred to as the “competition task”).

1.2 Current awareness of automation in production sites

Numerous automated devices, including industrial robots, have been introduced in mass production sites. The next domain of automation facilitated by the dissemination of robots is the small- to medium-scale production site. Medium-scale production fields are being considered as the target as a first step of this expansion. However, numerous manufacturing sites exist where the introduction of robots is not cost-effective. This is attributed to the robot’s inability to respond quickly and efficiently to fluctuations in production volume. In addition, this could be because

medium-scale production companies have a shortage of personnel with production techniques. Fostering such human resources is also a long-term issue.

Therefore, the competition task in WRS2025 will require robot systems to adapt quickly and efficiently to new workpieces. Additionally, the competition will focus on automating production processes that are typically challenging to automate due to high costs and system uptime requirements.

1.3 Competition task design concept

This competition will involve a task that assesses hand design, agility, and leanness. The problems presented in this competition will require object-handling technologies that go beyond high positioning accuracy alone, and will also involve cost assessments. The Competition Committee has selected the task of packing general consumer products, which do not necessarily require high machining accuracy for the workpieces being handled. It is anticipated that the packing task will pose greater challenges compared to the belt drive unit in WRS2020, as there is a possibility of workpiece deformation and unreliable shape accuracy. On the other hand, the variety of workpieces has been reduced in order to facilitate a faster competition process.

We also plan to directly address the challenges that robot users encounter by conducting comprehensive surveys on the experiences and viewpoints of robot user companies, and integrating their feedback into the competition rules. The objective of this competition, as opposed to WRS2020, which emphasized technical complexity, is to explore solutions to issues in an open forum.

1.4 Expected results

This competition task is aimed at determining the superior object handling technology. Therefore, it necessitates not only simple technological development but also application development skills. This domain can be easily tackled even by relatively small-scale companies, and it can expand the scope of robot technology development from university laboratories to small and medium-sized companies. Moreover, this competition task assesses implementation skills involved in integrating robot systems. Hence, it can be positioned within companies as a form of human resource training for young talent who choose to participate.

The competition focuses on general consumer products, making it visually accessible, even for non-engineers. This makes it easy to approach for individuals not specialized in robots. Specifically, we believe it can attract potential robot users. Companies that have not yet incorporated robots or have faced obstacles due to limited funds or human resources may be able to see the benefits of incorporating robots and their mid-term potential.

2 Overview of competition

2.1 Overview of WRS2025 Manufacturing Robotics Challenge

The WRS2025 Manufacturing Robotics Challenge is a competition where products of various numbers and types are packed into a box. Participants must have advanced sensing, handling, and system integration technology to assemble the entire system. Figure 2.1-1 shows an overview of the competition tasks. This competition involves carrying-in and assembling multiple products into cartons. The products are then packed into the cartons, the carton lids are closed, and they are fixed with a seal. The completed cartons are referred to as set boxes. These set boxes are then packed into a large box referred to as a package case. The finished products in the package cases are then carried out. Competition participants must develop a system that can perform these tasks

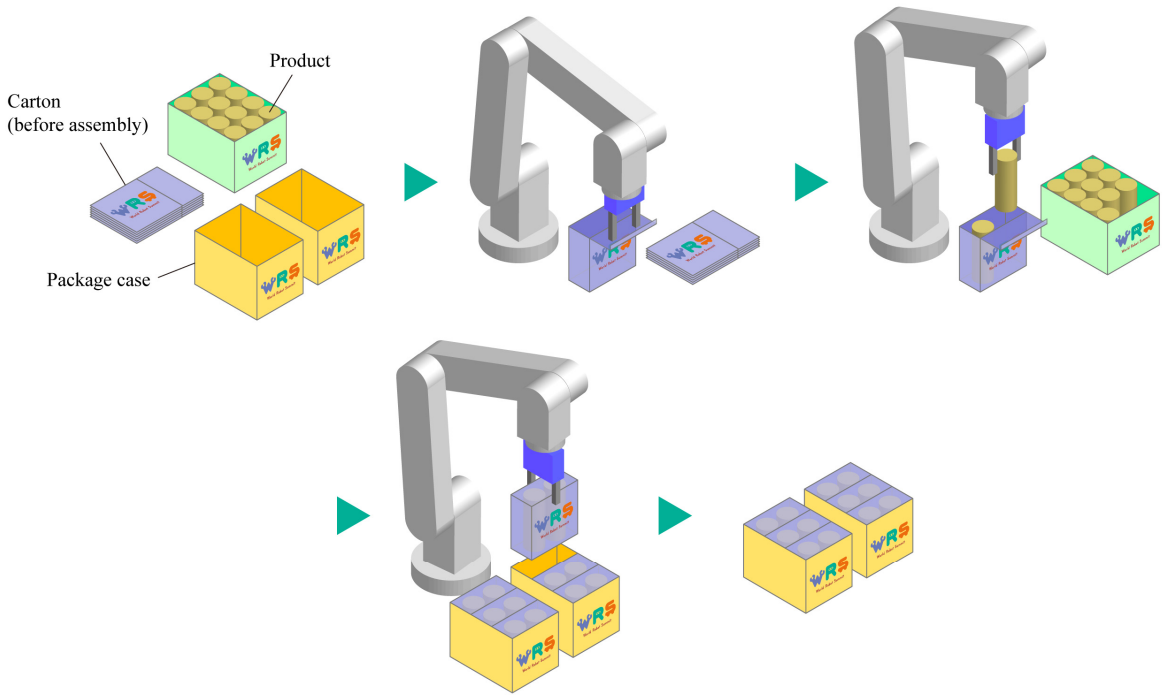


Figure 2.1-1: Competition task overview.

efficiently.

The competition tasks are broadly divided into two types: (1) the normal task involves packing multiple types of products (normal products), the details of which are announced in advance, into cartons and set boxes, whose sizes and other details are specified in advance. (2) The surprise task involves packing multiple types of products, including products with specifications that differ from those of the normal products (surprise products), in addition to the normal products in response to new production demands. The participants must change over quickly and efficiently to conduct these competition tasks. Competition tasks that include surprise products will also have cartons and package cases with specifications that differ from those for normal products. However, the minimum information about the surprise products will be announced in advance to enable the design of the robot hands and equipment for handling the surprise products and their boxes.

The WRS2025 Manufacturing Robotics Challenge aims to achieve a future production system that can quickly and efficiently respond to various changing production requirements, including ultimately to one-off production requirements. Competition tasks that involve surprise products will test competitors' ability to change quickly and efficiently.

Daily necessities will be selected as the products for the competition tasks, and benchmarks of the competition system will be established at various locations throughout the competition task. Samples of normal products, cartons, seals, and package cases to be used in the competition will be sent in advance to teams that have passed the preliminary document screening and are confirmed to participate in WRS2025.

2.2 Competition schedule and competition dates

Table 2.2-1 presents the competition schedule for WRS2025. The event is set to span six days, encompassing foundation work and the setup of the competition system. The initial three days will be dedicated to foundation work and setup. The competition with scoring (hereafter, “try”) will be held on Days 1 and 2, followed by the exhibition and award ceremony on Day 3. Each day, morning assemblies and team meetings involving all teams are scheduled from the day prior to Day 1 through Day 3.

The competition tasks are scheduled to include a standard competition try on Day 1, involving the boxing of normal products, and a surprise competition try on Day 2, where both normal and

Table 2.2-1: Competition schedule for WRS2025 Manufacturing Robotics Challenge.

Day	Foundation work/setup period (three days)			Day 1	Day 2	Day 3
People allowed to enter venue	Organizers	AM: Organizers PM: Organizers, teams	Organizers, teams	Organizers, teams, general visitors		
Implementation content	Foundation work	AM: Foundation work PM: System setup	System setup, adjustment, safety inspection, practice	Competition task		Exhibition, awards ceremony
				Normal competition (normal products)	Surprise competition (normal products and surprise products)	
Loading / unloading	Not possible	AM: Not possible PM: Loading	—	—	—	Unloading

surprise products will be boxed.

Details regarding the competition schedule, including specific dates and entry/exit times, will be disclosed at a later date. It is important to note that the team's loading period and the competition schedule are subject to potential modifications.

2.3 Ranking and awards

2.3.1 Prizes (overall winner, runner-up, third place)

Prizes in the competition will be awarded to the top three teams overall.

2.3.2 Competition Committee Special Awards

We plan to award not only the above-mentioned awards but also Competition Committee Special Awards to teams that excel in various aspects. Our hope in establishing these special awards is that participating teams will deepen their understanding of the purpose of the competition and be motivated to build systems that excel not only in the overall score but also in the assessment criteria for each award. This will result in the future social implementation of the developed systems. As is clear from the selection criteria, these special awards do not prevent teams from receiving the top three awards determined by the overall score. These awards will be selected by a Competition Review Committee that is separately organized in the manufacturing field and will be awarded by the Competition Committee.

At WRS2025, we plan to establish special awards that assess the following aspects:

i) Best Basic Performance Prize

The Best Basic Performance Prize will be awarded to the team that achieves the specified number of package cases completely and in the fastest time in Try 1 of the normal task on Day 1. “Completely” here indicates that the requirements for obtaining the achievement bonus described below are satisfied, and no penalties for damaging the product are applied. If multiple teams achieve “complete” products, then the team that took the shortest time to achieve the task will be awarded. The team with the best basic performance of the system, including the setup, will be awarded based on the results of the first try after the system is set up at the competition venue. This award will not be given if no teams achieve “complete” products.

ii) Best Agile & Lean System Prize

The Best Agile & Lean System Prize will be awarded to the team that achieves the specified number of package cases (including package cases containing the surprise product) completely and in the fastest time in Try 1 of the surprise task, including the surprise products, in the morning of Day 2. “Completely” here indicates that the requirements for obtaining the achievement bonus described below are satisfied, and no penalties for damaging the product are applied. If multiple teams achieve “complete” products, then the team that took the shortest time to achieve the task will be awarded. The team that most quickly and efficiently responded to the product requirements, including the surprise product, will be awarded based on the results of the first try after the surprise product information is disclosed to the team. This award will not be given if no teams achieve “complete” products.

iii) Most Cost-Effective System Prize

The Most Cost-Effective System Prize will be awarded to the team with the highest system cost performance:

$$\mathrm{CP} = (P - R)/(2Q)$$

Here, P denotes the total competition points (added value) from Day 1 and Day 2, R denotes the total operational costs from the competition tasks from Day 1 and Day 2, and Q denotes the system development cost (net cost before deducting threshold). If multiple trials are conducted on a single day, the result of the try with the better overall assessment in Section 7.3.9 will be used for the

calculation. However, to receive this award, the system must achieve a certain level of performance, and the requirements are expected to be at least one normal product package case achieved on Day 1, and at least one normal product and one surprise product package case achieved on Day 2; Note that this may be subject to change in the future.

In WRS2025, a certain cost constraint is imposed by deducting the excess of the net system cost Q from the threshold (standard value) Q_0, $\Delta Q = Q - Q_0$, from the competition points. However, if the cost is below the standard cost, then this will not be reflected in the assessment points, regardless of how low the cost of the system is. This award is given to the system with the best cost performance among systems that have at least a certain level of performance.

iv) Best Software Implementation Award

The Best Software Implementation Award is presented to the team that is recognized for possessing outstanding software technology, such as digital twins and network technology. This award will not be conferred in the absence of a qualifying team.

v) Best Hardware Design Award

The Best Hardware Design Award is awarded to the team that is recognized as having superior hardware technology, such as an excellent general-purpose hand. This award will not be given if there is no applicable team.

2.3.3 Safety Award

As will be stated in Section 6, ensuring health and safety is the top priority in this competition. The organizers will develop a comprehensive health and safety policy, along with specific rules, based on this principle. All participating teams must strictly comply with the established guidelines.

While all teams must follow the health and safety rules, the competition will introduce a Safety Award to encourage teams to go above and beyond in prioritizing health and safety. This award will be given to the team that demonstrates outstanding safety practices. While typically awarded to a single team, multiple teams may be recognized based on a thorough evaluation of their safety efforts before and during the competition.

The evaluation will take into account various factors, including pre-submitted risk assessments and on-site activities, such as setup at the competition venue. Candidate teams will be selected by

health and safety management teams, including the manufacturing health and safety management team. The final award recipients will be determined by the monitoring group, pending approval from the Competition Committee.

3 Competition area

3.1 Competition area configuration

Every team is assigned a designated area for the system to run, including the robot, as illustrated in Figure 3.1-1 (referred to as the "System Running Area") and an area for operating and monitoring the system (referred to as the "Operation Area"). The Operation Area will be utilized by teams for carrying-in workpieces, carrying-out finished products, and receiving scores from referees.

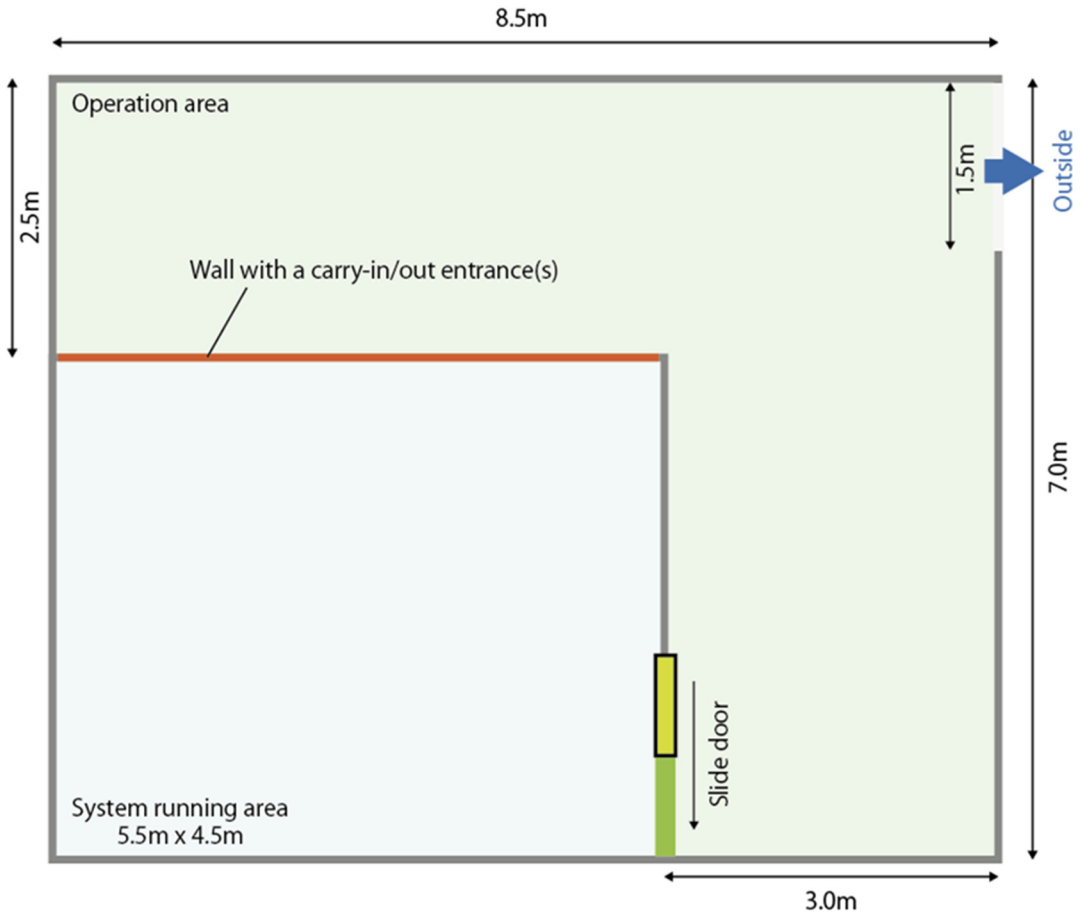


Figure 3.1-1: System running area and Operation Area (actual layout may change).

The Operation Area will consist of around four desks (1.5 m × 0.6 m) and roughly 10 folding chairs. Each team is responsible for arranging and setting up additional furniture, such as work tables, to be used in the System Running Area.

Figure 3.1-2 depicts a sample panel separating the System Running Area from the Operation Area. The complete wall will be constructed by assembling multiple panels in a similar fashion. Transparent polycarbonate panels will be used for the wall. The lower part of the wall (identified as “OPEN” in the figure) will remain panel-free to facilitate cable placement.

Teams may install carrying-in entries by processing panels on designated walls (orange walls in Figure 3.1-1) in the team area to carry workpieces into the System Running Area. Additionally, teams have the option to install carrying-out entries on the same walls (orange walls in Figure 3.1-1) to carry out finished products from the System Running Area. Moreover, teams have the flexibility to adjust the width of the panels or remove some panels based on the size of the carrying-in/out entries requested. However, the wall processing will be carried out by the Competition Committee. Thus, it is imperative for each team to seek approval from the Competition Committee in advance regarding the size and location of the carrying-in/out entries. It is important to note that each team must conduct thorough risk assessments for the carrying-in/out entries

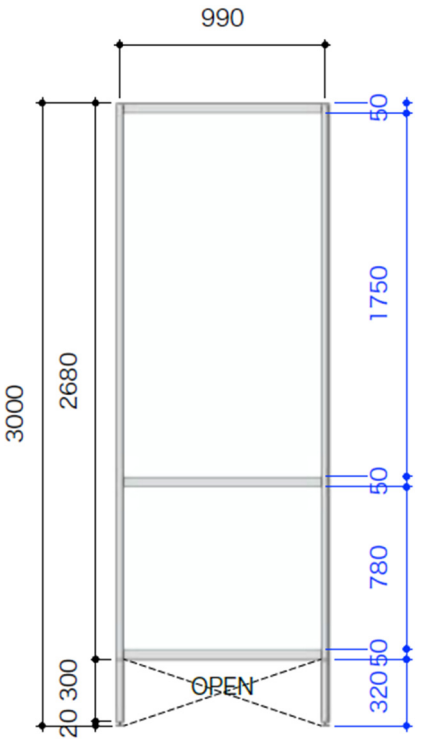


Figure 3.1-2: Example of wall unit between System Running Area and Operation Area (unit: mm) (width will be changed as needed).

configuration determined by the team.

Teams need to consider the visibility of equipment and items in the System Running Area to spectators during installation. For instance, parts shelves should not be placed on the spectator side of the System Running Area, and shades should not cover the area. To enhance spectator experience, organizers may install cameras in the System Running Area and Operation Area to provide footage of the competition. If a team sets up a pillar that obstructs the organizers' camera, the organizers' camera may be installed on the pillar. Flash photography is not allowed for spectators.

Caution is required when installing ceilings in the competition area, especially in the System Running Area. The Competition Committee should be informed in advance, and permission must be secured. Organizers will inspect each team's robot system beforehand. If a robot system has a ceiling structure, a smoke detector may be installed on-site by the organizer. Further details, including height restrictions and ceiling specifications, will be communicated at a later date in compliance with the Fire Service Act in Japan.

If anchor bolts are necessary to secure the robot system to the floor, the Competition Committee must be informed beforehand and approval must be obtained. Only anchor bolts with a diameter of ≤16 mm and a shield depth of ≤50 mm (with a drill diameter of ≤17 mm) that can be inserted into the core rod are permitted.

Please note that the layout of the team area, including the System Running Area and Operation Area, may be changed due to venue conditions.

3.2 Number of competitors

The number of competitors who can enter the team area (Operation Area and System Running Area) is limited, with a maximum simultaneous area occupancy of approximately 10 people being set. Members can rotate in and out after each try; however, members are not permitted to rotate in and out during a competition (try).

3.3 Power supply and air pressure source

A single-phase 100V power supply will be available. Teams that require it can also request a three-phase 200V power supply and an air pressure source in addition to the single-phase 100V

supply. Details on the supply method will be communicated to each team individually.

3.4 Lighting requirements

Venue lighting will be used. The Competition Committee will not install additional lighting in each team area. Therefore, the brightness and color of the lighting may differ for each team area. Curtains will also be used to block direct sunlight from the venue windows, but the brightness may change depending on whether there is sunlight. Each team may use shades to introduce their lighting, but they must be kept within their team area and not influence other teams. Teams must also take care not to interfere with the referees or other organizers, or block the view from the spectators.

3.5 Network infrastructure

Each team area will be provided with a wired internet connection. However, due to the best-effort delivery system, communication speeds cannot be guaranteed. Additionally, to prevent interference with other teams, the communication bandwidth will be restricted to 64 Mbps. Internet connections will be disabled during competition tasks to prevent remote operation.

Each team's competition system will be connected via a LAN. The use of Wi-Fi or other wireless communication is strictly prohibited. Teams are also not allowed to set up their own internet connection environment.

4 Requirements and restrictions for robots that can be used in competition

4.1 Basic functional requirements

Robots used in the competition must adhere to the health and safety standards set by the Competition Committee, as well as the environmental conservation, security, and disaster prevention regulations established by Japanese law.

4.2 Hardware requirements

4.2.1 Robot requirements

No restrictions are imposed on the number or weight of robots used in the competition; however, it is essential to consider the constraints on available space for robot installation and the floor load capacity of the competition venue. Additionally, the Competition Committee reserves the right to prohibit the use of any equipment deemed unsuitable, including devices generating excessive noise.

4.2.2 Actuator power and number requirements

No restrictions are imposed on the type, number, or output of actuators used in the robot. However, if the Competition Committee judges that problems exist in terms of health and safety, environmental conservation, or security and disaster prevention, then the committee may restrict the use of the robot.

4.2.3 Other peripheral devices to be used

No restrictions are imposed on the computers and peripheral devices to be used, for as long as they do not violate the basic functional requirements detailed in Section 4.1. Moreover, no restrictions are imposed on the cost of the devices to be used.

4.3 Software requirements

No restrictions are imposed on the software to be used in the competition. Local use at the venue is possible, as is the use of cloud computing. However, this competition is a challenge that anticipates automation of production sites, and therefore humans are not expected to remotely operate the robots. Therefore, during the competition, remote operation of the robots is not permitted. This includes direct operation with a joystick or other device, or indirect operation by voice or gestures. Network connection at the competition venue will be disconnected during the competition to block remote operation through the network. The use of external network connection means, such as Wi-Fi, is also not permitted at the venue.

5 Competition method

5.1 Definition of each phase in competition

Each try comprises a Preparation Phase, Operation Phase, Pause Phase, and Reset Phase (Figure 5.1-1). Transitions between phases are made by the team leader's declaration and the referee's approval of the declaration. Each phase is described in detail below.

5.1.1 Preparation Phase

During the Preparation phase, the referee distributes the items to be used in the competition (products, cartons, seals, package cases) to the teams, and the teams check them and set up the necessary items in the System Running Area. A minimum time of 10 min is allocated for the Preparation Phase. Teams will inspect the distributed items and request replacements for any defects identified. However, no competition activities may take place during the Preparation Phase, and teams are only permitted to confirm and set up the mentioned items. Additionally, the referee assesses for any defects in the Operation Area and System Running Area.

5.1.2 Operation Phase

During the Operation Phase, robots and other equipment operate and compete within the

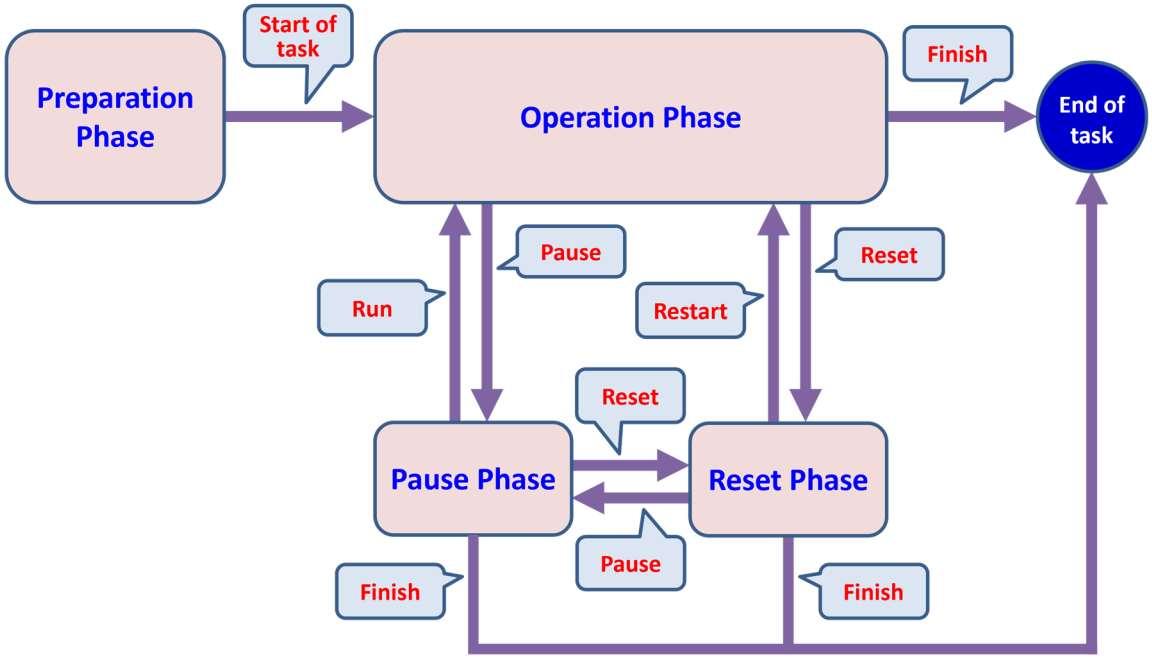


Figure 5.1-1: Transition of competition phases by team leader declaration and approval.

System Running Area. The team leader will declare “Start of task” to the referee once the work in the Preparation Phase is completed, and upon approval, the Preparation Phase will transition to the Operation Phase. If the minimum time for the Preparation Phase has not elapsed, the team will wait until it has. After the declaration is made and approval is received, the team will transition to the Operation Phase.

During the Operation Phase, entry into the System Running Area is prohibited due to the operation of robots and other equipment. As a result, individuals are not permitted to touch the robot, its work environment, items used in the competition, tools, or any other objects in the System Running Area during this phase. Additionally, paper or other obstructive items will be placed on input devices, such as keyboards, to indicate that team members are not allowed to touch them as remote operation is prohibited. It should be noted that there is no specified order for the series of tasks, such as the assembly of cartons, packing of cartons with products, and packing of package cases with set boxes, allowing the robots to complete the tasks in any order.

In the competition, the team must carry in the products for the boxing work and carry out them in the package cases. Additional products such as cartons (folded), seals, and package cases may also be carried in during the Operation Phase if necessary. However, as a general rule, carrying-in and carrying-out during the Operation Phase should be done automatically using a conveyor belt or robot. If carrying-in and carrying-out cannot be conducted automatically, then the team must transition to the Pause Phase as described in Section 5.1.3. If a system, such as a robot, behaves unintentionally during the Operation Phase or fails a competition task, then the team can recover by transitioning to the Reset Phase as described in Section 5.1.4.

A try ends when the specified competition time has elapsed, or the team leader declares “Finish”.

5.1.3 Pause Phase

The Pause Phase is designated for team members to manually carry in and carry out items that were intended to be handled automatically during the Operation Phase. In situations where automatic carrying-in and carrying-out is not achievable during the Operation Phase, the team leader will announce “Pause”. Subsequently, upon approval by the referees, the team will transition from the Operation Phase to the Pause Phase.

During the Pause Phase, once the robot has been confirmed to be in a safe state (Emergency

Stop mode or Manual mode) as outlined in Section 6.3, team members are permitted to open the door that links the Operation Area to the System Running Area (refer to Figure 3.1-1) and manually move finished or semi-finished products to the Operation Area or replenish additional products in the System Running Area. It is imperative that team members solely engage in activities related to the carrying-in and carrying-out of items throughout the Pause Phase.

Upon closing the door, when the team leader announces “Run” and upon the referee's approval, the team will transition from the Pause Phase back to the Operation Phase. However, despite the fact that the competition time will progress upon the commencement of the Pause Phase, this phase must persist for a specific duration (scheduled to be 3 min) to ensure safety preconditions during carrying-in and carrying-out operations. Additionally, when the team leader declares “Finish” after this period has elapsed, then the try will end.

If a robot is interfering with an item to be carried out during the Pause Phase and is unable to remove it, then the team must transition to the Reset Phase by declaring “Reset” as described in Section 5.1.4 even during the Pause Phase to move the robot to a safe position. The transition from the Pause Phase to the Reset Phase may occur before the above-mentioned period (scheduled to be 3 min) has elapsed during the Pause Phase. However, if carrying-in or carrying-out is conducted during the Pause Phase, or if work for carrying-in or carrying-out is conducted, then when the team transitions to the Reset Phase, the items that were the subject of the carrying-in or carrying-out must be returned to the state they were before the transition to the Pause Phase. Additionally, as mentioned above, if the team transitions to the Reset Phase before the fixed period in the Pause Phase has elapsed, then the Reset Phase must continue for a certain period (scheduled to be 3 min) from the transition point, as described in Section 5.1.4.

Furthermore, the team can transition directly from the Reset Phase to the Pause Phase (refer to Section 5.1.4 for details).

5.1.4 Reset Phase

The Reset Phase is the time to recover from situations where a robot or other system has made an unintended action during the Operation Phase or failed at a competition task, or where the robot is interfering with items involved with carrying-in and carrying-out during the Pause Phase. This also includes the time for changing the competition system to handle surprise products on Day 2. If this occurs, then the team leader declares “Reset”, and upon approval by the referees, the

team will transition from the Operation Phase or Pause Phase to the Reset Phase.

When transitioning from the Operation Phase to the Reset Phase, once confirmed that the robot has transitioned to a safe state (Emergency Stop mode or Manual mode) as described in Section 6.3, then team members can open the door leading from the Operation Area to the System Running Area, enter the System Running Area, and recover the robot system or other equipment. Meanwhile, when transitioning from the Pause Phase to the Reset Phase, the team can start the Reset Phase work immediately from the Pause Phase with the door open. In either case, after recovering the system, the team will return the target items of the competition task and robots to their specified initial states and prepare to resume work. Please refer to Section 7.3.6 for details on resetting tasks.

After closing the door, the team leader declares “Restart”, and if approved by the referees, the team will return from the Reset Phase to the Operation Phase. However, when the team transitions to the Reset Phase, the competition time will advance; however, the Reset Phase must continue for a certain period (scheduled for 3 min) to prevent frequent Reset Phases. Additionally, when the team leader declares “Finish” after this period has elapsed, then the try will end.

If a team member wants to manually carry in or carry out items following the completion of the recovery work in the Reset Phase, then the team leader can declare “Pause” after the above-mentioned period (scheduled for 3 min) in the Reset Phase, and if approved by the referees, the team can transition directly from the Reset Phase to the Pause Phase without going through the Operation Phase.

5.2 Method for carrying items into System Running Area

When the Preparation Phase begins, the referees hand over the items to be used in the competition (products packed in container boxes, folded cartons, seals, package cases) to the teams, and the teams confirm that no defects are present in each item. At this time, the teams must not assemble the cartons or rearrange the products packed in the container boxes. If no problems are present in the items, then the teams will place the cartons (in a folded state) and seals anywhere in the System Running Area. During the Preparation Phase, no items other than the folded cartons and seals may be brought into the System Running Area.

During the Operation Phase, when products, package cases, additional cartons (in a folded

state), and seals are to be carried into the System Running Area, then as a general rule, they should be carried in automatically from the Operation Area using a conveyor belt installed from the Operation Area to the System Running Area. However, if a product needs to be manually supplied to a conveyor belt or such in the Operation Area, then that work may be conducted by a worker assigned to each team by the organizers, rather than by a team member. Note that if this task is manually conducted, then the assessment will assume that labor costs have been incurred, as described in Section 7.3.8. The products may be carried in using any of the following methods: (a) in the container boxes provided by the referees in the Preparation Phase; (b) removed from the container boxes; or (c) re-packed in a carrying-in box prepared by the team. However, the removal in (b) and re-packing in (c) may be conducted by workers assigned to each team by the organizers rather than by the team members. Furthermore, in the case of (b) or (c), the assessment will assume that labor costs have been incurred, as described in Section 7.3.8.

Meanwhile, if automatic carrying-in is not possible as described above, then the team will transition to the Pause Phase as described in Section 5.1, and the team members will manually place the products, package cases, additional cartons (folded), and seals anywhere in the System Running Area. However, in this case, the assessment will assume that labor costs have been incurred, as described in Section 7.3.8.

Note that no processing or modification of any of the items to be carried in should be conducted before carrying-in.

5.3 Method for carrying items out of System Running Area

Generally, unnecessary items such as finished or semi-finished products and empty container boxes should be automatically carried out from the System Running Area. This can be achieved through the use of a conveyor belt or a similar mechanism installed between the Operation Area and the System Running Area. If automatic carrying-out is not feasible, then the team will need to transition to the Pause Phase, as outlined in Section 5.1, where team members will manually carry out the items from the System Running Area to the Operation Area. It is important to note that in such cases, labor costs will be incurred, as detailed in Section 7.3.8.

Only products that are removed from the System Running Area within the allotted competition time will be subject to scoring. Additionally, team members may not touch set boxes in the package

cases until the referees have finished scoring.

5.4 Time extension due to problems

If a problem occurs within the team area during the competition, then this will be the responsibility of each team, and the competition time will not be extended. A “problem” refers to a malfunction in communication with the robot. However, the competition may be temporarily suspended at the discretion of the referees. Additionally, if a problem that affects the entire competition occurs, such as a power outage, then the Competition Committee may discuss and approve a time extension.

5.5 Scoring

The referees will score according to the scoring criteria for each competition. Scoring will be based on the assessment of the state of the finished or semi-finished products that are carried out. Please refer to Section 7.3.6 for details on the scoring.

If all the products are completely carried out, then the team will receive a time bonus based on the remaining time, which is determined by taking the time spent on actual work, such as assembling and packing the boxes, and subtracting this from the allotted competition time. The “time spent” here is the total time spent in the Preparation Phase, Operation Phase, Pause Phase, and Reset Phase. Please refer to Section 7.3.7 for details on time bonuses.

Team members may not touch any items, such as products, or operate the robot until the referees have finished scoring and given the team permission.

5.6 Penalties

In this section, we explain what happens if the rules and regulations are violated. If a problem that is not mentioned in this section occurs, then a decision will be made after deliberation by the referees.

5.6.1 Competition withdrawal and suspension

If a participating team withdraws from certain competitions or if the referees determine that the team's performance in the competition is tantamount to a withdrawal, the team may not undergo

a ranking assessment and may also be ineligible for awards. Teams failing to meet health and safety standards or comply with the directives of the health and safety management team will likewise be deemed as having withdrawn from the competition. The health and safety management team is outlined in Section 5.7, while health and safety standards are detailed in Section 6.

5.6.2 Damage to competition venue

Teams should avoid colliding with or damaging items in the competition venue. Teams that cause irreparable damage will be disqualified from the competition. This item applies not only to damage caused by the robot but also to damage caused by competitors.

5.6.3 Interference with other teams

Team areas are adjacent to each other, and therefore, teams should be considerate to not cause problems to adjacent teams. Teams should not only place their belongings outside of the designated space for each team but should also be mindful of noise, radio interference, vibrations, heat, exhaust, odors, lighting, and other environmental factors.

5.6.4 Damage to equipment and prohibited items

If the referees determine that equipment allocated to a team has been damaged and it becomes challenging to proceed with the competition under normal circumstances, deductions will be made according to the guidelines outlined in Section 7.3.8. Items deemed to necessitate replacement will be swapped with spare parts; nonetheless, the replacement of items may be constrained by the limited accessibility of spare parts.

Teams are not permitted to attach markers to items distributed and prepared by the organizers. However, a robot may attach a marker during the competition and remove it by the end of the competition.

5.6.5 Absence

If there are no team members in the team area at the start of the competition, or if the competition is unable to begin, then the team will be considered to have withdrawn from the competition.

5.7 Referees and health and safety management team

At least two referees will be present for each team during the competition. Team members must follow the instructions of the referees. In the WRS Manufacturing Robotics Challenge, the referee group comprises individuals other than the team members, and no referees are planned to be selected from the teams. The referees' decisions are final. However, if a clear mistake is identified, the referees may overturn the decision at the discretion of the Competition Committee chair.

The health and safety management team will conduct safety patrols at any time to identify unsafe acts and safety issues. If necessary, the competition may be paused, and teams may be asked to make improvements. All instructions from the health and safety management team must be followed. During the team setup period, the health and safety management team will conduct an inspection to ensure compliance with safety standards.

6 Health and safety

This competition will be run with health and safety as the top priority. Rules regarding health and safety are established under the health and safety management policy. Any inconsistencies with the policy will be corrected immediately.

6.1 Health and safety management policy

6.1.1 Compliance standards

The competition will comply with international standards, such as ISO12100 (JIS B 9700), ISO10218-1, -2, and higher-level international standards. The durability and reliability of the system for safety measures is acceptable if it can continue to function for more than the duration of the competition.

6.1.2 Safety based on principle of separation and functional safety

Each area of the competition is defined as follows. Based on this definition, safety will be maintained by separating the areas. Intrinsic safety and functional safety will be maintained through appropriate risk assessment.

Spectator Area: Designated as a general living area, similar to an urban environment, this space

is separated from team areas by partitions or safety fences. These barriers help prevent unauthorized entry by team members, spectators, and competition staff (including the Competition Committee and organizing staff) while also containing any objects within the team area.

Team Area (Operation Area): Designed to resemble a factory environment, this area is restricted to personnel with a certain level of expertise.

Team Area (System Running Area): A high-risk zone enclosed by safety fences. Participating teams must assess potential hazards and implement appropriate safety measures.

6.1.3 Obligation to comply with health and safety rules

All participants have a responsibility to ensure each other's health and safety. Participating teams must strictly follow the health and safety regulations set by the Competition Committee. Spectators are expected to cooperate with competition staff by staying out of restricted areas and being aware of potential hazards during the event.

Failure to comply with health and safety regulations or engaging in actions that put others at risk may result in appropriate measures being taken. These measures may include issuing warnings, requiring compliance with safety rules, or, in severe cases, canceling the competition or disqualifying the participant.

6.1.4 Operation of health and safety management team

A health and safety management team will be established to oversee compliance. Members of this team will review submitted documents, conduct pre-competition safety inspections at the venue, and perform safety patrols during the event to identify unsafe actions, conditions, systems, and areas.

If necessary, they may suspend the competition until improvements are made and instruct teams to stop work or face disqualification. All teams are required to follow the instructions of the health and safety management team.

6.1.5 Operation of health and safety advisory organization

An advisory organization will be established to provide guidance on health and safety measures

before the competition. Participating teams may consult this organization for advice on safety measures and the required documents outlined below as needed.

6.2 Health and safety rules

6.2.1 Robot system safety requirement specification

Robot systems must comply with all requirements outlined in the "Robot System Safety Requirement Specification for Ensuring Safety at Competitions, Exhibitions, etc." published by the Robot System Safety Subcommittee of the Institute of Global Safety Promotion. This specification is provided in **Appendix A** of this document. For hardware requirements, please refer to **Section 4.2**.

Additionally, participants' competition systems must be integrated with the venue's **emergency stop button, safety fence door switch, and signal lights**. Detailed connection instructions will be provided to each team separately.

6.2.2 Safety-related pre-submissions

Each team must submit a **risk assessment sheet**, which includes **risk reduction measures based on the assessment results** and a **list of residual risks** (see **Appendix B**). This document is part of the **pre-submissions** outlined in **Section 9**. Required materials are subject to change.

6.2.3 Venue preparation before the start of the competition

Safety circuits will be supplied to teams via connectors. Teams must set up their competition systems exclusively within the safety fence (the System Running Area) and ensure they are connected to the safety circuit. However, computers and controllers with fixed housings may be placed in the Operation Area. All equipment must stay within the designated team area, regardless of its placement.

The safety circuit will include a safety fence door switch, emergency stop button, signal light, and connection connector (electrical contact). Detailed specifications for the safety circuit will be provided separately.

6.2.4 Obligation to pass pre-competition inspection at the venue

The health and safety management team will conduct an individual inspection of each team's health and safety system upon request. This inspection is expected to take place on the final day of the setup period.

Teams that fail to meet the required standards will be asked to make the necessary improvements. Participation in the competition will only be permitted once the team successfully passes the inspection.

6.2.5 Conducting safety patrols at the venue

Health and safety patrols will be conducted as needed or on an ongoing basis. Corrective actions will be recommended for any identified health and safety concerns.

Issues that may be flagged include: the discovery of undeclared items during inspection, competition systems with safety-related problems, failure to use required protective equipment, non-functional safety devices, live electrical work, team members running within their designated areas, other hazardous behaviors, or exceeding the permitted number of participants.

Depending on the situation, measures such as halting the competition, issuing a suspension order to the team, or disqualifying the team may be enforced.

6.3 Operation mode

6.3.1 Mode definition

Operating the system safely requires the robot and robot system to have the modes shown below, and the current mode of the competition system must be known by a third party. Therefore, the signal light provided by the venue needs to be used.

6.3.2 Mode implementation

Automatic/manual high-speed mode　Signal light is green　Always on

State where the team's competition system is being operated automatically by a program. Alternatively, state where the system is being operated in manual high-speed mode to check the operation of the entire program at actual speed in manual mode. None of the participants

are allowed to enter within the safety fence. If the door switch of the safety fence is opened, then the system must be stopped immediately. When entering the safety fence (door switch is open), a mode will be set up in which a protective stop will be activated based on the risk assessment and operation, and this will be displayed. The definitions of each mode are shown below.

Manual mode　Signal light is yellow　Always on

State where the team's competition system is operating in manual mode for adjustments or other purposes. Even when the door switch is open, team members can enter within the safety fence (however, safety must be ensured through risk assessment. Pay attention to working posture, hot and sharp points, no running, etc.).

Emergency stop mode　Signal light is red　Always on

State where the team's competition system is completely stopped. State where the competition system is powered by electricity. Even when the door switch is open, team members can enter within the safety fence (however, safety must be ensured through risk assessment. Pay attention to working posture, hot and sharp points, no running, etc.).

7 Task description

7.1 Task overview

The competition tasks standardize the process of packing a variety of everyday items into boxes. The work is relatively simple, but the entire system needs to be quick, flexible, and economical.

The objective of the competition task is to pack bottles of daily necessities into cartons, pack the cartons into package cases, and ship them. This requires conducting the following automatically:

- Assemble folded cartons
- Place bottles into cartons
- Close carton lids
- Apply seals to carton lids

- Place cartons in package cases
- Carry out package cases

On Day 1, participants must pack multiple bottles (Figure 7.1-1) of normal products into cartons (Figure 7.1-2) to create set boxes, and subsequently pack multiple set boxes into a package case to ship them. Multiple package cases must be created and shipped. On Day 2, participants must create and ship surprise package cases in addition to the above-mentioned normal package cases. Specifically, participants must pack normal product bottles and surprise product bottles (products and number of bottles will be disclosed at a later date) into surprise cartons to create set boxes, and then pack multiple surprise set boxes into the surprise package case to ship them.

Figure 7.1-1: Normal products used in competition (planned).

Figure 7.1-2: Carton filled with workpieces for normal products. (Details to be announced at a later date)

7.2 Economic assessment

7.2.1 Concept of economic assessment

The cost of the developed robot system must not be overlooked in the context of social implementation. It is essential to consider not only the manufacturing cost but also the development, operation, and maintenance costs, as well as disposal expenses. Within this competition, the amalgamation of development, manufacturing, and certain operation costs are collectively termed as the total cost, which is an evaluation criterion at the end of the competition. This criterion has been incorporated as one of the scoring elements. The Competition Committee acknowledges the challenges associated with cost evaluation and is striving to ensure a fair and equitable assessment process to maintain the competitiveness of the competition. We anticipate the collaboration of all participants in this endeavor. The materials utilized for total cost assessment are detailed in the cost estimate table provided in the pre-submission.

7.2.2 Pre-submission cost estimate table

The items included in the cost estimate table (Table 7.2-1) are explained as follows.

First, in the cost estimate table, the cost of the robot and the labor costs spent on building the system are assessed according to the following criteria. The cost of the robot used is calculated as

Table 7.2-1: Items and units in cost estimate table.

Total number of axes used in robots		Number of axes used for single-arm robots (unit: number of axes) Number of axes for dual-arm robots (unit: number of axes)
Robot-related device costs (mainly goods costs)	Includes robot hands, stands, controllers, such as PLCs, cameras, etc.	(Unit: JPY)
Robot peripheral device costs (mainly goods costs)	Includes jig creation costs, safety-related costs, workpiece carrying-in/carrying-out equipment, software purchases, etc.	(Unit: JPY)
System construction-related costs (mainly labor costs)	Design costs (process analysis, planning, concept, design) Manufacturing, assembly Teaching, program development On-site installation and adjustment costs (enter number of people and time) Verification work (enter number of people and time)	(Unit: number of people × number of hours worked H)
Other	Enter item and amount if there are other costs	(Unit: JPY)

the number of axes × 500,000 JPY (provisional amount). Devices that combine three or more axes are defined as a robot. Single-axis devices are not counted as robots as described above. The cost can be recorded as a normal peripheral device. For dual-arm robots, the cost per axis is reduced by 20% (provisional amount) in the cost calculation. The axis definition only applies to the degrees of freedom that are directly related to the manipulation of the workpiece. For example, a drive unit equipped with only a sensor is not included in the robot's cost. This is recorded as the cost of a peripheral device. Labor costs are not counted as the wages paid to workers, but as the number of people involved in building the system * the number of hours worked to achieve the goal of this

competition.

Appendix C shows a sample cost estimate table. It is required to compute the cost for each item listed in Table 7.2-1 and input the values in JPY, excluding the expenses related to the robot and labor. The specific rate to be utilized will be communicated to the teams at a later date.

The cost of creating documents associated with participation in the competition, including pre-submissions, is considered to be the same for all competitors, and thus does not need to be added to the costs. Transportation costs to the venue also depend on the distance to the venue, and therefore, they will not be included in the cost estimate table for fairness.

7.2.3 Inspection of pre-submitted cost estimate table at competition venue

The cost estimate table submitted by each participant in advance will be assessed for validity by two assessors on the last day of the foundation work and setup period immediately before the competition for participants who have passed the safety inspection. If any doubts exist about the estimated cost as a result of the assessment, then the cost will be revised by consensus, including one new referee, and the result will be notified to the competitors. Competitors will not be allowed to appeal or propose revisions regarding this result. During this validity assessment, competitors may submit estimates and delivery notes for the equipment they used in advance to the assessment committee members to assert the validity of the costs.

7.3 Task details

7.3.1 Competition schedule

First, the schedule for the entire competition is shown below.

The first day of the competition (Day 1) is a try where the team packs normal products that have been announced in advance. A rehearsal will be held in the morning, and the actual try will occur in the afternoon of the same day. The second day of the competition (Day 2) is a try where the team will not only pack normal products but also try packing surprise products that are different from the normal products. Each team will have two tries on Day 2.

The time schedule for each day is shown below.

- Day 1, morning: Rehearsal. Competition time is 30 min (scheduled).

- Day 1, afternoon: Competition time is 30 min (scheduled).
- Day 2: Each team will have two tries. Competition time is 30 min each (scheduled).

The competition time refers to the time from the start of the Preparation Phase to the deadline for the end of the try. However, items to be used in the competition will be distributed a certain period before the Preparation Phase (the certain period is scheduled to be approximately 5 min), and therefore each team must receive these items. An assessment time (scheduled to be 10 min) for scoring by referees will also be established after the end of the competition time.

7.3.2 Competition time flow

When a try begins, a team first works in the Preparation Phase. Next, the team transitions to the Operation Phase after the team leader makes a declaration and an approval is given by the referees, and the competition task is started. If needed during the Operation Phase, then the team transitions to the Pause Phase or Reset Phase to perform necessary tasks after the team leader makes a declaration and approval is given by the referees. When the try ends after the end of the competition time or after the declaration by the team leader has been made, then the referee records the end time and conducts scoring. Please refer to Section 5.1 for details on each phase of the competition, and Section 7.3.6 for details on scoring.

7.3.3 Task element definition

The competition tasks may be conducted in any order, but the finished level of the assembled product will be assessed for each task element. The task elements are defined below. Please refer to the list of items in Appendix D for the relevant item numbers. Please refer to Appendix E for details on the completion requirements for each task element.

- Task element A – Assemble the folded carton.
  - Relevant item numbers: 1 (for normal task), 2 (for surprise task)
  - Work completion requirements: In both normal and surprise tasks, the bottom of the carton must be lined up.
- Task element B – Pack the carton with products (bottles).
  - Relevant item numbers: 1, 3 (for normal task), 2, 3, 4 (for surprise task)

- Work completion requirements: For the normal task, the specified number of normal products must all be packed in the carton in the correct vertical direction and without protruding from the carton. For the surprise task, the specified number of normal products and surprise products must all be packed in the carton in the correct vertical direction and without protruding from the carton.

- Task element C – Close carton lid.
  - Relevant item numbers: 1 (for normal task), 2 (for surprise task)
  - Work completion requirements: For both normal and surprise tasks, the lid of the assembled carton must be closed.

- Task element D – Affix seal to carton lid.
  - Relevant item numbers: 1, 5 (for normal task), 2, 5 (for surprise task)
  - Work completion requirements: For both normal and surprise tasks, the lid of the assembled carton must have the seal affixed such that the lid does not open.

- Task element E – Pack package case with cartons.
  - Relevant item numbers: 1, 6 (for normal task), 2, 7 (for surprise task)
  - Work completion requirements: For both normal and surprise tasks, the specified number of assembled cartons must be packed in the correct vertical and front-to-back orientation, and not protrude from the package case.

- Task element F – Carry out package case.
  - Relevant item numbers: 6 (for normal task), 7 (for surprise task)
  - Work completion requirements: For both normal and surprise tasks, the package case must be removed from the System Running Area and placed in the Operation Area.

Note that the referees will randomly check whether the products (bottles) or cartons are in the correct orientation in task elements B and E.

7.3.4 Surprise products

Information about surprise products, cartons, and package cases used in the surprise competition (such as approximate shape and range of dimensions) will be made public in advance such that teams have sufficient time to prepare hands and other necessary equipment for handling these items.

7.3.5 Resetting competition tasks and initial state of each task element

When the team leader declares “Reset” and approval is given, the currently executed task element must be returned to the specified initial state described below. If multiple task elements are being executed simultaneously, then the team must select at least one task element to be returned to its initial state. If the team wishes, then it may reset multiple task elements that are being executed. This rule also applies when multiple robots are executing multiple task elements simultaneously, or when the same task element is executed simultaneously for multiple products, cartons, package cases, or other items.

The initial state when resetting each task element is as follows, regardless of whether it is a normal task or surprise task.

- Initial state of task element A
  - State where the carton to be reset is folded, and its supply position matches, or approximately matches, the position at an arbitrary time before the “Reset” declaration.
- Initial state of task element B
  - State where all target products (normal products and surprise products) in the task element to be reset have been taken out of the target carton of the task element, and their supply positions match, or approximately match, the positions at an arbitrary time before the “Reset” declaration.
- Initial state of task element C
  - State where the lid of the carton to be reset is open.
- Initial state of task element D

- State where the seal is not affixed to the flap of the carton that was reset, or the seal that was once affixed has been peeled off.

- Initial state of task element E
  - State where all target cartons in the task element that has been reset have been removed from the target package case of the task element, and their positions match, or approximately match, the positions at an arbitrary time before the “Reset” declaration.

- Initial state of task element F
  - State where the target package case of the task element that was reset is in the System Running Area, and their positions match, or approximately match, the positions at an arbitrary time before the “Reset” declaration.

When resetting task element D, if a seal is already affixed, then a team member must peel it off. However, any traces of the seal that were removed are subject to point deductions, as described in Section 7.3.8, and therefore, starting over from task element A to avoid point deductions is acceptable. However, in this case, the carton must be replaced with a new one.

7.3.6 Scoring

Scoring will be conducted for the items that are carried out into the Operation Area by the specified time. Note that the values used in the following score calculations may change to adjust the balance of the competition.

Table 7.3-1 shows the scores for normal product cartons. For example, if one carton is finished and carried out, then the score is $1+5\times3+8+16 = 40$ points.

Table 7.3-1: Point Table for Normal Task Cartons.

Elementary Operation	Points
Assemble carton (task element A)	1 (per carton)
Put bottles into cartons (task element B)	5 (per bottle)
Up until carton lid is closed (task element C)	8 (per carton)
Up until seal is affixed on carton (task element D)	16 (per carton)

The criteria for scoring are as follows. These are assessed after carrying-out, and therefore, merely satisfying these requirements temporarily during the competition will not award the team points.

- Assemble the folded carton (task element A): The carton is completely unfolded. This is determined by the judging line printed at the bottom of the carton.
- Put bottles into cartons (task element B): All of the following requirements must be satisfied.
  - The carton is assembled (task element A requirement is satisfied).
  - The bottles are placed in the carton without protruding.
- Carton lid is closed (task element C): All of the following requirements must be satisfied.
  - All the specified number of bottles are in the carton (task element B requirement is satisfied for all bottles).
  - The lid is completely closed. This requires that the judging line printed on the lid insertion part cannot be observed from the outside.
- Affix a seal to carton (task element D): All of the following requirements must be satisfied.
  - The carton lid is closed (task element C requirement is satisfied).
  - A seal is affixed along ridge where carton lid is inserted.
  - A seal is glued across the lid and sides of the cartons.

Furthermore, when a package case is inserted in the carton, your points will increase based on Table 7.3-2. For example, if you place two completed cartons (set boxes) in one package case, you will get (40+40) × 2 × 2.5 = 400 points.

Table 7.3-2: Increased point table for package cases.

Package Case Operations	Score
Put carton into package case	Double the points of carton
Put all cartons into package case (task element E)	2.5 times points for all cartons in applicable package case (5 times when combined with above)
All cartons placed in all package cases	Time bonus (7.3.7) added

The criteria for obtaining points are as follows.

- Place carton into package case: Some part of the bottom of the carton (including the periphery of the bottom) is in contact with the bottom of the package case.
- Place all cartons into package case (task element E): The specified number of cartons are placed in the package case (all cartons meet the aforementioned requirements).
- Place all cartons into all package cases: All the following requirements are satisfied.
  - All cartons are placed in all package cases (all package cases meet the conditions of task element E)
  - All package cases are carried out within the competition time.
  - No manual carrying-out during the Pause Phase is conducted.

On Day 2, not only cartons for normal products but also cartons for sets containing surprise products are used. Table 7.3-3 shows the scores for this. As an example, let us assume that the surprise carton contains one bottle of the surprise product. In this case, completing and carrying out one surprise set box will earn $6+10\times1+40\times1+48+96 = 200$ points. Additionally, if two surprise set boxes are placed in a surprise package case and carried out, then the score will be $(200+200) \times 2 \times 2.5 = 2000$ points.

Table 7.3-3: Scoring table for surprise task cartons.

Elementary Operation	Points
Unfold carton (task element A)	6 (per carton)
Place bottles (normal products) into cartons (task element B)	10 (per bottle)
Put bottles (surprise products) into the carton (task element B)	40 (per bottle)
Close carton lid (task element C)	48 (per carton)
Affix seal on carton (task element D)	96 (per carton)

7.3.7 Time bonus

The time bonus is calculated using the following equation (rounded down).

$$\left(\frac{\text{Remaining time}}{\text{Time spent} - \text{Minimum time for Preparation Phase}}\right)$$
$$\times \text{ Points when all the specified number of package cases are completed and carried out}$$

Please refer to Section 5.5 for definitions of "remaining time" and "time spent", and Section 5.1.1 for "minimum time for Preparation Phase". On Day 1, the points for completing and carrying out all the required number of package cases will be 1,200 points. For example, if the carrying-out of all the package cases is completed with 5 min remaining, and the time spent is 25 min, and the minimum time for the Preparation Phase is 10 min, the score will be:

$$\frac{5}{25 - 10} \times 1200 = 400 \text{ pts.}$$

Note that on Day 2, the points for completing and carrying out all the required number of package cases will be different from those on Day 1.

7.3.8 Penalties

If there are problems with the carried-out product or the team's behavior, points will be deducted as a penalty.

- Product quality problems: Damage to the product, carton, or package case during the competition (including unnecessary seals or traces of a peeled-off seal), or intentional rough handling of the product will result in a 10% deduction from the package case's score. If the product is delivered in a carton instead of a package case, a 10% deduction will be applied to the carton's score. Additionally, if a time bonus is in place, a 10% deduction will also be implemented.

- Manual work: If manual carrying-in and carrying-out are conducted due to a pause, then points will be deducted as operational costs under the overall assessment described below.

- If there are changes made to the bottles, cartons, package cases, and seals from their original distribution and supply method, it will be assumed that one worker was needed for each operation, and labor costs will be deducted as operational costs. An exception to this rule is if the seals are supplied in a partially or fully peeled state from the backing, in which case

they will not be considered operational costs, and instead, 300,000 JPY equivalent to the label peeling machine will be added to the development and manufacturing costs.

- Unsafe behavior: If a team is found to have engaged in unsafe behavior during the competition, the Competition Committee will deduct up to 50% of the points that would have been awarded if the team had completed and carried out all the required number of package cases.
- Misconduct: If a team is found to have engaged in misconduct, the Competition Committee will deduct points, potentially resulting in the loss of all points, at the committee's discretion.

7.3.9 Overall assessment

The overall assessment for each try is based on the following equation to assess the system's agility and leanness as well as its economic feasibility:

$$B = P' - R' - Q'$$

$$P' = \text{Score}$$

$$R' = \text{Conversion factor} \times \text{Standard hourly wage} \times \left(\frac{\text{Total suspension time due to pause [seconds]}}{60 \times 60} + \text{Number of workers required for operation} \times \frac{\text{Standard actual competition time [minutes]}}{60}\right)$$: Operational costs (labor costs) (rounded down)

$$Q' = \text{Conversion factor} \times \max(\text{Development and manufacturing costs [JPY]} - \text{Standard costs},\ 0) \times \frac{\text{Standard actual competition time [minutes]}}{\text{Expected total operation time [minutes]}}$$: Development and manufacturing costs include development and manufacturing-related labor costs (Section 7.2). The conversion of foreign currencies to JPY uses the rate set by the Competition Committee (rounded down).

Expected total operation time: 900,000 min (20 h × 250 days × 3 years) (provisional amount), Standard actual competition time: 20 min (scheduled), Standard hourly wage: 2,000 JPY (provisional amount), Standard costs: 30,000,000 JPY (provisional amount), Conversion factor: 4 (provisional amount)

For example, if the score is 2,400 points, total suspension time due to the pause is 0 min, the total number of workers required for operation is one person, and development and manufacturing costs are 35,000,000 JPY, then:

$$P' = 2400, R' = 4 \times 5{,}000{,}000 \times \frac{20}{900000} = 444, Q' = 4 \times 2{,}000 \times \left(\frac{0 \times 60}{60 \times 60} + 1 \times \frac{20}{60}\right) = 2666$$

$$B = 2400 - 444 - 2666 = -710$$

Furthermore, if the score is 480 points, the total suspension time due to the pause is 3 min, the total number of workers required for operation is 0 people, and development and manufacturing costs are 28,000,000 JPY, then:

$$P' = 480, R' = 4 \times 0 \times \frac{20}{900000} = 0, Q' = 4 \times 2{,}000 \times \left(\frac{3 \times 60}{60 \times 60} + 0 \times \frac{20}{60}\right) = 400$$

$$B = 480 - 0 - 400 = 80$$

The overall score for the entire schedule will be the sum of the overall assessments for Days 1 and 2 for each trial. However, if multiple tries are conducted on the same day, then the best assessment will be used for the total.

8 Preliminary document screening

The documents shown in Table 8.1-1 must be submitted by the document screening deadline (scheduled for the end of April 2025, submission methods will be notified separately). This document will be used by the WRS Manufacturing Robotics Challenge Competition Committee to determine whether or not applicants who have entered the competition can participate.

9 Pre-submission

Pre-participating teams must submit the documents indicated in Table 9.1-1 by the pre-submission deadline (expected to be two weeks before the competition. The exact date and time will be notified after confirmation of participation), as well as the contents of Table 8.1-1 updated to the situation as of the deadline. This document will be utilized for scoring the competition.

Table 8.1-1: List of submissions at time of document screening.

Submissions at time of document screening	Expected content
Definition of automation requirements	1. Overview of automation system Name of automation system: ＊＊＊＊＊＊ Objectives and goals of automation: ＊＊＊＊＊ 2. Anticipated process to be automated 3. Description of anticipated robot operation 4. Required operating environment (power supply, air supply, etc.)
Prerequisites for automation system	List of prerequisites when considering the aforementioned system
Layout concept for automation system	Conceptual diagram of automation system to be produced at the time of submission. This diagram is expected to depict the equipment that constitutes the system, locations for inserting and removing workpieces, positioning of the robots, power and air supply points (if applicable), and the external signal line connection points.
System construction status	Video of actual machine putting samples into boxes, or simulation video in its place

Table 9.1-1: Pre-submissions.

Pre-submission	Expected content
System specifications	Please describe the operating environment required for using the system, such as the installation area, power supply, and air piping required by the automation system.
System cost estimate table	(Refer to Section 7.2.2 and Appendix C)
Risk assessment table	(Refer to Section 6.2.2 and Appendix B)
Team introduction video	Details will be provided separately.

Appendix

Appendix A: “Safety Requirements Specification for Robot Systems in Competitions, Exhibitions, and Similar Events” by the Robot System Safety Committee of the Institute of Global Safety Promotion

Appendix B: Risk assessment sheet

Appendix C: Sample cost estimation table

Appendix D: Item list for the item number

Appendix E: Details of completion requirements for each task element

English translated version of Ver.1.0.2

Safety Requirements Specification for Robot Systems in Competitions, Exhibitions, and Similar Events

The Institute of Global Safety Promotion

Robot System Safety Committee

Introduction

This safety requirements specification is intended to ensure the safety of workers and third parties, such as spectators, when constructing robot systems for temporary or short-term use in exhibitions, competitions, and similar events. For long-term use, a risk assessment must be conducted, and appropriate protective measures must be implemented with reference to relevant standards. Additionally, any rules provided by the event organizers must be followed.

Safety Requirements Specification

NO	Items	Safety Requirements Specification
1	**Risk Assessment**	A risk assessment must be conducted during the specification determination stage (or design stage) to reduce risks to an acceptable level. Additionally, the risk assessment sheet must be submitted to the event organizer. **Note**: An acceptable risk level is defined as evaluating the risk by considering the severity of harm and the probability of occurrence of hazardous events. Risk reduction measures must be implemented for unacceptable events. **Reference Standards**: ISO 12100 (JIS B 9700), ISO 10218-1, -2 (JIS B 8433-1, -2)
2	**Restricted Space**	Fences or enclosures must be installed around the robot system, ensuring sufficient gaps between the end effector and the fence or enclosure to prevent people from being trapped. **Note 1**: Ensure sufficient space for non-routine tasks such as teaching and maintenance work within the fence or enclosure. **Note 2**: A gap of at least 500 mm must be provided between the fence or enclosure and the robot's restricted space to avoid the hazard of crushing the human body. **Note 3**: When performing operation checks in manual high-speed mode, do so from outside the fence or enclosure. **Reference Standards**: ISO 10218-2 (JIS B 8433-2), ISO 13854 (JIS B 9711), ISO 13857 (JIS B 9718)

3	**Limitations on Force, Energy, and Pressure**	When constructing a robot system without fences or enclosures, a risk assessment must be conducted. Adequate safety measures must be implemented to mitigate impacts between the robot arm and the human body, as well as entrapment and puncture hazards involving the end effector. The system must be used at an acceptable risk level. **Note 1**: Measures such as pausing the robot before approaching its restricted space or stopping the robot upon contact with a moving robot arm or end effector should be applied. **Note 2**: The robot's output should be limited so that the thrust force on parts of the body other than the head or neck does not exceed 28 N, and the surface pressure does not exceed 22 N/cm². **Reference Standards**: ISO 10218-1 (JIS B 8433-1), ISO/TS 15066 (JIS TS B 0033), ISO/WD TR 21260 If you have more text or specific sections you'd like translated, feel free to share them! I'm here to help.
4	**Sharp Edges and Corners of Enclosures**	Sharp edges must be removed and shaped so they do not cause pain upon contact. (Verification method: Touch with thin rubber gloves without causing holes. Use corner cushions on corners.) **Note 1**: Ensure sufficient space for non-routine tasks such as teaching and maintenance work within the fence or enclosure. **Note 2**: A gap of at least 500 mm must be provided between the fence or enclosure and the robot's restricted space to avoid the hazard of crushing the human body. **Note 3**: When performing operation checks in manual high-speed mode, do so from outside the fence or enclosure. **Reference Standards**: ISO 10218-2 (JIS B 8433-2), ISO 13854 (JIS B 9711), ISO 13857 (JIS B 9718) If you have more text or specific sections you'd like translated, feel free to share them! I'm here to help.
5	**Voltage**	When using AC 25V or DC 60V and above, the equipment must be housed in an enclosure with a rating of IP2x or IPxxB, locked, or designed to cut off power when the door is

		opened. Alternatively, terminal covers or other obstacles must be installed on live parts. **Note**: Lower voltages prevent large currents from flowing, thereby preventing electric shock (PELV voltage). **Reference Standards**: IEC 60204-1 (JIS B 9960-1) If you have more text or specific sections you'd like translated, feel free to share them! I'm here to help.
6	**Grounding**	Appropriate equipotential bonding (grounding) must be performed to prevent electric leakage. All protective conductors, exposed conductive parts of conductive structural components, and conductive structural parts of machinery must be interconnected. **Note**: To prevent electric shock from contact with metal surfaces (exposed conductive parts) that become live due to insulation failure (leakage), consider using Class II equipment or implementing measures to automatically cut off power with a leakage circuit breaker in case of insulation failure. **Reference Standards**: IEC 60204-1 (JIS B 9960-1) If you have more text or specific sections you'd like translated, feel free to share them! I'm here to help.
7	**Heat**	The surface temperature of parts that people may touch should not exceed 43 degree Celsius to prevent burns. If the surface temperature of the equipment exceeds 43 degree Celsius protective measures must be implemented to prevent burns, and a high-temperature warning label should be affixed. **Note**: There is a risk of low-temperature burns if the surface temperature of contact parts is 43 degree Celsius for 8 hours or 48 degree Celsius for more than 10 minutes. **Reference Standards**: ISO 13732-1 If you have more text or specific sections you'd like translated, feel free to share them! I'm here to help.
8	**Noise**	Follow the instructions from the event organizer or the venue regarding noise levels. If no instructions are provided, take measures to suppress the sound pressure emitted by the

		system (e.g., using protective equipment or guards). **Note**: The A-weighted emission sound pressure level should not exceed 70 dB(A), and the A-weighted sound pressure level should not exceed 80 dB(A) (EU Machinery Directive). **Reference Standards**: JIS C 1502 If you have more text or specific sections you'd like translated, feel free to share them! I'm here to help.
9	**Laser Light**	Laser equipment used in exhibitions and competitions should be limited to Class 1, Class 2, Class 3M, and Class 3R visible light. For Class 2 and above, precautions must be taken to ensure that people do not continuously look directly at the laser. **Note**: Class 2 and above laser light poses a risk of blindness if continuously viewed. Therefore, do not direct it at people, or implement safety measures using protective equipment. **Reference Standards**: JIS C 6802
10	**Door Interlock**	Use equipment with a direct opening action mechanism for door interlock switches. If a sufficient safety distance between the hazardous area and the robot system cannot be ensured, use a locking interlock. **Note**: Using an interlock with a direct opening action mechanism can avoid dangerous failures such as contact welding. **Reference Standards**: ISO 14119 (JIS B 9710)
11	**Light Curtain**	When using a light curtain for intrusion detection in automatic mode, Type IV hand or finger types must be used. **Note**: Using a Type IV light curtain with automatic monitoring functions and safety outputs can avoid dangerous failures. **Reference Standards**: IEC 61496 (JIS B 9704) If you have more text or specific sections you'd like translated, feel free to share them! I'm here to help.
12	**Emergency Stop**	When the emergency stop device is activated, the entire robot system must be stopped.

		Note: To completely stop the system, it must either cut off the power source immediately (Stop Category 0) or cut off the power source after the system has stopped (Stop Category 1). **Reference Standards**: ISO 13850 (JIS B 9703) If you have more text or specific sections you'd like translated, feel free to share them! I'm here to help.
13	**Protective Stop**	Distinguish between the emergency stop function and the protective stop function in the robot system according to their respective uses. When using the protective stop function in Stop Category 2, ensure that the stop monitoring function is operational (use of SOS in IEC 61800-5-2). **Note**: The use of the protective stop function in Stop Category 2 must always comply with the rules of the event organizer. **Reference Standards**: ISO 10218-1, -2 (JIS B 8433-1, -2) If you have more text or specific sections you'd like translated, feel free to share them! I'm here to help.
14	**Teaching Operations**	Use a teaching pendant equipped with an enabling device and operate at a speed of 250 mm/s or less. When using manual high-speed mode solely for program verification, initially limit the speed to 250 mm/s or less and gradually increase the speed. **Note**: The use of manual high-speed mode must comply with the rules of the event organizer. Additionally, perform operations from outside the safety fence or enclosure. **Reference Standards**: ISO 10218-1, -2 (JIS B 8433-1, -2) If you have more text or specific sections you'd like translated, feel free to share them! I'm here to help.
15	**Mode Switching**	Install a switch to toggle between automatic and manual modes in the robot system. When performing non-routine tasks such as maintenance, inspection, or setup within hazardous areas, turn off the power and switch to manual mode for test operations. In this case, operate at low speed, low drive, and in incremental steps. **Note**: Always switch modes to prevent accidental startup and

		ensure safety when performing test runs within the fence or enclosure during teaching or maintenance tasks. **Reference Standards**: ISO 12100 (JIS B 9700), ISO 14118 (JIS B 9714) If you have more text or specific sections you'd like translated, feel free to share them! I'm here to help.
16	**Partial Cover**	Install enclosure guards on hazardous moving parts to prevent fingers from entering. **Note**: The most common accidents in mechanical systems are entrapment and entanglement. Therefore, especially ensure guards are installed on exposed drive parts. **Reference Standards**: ISO 14120 (JIS B 9716) If you have more text or specific sections you'd like translated, feel free to share them! I'm here to help.
17	**Handling Heavy Objects**	When manually moving heavy objects, assign appropriate personnel and conduct a pre-task meeting to discuss the work details. Use lifting equipment or other transport tools appropriately. **Note**: This is to prevent accidents during loading and unloading.
18	**Work Space**	Ensure sufficient work space within hazardous areas to perform tasks safely. Specifically, maintain a gap of at least 500 mm between the robot end effector's restricted space and the fence or enclosure. If this is not possible, implement measures to prevent entry. **Note**: Mark the work area and restricted entry area with lines or other identifiers to distinguish them clearly. **Reference Standards**: ISO 13854 (JIS B 9711), ISO 13849-1, -2 (JIS B 8433-1, -2) If you have more text or specific sections you'd like translated, feel free to share them! I'm here to help.
19	**Indicator Lights**	The colors of the indicator lights should be as follows: • **Automatic/High-Speed Mode**: Green • **Manual Mode**: Yellow • **Emergency Stop**: Red

		Note: The indicators must be identifiable not only by workers but also by third parties. Additionally, follow any rules provided by the event organizers. **Reference Standards**: IEC 60204-1 (JIS B 9960-1) If you have more text or specific sections you'd like translated, feel free to share them! I'm here to help.
20	**Protective Equipment and Clothing During Work**	To prevent accidents and reduce the severity of injuries during work: • **Hair**: Long hair must be tied back. • **Work Clothes**: Wear long sleeves and long pants that are not loose-fitting. • **Helmet**: Wear an appropriate type of helmet to reduce head injuries. • **Protective Glasses**: Always protect your eyes. Wear suitable protective glasses to shield your eyes from light, debris, and hazardous materials. • **Protective Gloves**: Wear appropriate types of gloves to protect against static electricity and cuts from various materials. However, gloves must not be worn when using rotating tools due to the risk of entanglement. • **Earplugs**: Wear suitable earplugs to protect hearing when exposed to impact noise or other loud sounds. • **Safety Shoes**: Always protect your feet. Wear appropriate types of shoes as needed. Additionally, the necessity of using protective equipment should be considered based on the residual risks after applying technical risk reduction measures.
21	**Control Circuit**	The emergency stop device must directly stop the load. Safety circuits for protective devices such as interlocks must be appropriately designed based on the results of risk assessments. **Note**: To prevent unintended activation, it is desirable to separate safety-related parts from non-safety-related parts, and connect protective devices to the safety-related parts. Additionally, if the risk assessment indicates a high risk, the control circuit should be Category 3, PL=d.

		Reference Standards: ISO 10218-1, -2 (JIS B 8433-1, -2), ISO 13949-1 (JIS B 9705-1)

References

Safety Standards for Laser Products According to JIS C 6802

The **JIS C 6802** standard outlines the safety requirements for laser products, ensuring their safe use and handling. This standard is based on the **IEC 60825-1**

Weight Restrictions under Japan's Labor Standards Act

Weight Restrictions for Minors (Under 18 Years Old)

- **Males under 16 years old**: Less than 10 kg for continuous work, less than 15 kg for intermittent work.
- **Females under 16 years old**: Less than 8 kg for continuous work, less than 12 kg for intermittent work.
- **Males aged 16 to 18 years old**: Less than 20 kg for continuous work, less than 30 kg for intermittent work.
- **Females aged 16 to 18 years old**: Less than 15 kg for continuous work, less than 25 kg for intermittent work.

Weight Restrictions for Women

- **Women aged 18 and over**: Less than 20 kg for continuous work, less than 30 kg for intermittent work.
- Pregnant women and women within one year postpartum are prohibited from handling heavy loads.

Weight Restrictions for Adult Men

- **Men aged 18 and over**: There are no specific legal limits, but the Ministry of Health, Labour and Welfare recommends keeping it below approximately 40% of body weight.

These restrictions are crucial for ensuring the health and safety of workers, particularly in preventing back injuries. Proper weight management and a well-organized work environment are essential.

労働基準法における重量物の制限

年齢	重量（上限）単位：kg			
	断続作業		継続作業作業	
	男性	女性	男性	女性
満16歳未満	15 kg	12 kg	10 kg	8 kg
満16歳以上満18歳未満	30 kg	25 kg	20 kg	15 kg
満18歳以上	規定なし。ただし通達で55 kg以下	30 kg	規定なし。ただし通達で体重の約40%以下	20 kg

ロボット周辺の空間

最大空間　Maximum space

製造業者が定めたロボット可動部が届く空間に、
エンドエフェクタ及びワークが届く空間を加えた空間。

制限空間　Restricted space

最大空間の一部であり、超えてはならない限度を
設定する制限装置によって制限する空間。

運転空間　Operating space/Operational space

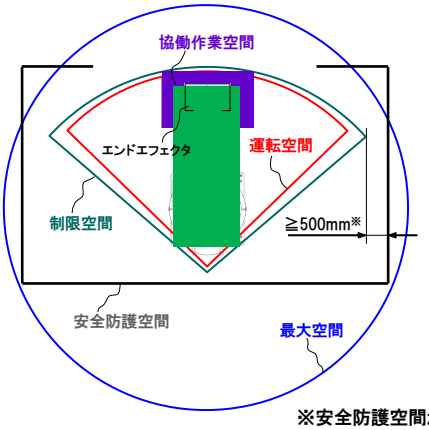
制限空間の一部で、タスクプログラムによって指令される
全ての運動を実行するときに実際に使われる空間。

安全防護空間　Safeguarded space

周囲の安全防護で定義された空間。

協働作業空間　Collaborative workspace

生産作業中にロボット及び人間が、同時に作業を
遂行できる安全防護空間内の作業空間。



※安全防護空間が機械柵の場合

本図は、日本認証のロボットアセッサテキストを参考に再作図したものである。

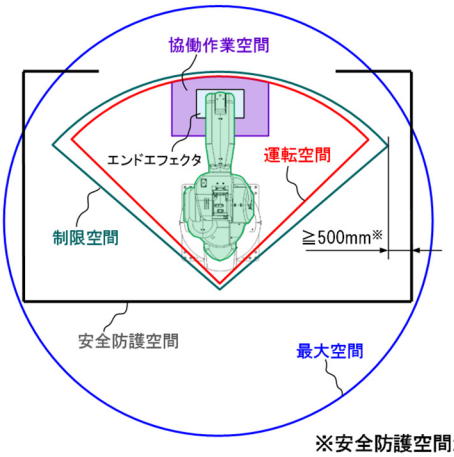
・『ロボットの可動範囲』とは、制限空間と同義であると考えるのが自然。
・『ガード』とは、安全防護空間の境界と同義である。

Robot Surrounding Space

Maximum Space: The space around the robot, as defined by the manufacturer, includes the area reachable by the robot's moving parts, as well as the space reachable by the end effector and the workpiece.

Restricted Space: A part of the maximum space, limited by a restricting device, beyond which the robot must not move.

Operating Space: (operational space) A part of the restricted space actually used when executing all movements commanded by the task program.



※安全防護空間が機械柵の場合

"This diagram was redrawn with reference to the Robot Assessor Text by Japan

Safeguarded Space: The space defined by the surrounding safety guards.

Collaborative Workspace: The workspace within the safeguarded space where both the robot and human can perform tasks simultaneously during production operations.

- It is natural to consider the "robot's range of motion" as synonymous with the restricted space.

- The term "guard" is synonymous with the boundary of the safeguarded space.

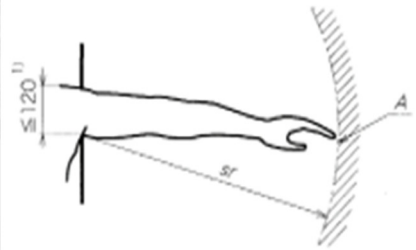
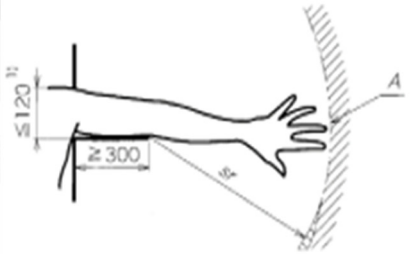
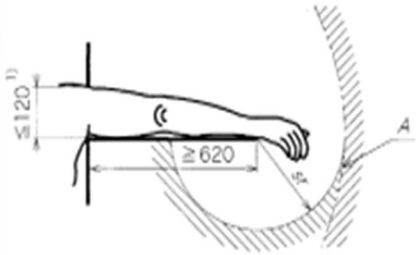
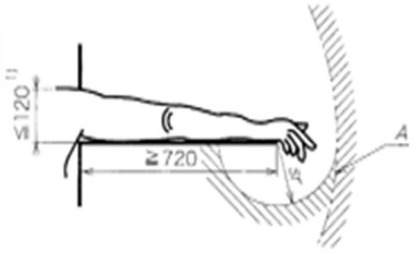
表 1

単位 mm

人体部位	minimum gap [mm]	図示
人体	500	
頭（最悪の位置）	300	
脚	180	
足	120	
つま先	50	
腕	120	
手 手首 こぶし	100	
指	25	

表 3

単位 mm

動作の制限	Safety distance [mm]	図示
肩及びわき（脇）の下においてだけの動作の制限	≧850	
ひじ（肘）まで支えられる腕	≧550	
手首まで支えられる腕	≧230	
指の関節まで支えられる腕及び手	≧130	

A は腕の動作の範囲

注 1）これは円形開口部の直径，又は正方形開口部の辺，若しくは長方形開口部の幅を示す。

Appendix C:

Quotation (example)

Team name :

Date : */*/*

System name	Contact information Country : Address :
	Contact Person's Name :
Total: 26,760,000 (JPY)	Mail address :

Remarks		Quantity	Unit	Unit price	Amount (JPY)
FAROBOT-3200A (Model number of robot)		6	Number of axes	500,000	3,000,000
DoubleArm ROBOT (Model number of robot)		12	Number of axes	400,000	4,800,000
Robot related equipment cost					
Hand		4	Units	300,000	1,200,000
Tool changer		1	Units	300,000	300,000
Stand		2	Units	200,000	400,000
Controller (PC,PLC, etc.)		1	Units	500,000	500,000
Cameras		3	Units	300,000	900,000
Robot peripheral equipment cost					
Jigs (list of jigs, e.g., hand attachment jigs, work stand)					
	Jig No.1 (Pneumatic chuck)	1	Units	120,000	120,000
	Jig No.2 (Carton transfer equipment)	1	Units	120,000	120,000
Safety-related equipments (list of equipment, e.g., signal indicators, laser curtain)		1	Units	1,000,000	1,000,000
	...				
Loading/unloading equipment (list of equipment, e.g., stockers, conveyors, feeders)		1	Units	10,000,000	10,000,000
	...				
Cost for system construction (number of persons * hourly rate)					
Design costs (process analysis, planning, concept, design, risk assessment)		650	Person*time(h)	3,000	1,950,000
Detailed design		1000	Person*time(h)	3,000	3,000,000
Teaching, program development		400	Person*time(h)	3,000	1,200,000
Assembly and adjustment costs		400	Person*time(h)	3,000	1,200,000
Verification		20	Person*time(h)	3,000	60,000
Others					
Other costs (e.g., safety training, hand outsourcing...)		1	Unit	10,000	10,000
				Total	26,760,000

備考
*The cost of documentation is required for all teams and does not need to be included in the personnel costs. *Transportation costs to the venue are not included.

Appendix D: Item list for the item number

Table D: Item list for the item number

#	Item
1	Carton (for the normal task)
2	Carton (for the surprise task)
3	Normal product
4	Surprise product
5	Seal
6	Package case (for the normal task)
7	Package case (for the surprise task)

Appendix E: Details of completion requirements for each task element

- Task element A: The carton is completely unfolded. This is determined by the judging line printed at the bottom of the carton.
- Task element B: All of the following requirements must be satisfied.
  - The carton is assembled (task element A requirement is satisfied).
  - The bottles are placed in the carton without protruding.
- Task element C: All of the following requirements must be satisfied.
  - All the specified number of bottles are in the carton (task element B requirement is satisfied for all bottles).
  - The lid is completely closed. This requires that the judging line printed on the lid insertion part cannot be observed from the outside.
- Task element D: All of the following requirements must be satisfied.
  - The carton lid is closed (task element C requirement is satisfied).
  - A seal is affixed along ridge where the carton lid is inserted.
  - A seal is glued across the lid and sides of the carton.
- Task element E: The specified number of cartons are placed in the package case. Some part of the bottom of each carton (including the periphery of the bottom) must be in contact with the bottom of the package case.
- Task element F: the package case must be removed from the System Running Area and placed in the Operation Area.