Test Project

Robot Systems Integration

Submitted by: Nigel Ramsden, Skill Competition Manager

Contents

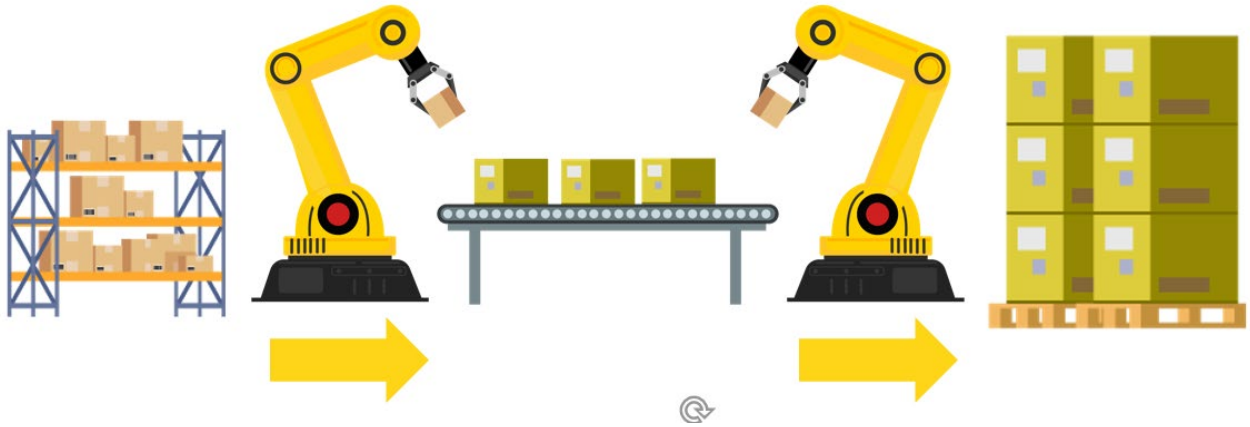
Please note that each section is labelled "F /C1/C2/C3/C4"

This refers to the timing of the release of each part of the Test Project to the Competitors and Interpreters.

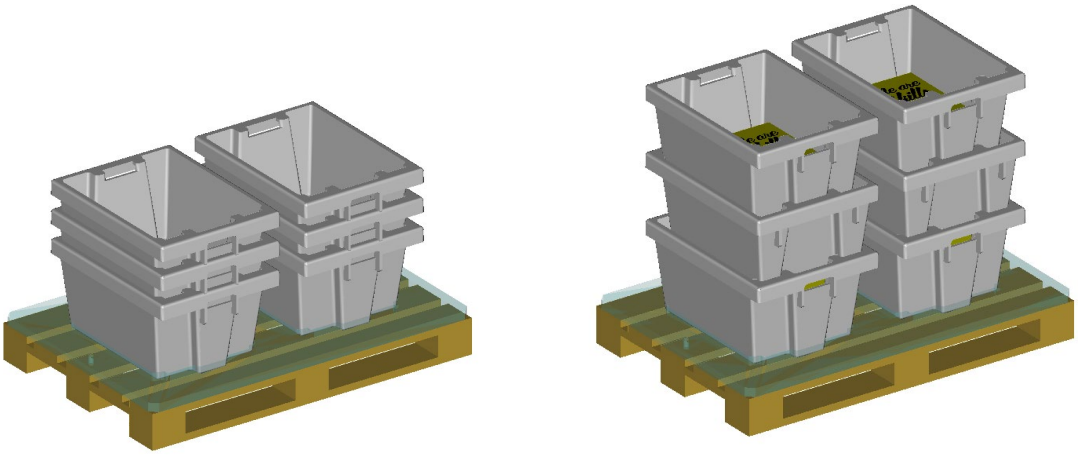
F – During Familiarization

Cn – At start of C1 / C2 / C3 /C4

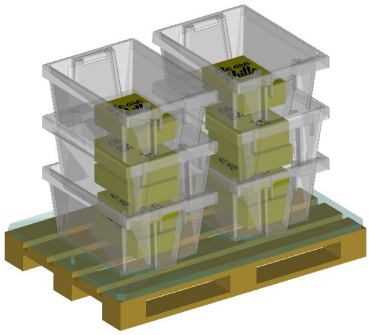
Introduction to Test Project (C1)



The project is to complete the Robot System Integration of a cell to Load and Stack Totes onto a Pallet ready for shipment. Normally this process would use several robots, but for the Test Project we will only use one.



The totes must be loaded with specific numbers of packages of different sizes, 16 mm or 19 mm thick:



The project is divided into stages, setting up the robot and cell, completing the Basic Task and then attempting an Extension Task if the Competitors have time.

Introduction – Education Cell (F)

The competition is based upon the standard FANUC Europe Education Cell:

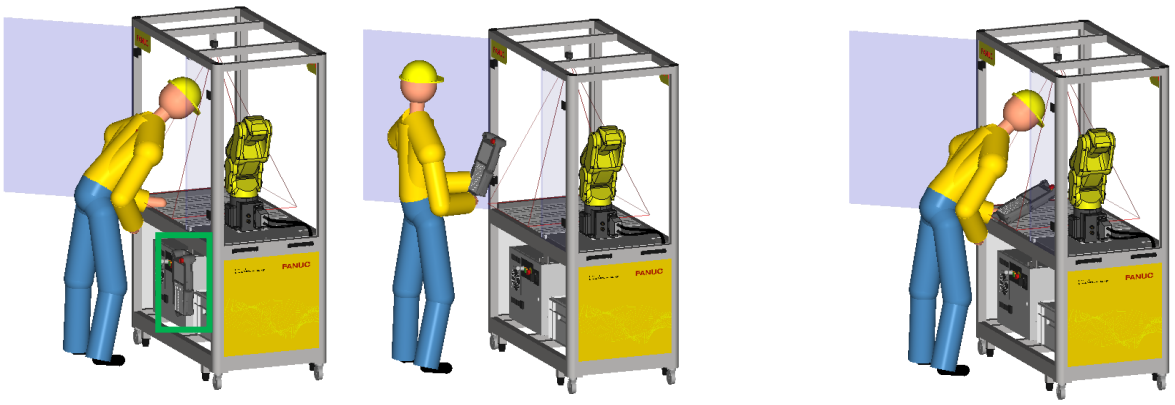
The Education Cell is delivered ‘ready to run’ – there is no need for the Competitors to physically install the robot or connect input power.

But the Competitors must decide on the layout of the cell components and install, connect, and configure all cell equipment.

Introduction – Safety (F)

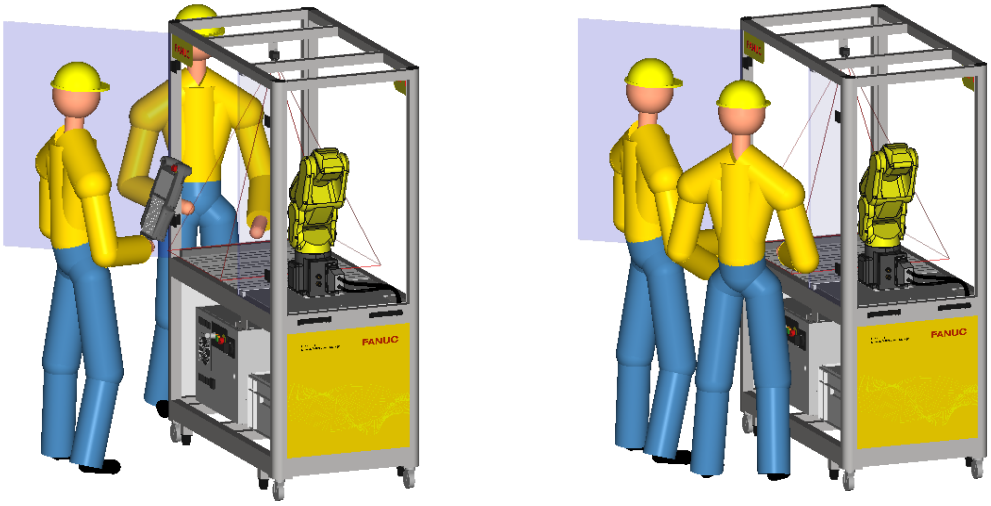
Each Expert is responsible for the safety of their team
Competitors bodies should not enter the cell while moving/programming the robot

OK	OK	NOK
Working in Cell **without**	Programming	Programming with TP
Teach Pendant/Servo OFF	Outside Cell	Inside Cell

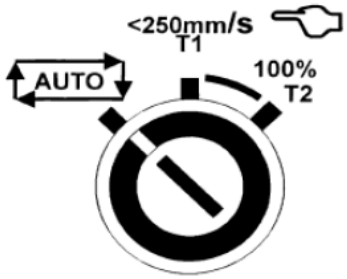


When installing, connecting peripherals etc, Servo power must be cut by E-Stop on Teach Pendant or Controller.
Competitors should not crowd around one another, especially in front of the cell door

OK	NOK



AUTO/T1/T2 Switch



Competitors should do all setup/programming etc in T1 mode (<250 mm/s)

For Test Run, Auto, or T2 Mode can be used.

The Auto/T1/T2 switch position must be changed by the Experts only.
The Experts are responsible for the Auto/T1/T2 key.

Personal Protective Equipment

Safety shoes must be worn by Competitors and Experts while in the competition workshop. Safety glasses and gloves may be worn but are not required.

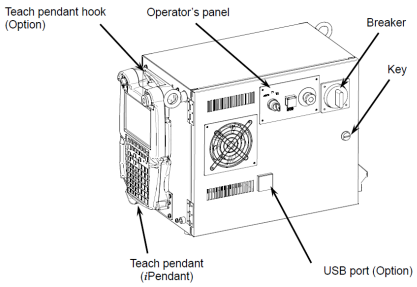
Controller Access/Open Controller Door

There is no specific reason foreseen for the Competitors to open the controller door.

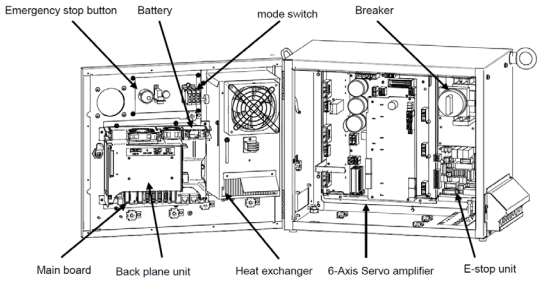
But in case Competitors request, for instance to check a proper Ethernet connection, the door may be opened **by FANUC Technical Support Staff or two non-compatriot Experts only**.

Power must be turned off before opening controller!

OK



NOK

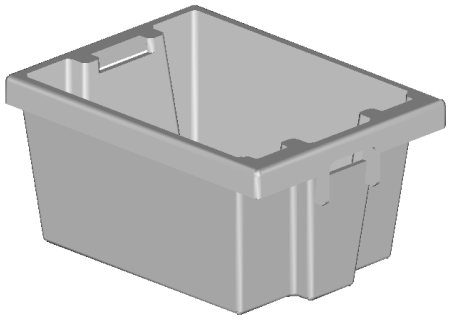


Description of project and tasks

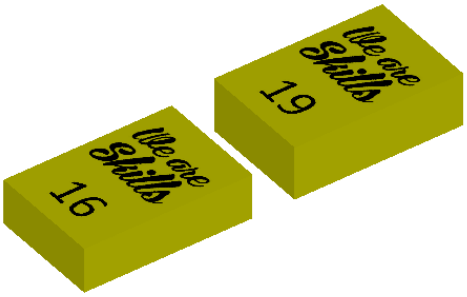
Description – Parts (C1)

The necessary parts for the application are supplied:

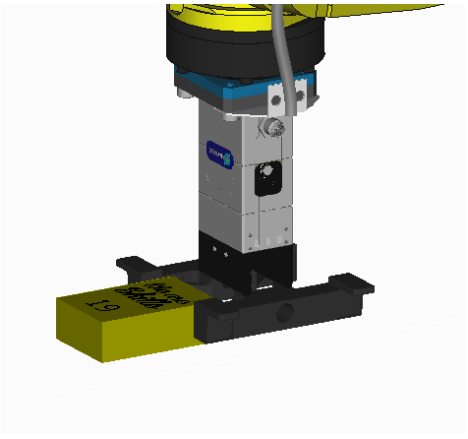
Totes (6)

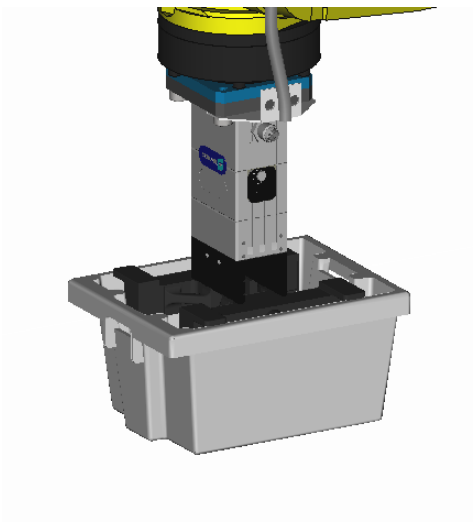


Packages (10 mm x 16 mm and 10 mm x 19 mm)



A Servo Gripper, with two fingers to be mounted on the Robot, which can be used to grip both the Totes and the Packages:

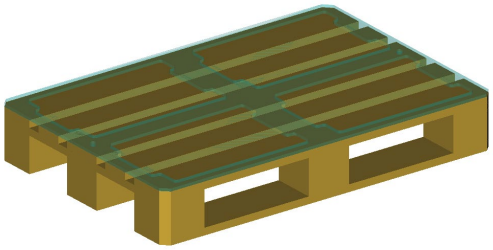




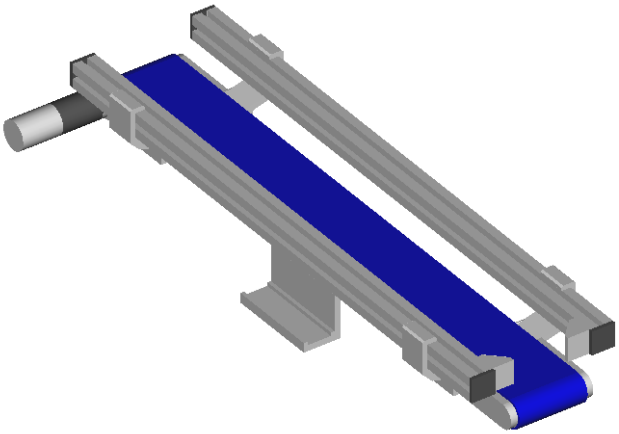
Description – Equipment (F)

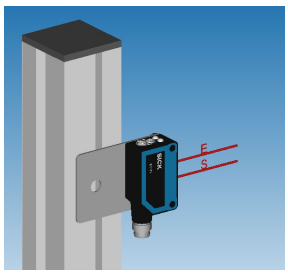
The necessary equipment for the application is supplied:

Pallets (2), with Perspex pallet locators:

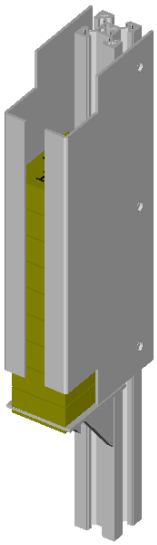


Conveyor, with 2 x Sensors for mounting at the ends of the conveyor:



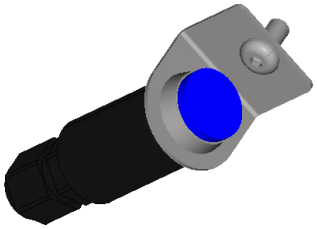


Magazines (2) for holding parts:



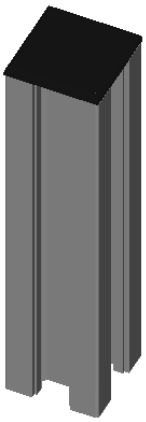
Different coloured LEDs to be used to indicate the Cell Status:

One is Red/Green (two outputs): the other is just Blue (one output):



(Plus some extension cables if desired)

Various support pillars for mounting the process equipment in the cell:



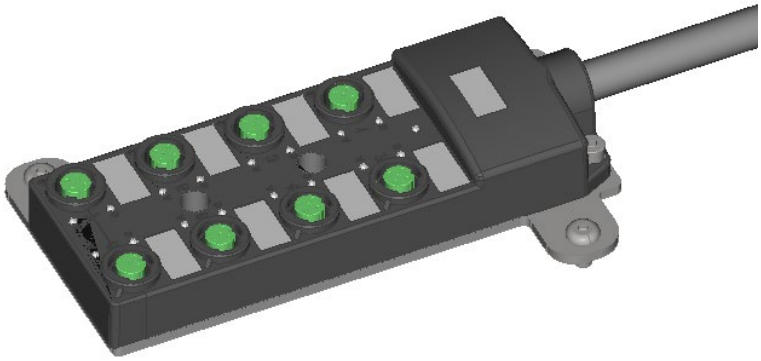
Competitors are supplied with 4 x pillars 200 long for mounting equipment.

Competitors may use as many or as few of the pillars as they wish.

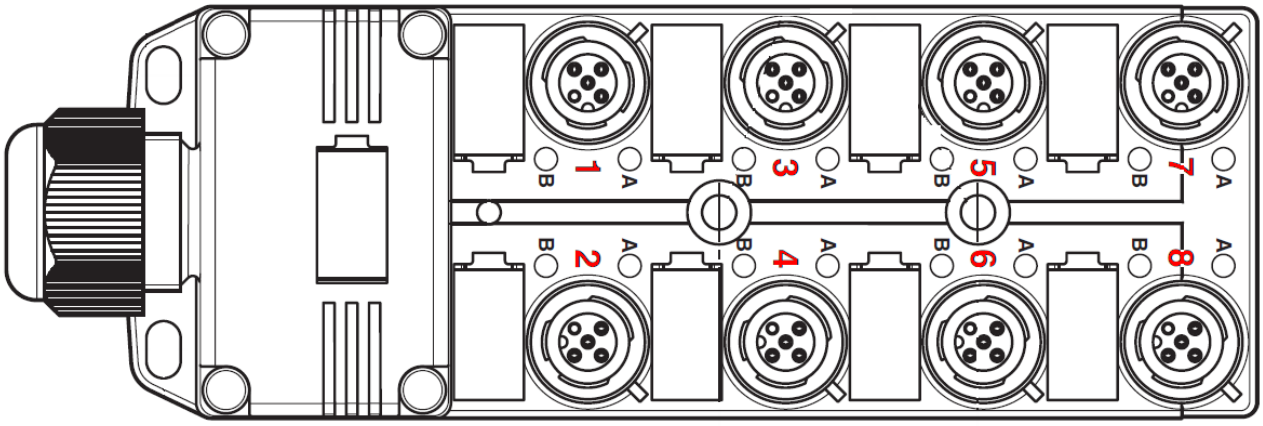
Teaching Pin is supplied to be used for teaching Frames, Tools – if competitors choose to use it.

Description – I/O Block (F)

An I/O Connection Block is supplied to connect peripheral equipment:



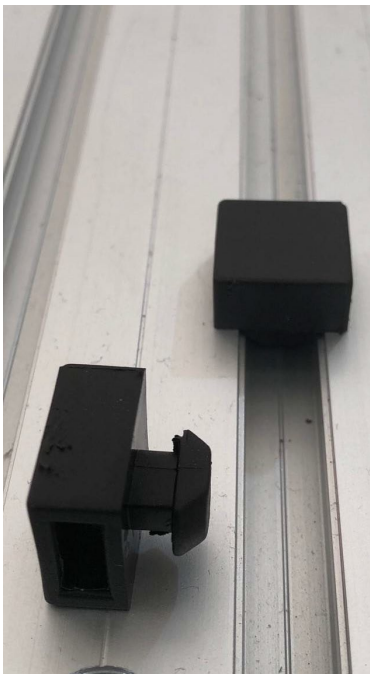
The I/O Block has sockets numbered 1 to 8 as shown below:



The robot I/O is pre-connected to the sockets as shown in the table below:

SOCKET	A (PIN 4)	B (PIN 2)
1	DI[101]	DI[102]
2	DI[103]	DI[104]
3	DI[105]	DI[106]
4	DI[107]	DI[108]
5	DO[101]	DO[102]
6	DO[103]	DO[104]
7	DO[105]	DO[106]
8	DO[107]	DO[108]

The Input and Output cables can be connected directly to the socket or via a Y-connector as shown below, to make the most efficient use of the available I/O. Plastic clips are supplied to clip cables to the table if needed – see examples below:



PLEASE NOTE THAT NO ELECTRICAL MODIFICATION OF CABLES OR CONNECTORS OR ANY OTHER COMPONENTS IS REQUIRED OR ALLOWED!

Description – PC and Software (F)

One laptop is supplied, equipped with:

- Mouse
- Microsoft Windows.
- Microsoft Office: Word, Excel, PowerPoint, acrobat reader etc – for Documentation
- Microsoft Office Sharepoint Designer for Web Page construction
- Microsoft Internet Explorer for connection to Robot Controller
- FANUC Roboguide for Simulation (and template RG Cell)
- Payload checker
- One USB key for file transfer etc.
- Ethernet cable for connection to robot controller for file transfer, iRVision etc.

All necessary FANUC Manuals are also supplied in PDF form on the PC

- HTML Editor
- Manuals
- Payload Checker
- Roboguide

Description – Ethernet (F)

An Ethernet cable is supplied to connect from Laptop to Robot for setup, entering comments, iRVision, etc. There is Ethernet connection cable already installed in robot controller with external connector so there is no specific need to open the controller to make the Ethernet connection.

PC and Robot IP addresses and Subnet Masks should be set as shown below

PLEASE DO NOT USE OTHER VALUES!

ROBOT	IP ADDRESS ROBOT	IP ADDRESS PC	SUBNET MASK
All	192.168.1.10	192.168.1.1	255.255.255.0

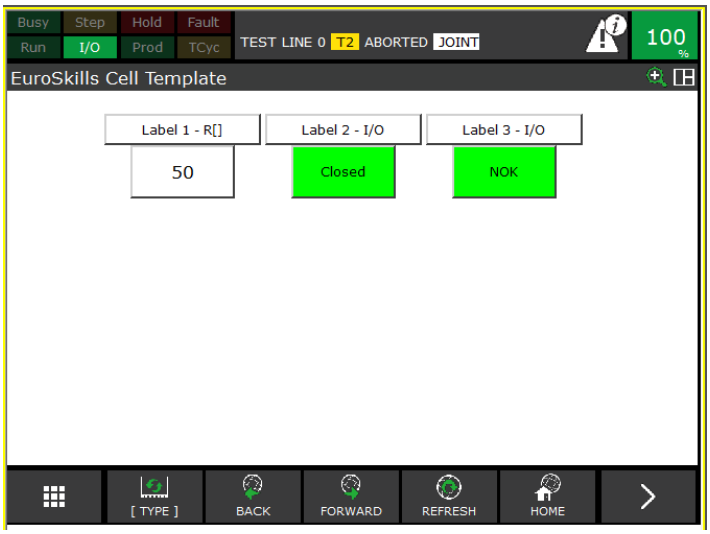
Description - HMI (F)

A template HMI (User Interface) file WS2022SE.STM is provided - This file should be loaded and set up so that it can be displayed on the Teach Pendant.

It should be possible to display it manually whenever the operator wants to display it, and it should be automatically when the main program is started in Automatic mode.

The minimum functions of the HMI should be:

Display a Counter showing the number of the part being processed.
Display the Open/Closed status of the Gripper
Display the Error/Fault status of the Robot (equivalent to the Fault LED on the TP)



It is not enough to just load this file – it must be set up correctly with correct labels, I/O and Register values and Colours

You can use Microsoft Sharepoint designer or a text editor or any other function installed on your PC to modify it.

You may improve/extend this basic HMI as much as you wish.

For further information on the HMI / User Interface Setup please refer to the information on the standard Education Cell: FEC_Ed_Cell_Technical_V5_4.pdf

Description – Reserved Programs (F)

There are two reserved programs:

Z_HOME

Z_ZERO

These are for Workshop Manager / Assistants & SMT to use – please do not use/modify/delete these programs

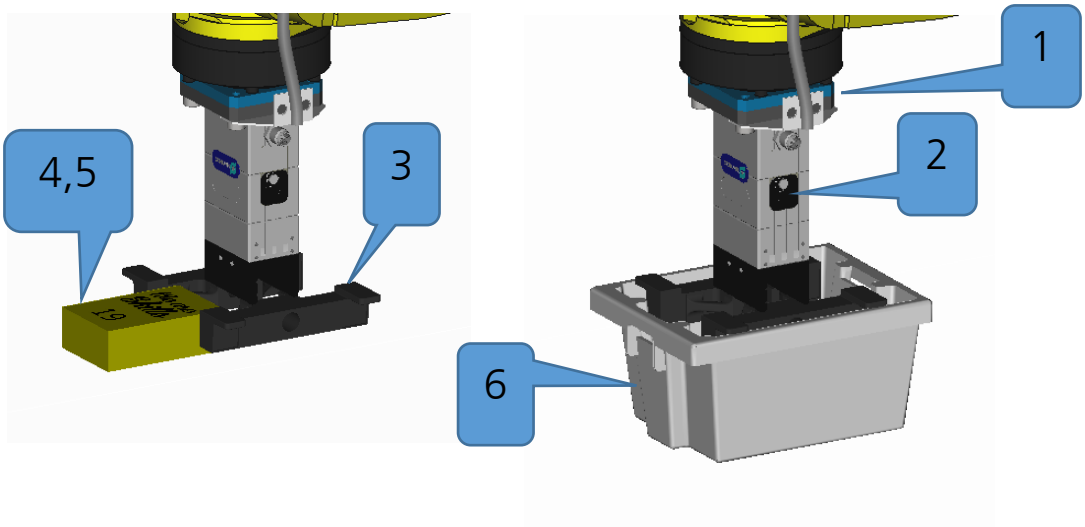
Instructions to the Competitor

Instructions – Robot Setup – Gripper (C1)

Mechanically and electrically install and connect the gripper and set up the robot system to use it. Additional marks will be awarded for the most complete setup.

Set up the Robot payload(s) according to the data given:

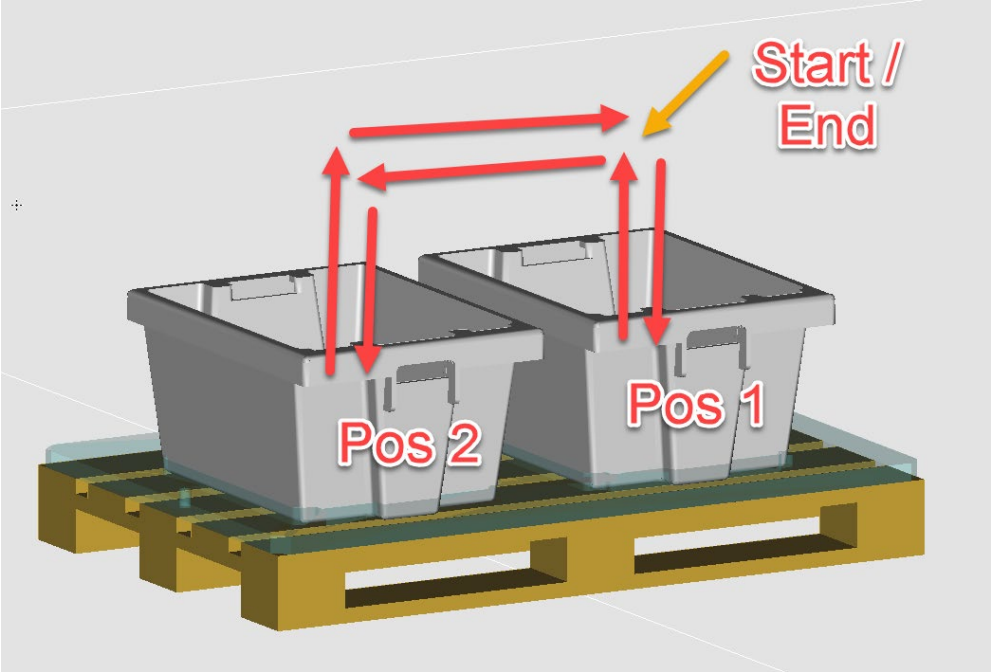
ITEM	DESCRIPTION	MASS (GRAMS)
1	Total Mass of adaptor plates	60
2	Mass of gripper body	320
3	Mass of one finger	20
4	Mass of 16mm package	25
5	Mass of 19mm package	30
6	Mass of Tote	70



Set up also appropriate TCP – Tool Centre Point – User Tool value – one or more.

Instructions – Gripper Test (C1)

First step of the Test Project is a simple test that the gripper is correctly set up and working



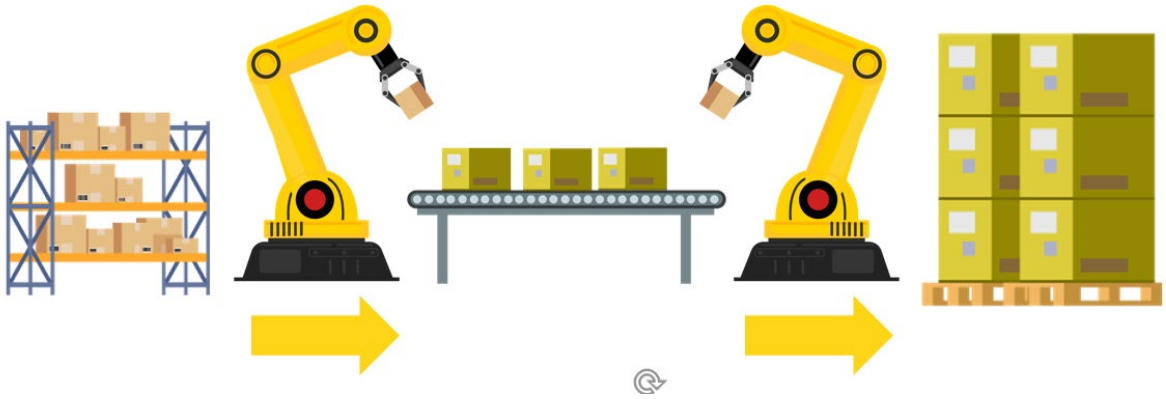
Program this sequence:

STEP	ACTION
0	Start with one Tote (top part, bottom part or inner cylinder) in Position 1
1	Open Gripper
2	Move above Position 1
3	Move down to Position 1, close gripper, move up above Position 1
4	Move above Position 2
5	Move down to Position 2, open gripper, move up above Position 2
6	Move down to Position 2, close gripper, move up above Position 2
7	Move above Position 1
8	Move down to Position 1, open gripper, move up above Position 1
9	Repeat steps 1-8 for 3 cycles

Test Run Conditions: three cycles,three attempts, total five minutes

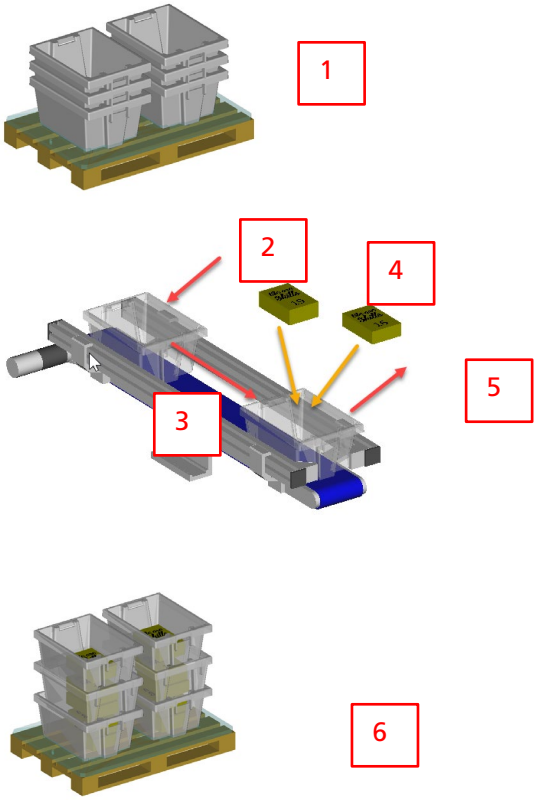
Instructions – Basic Task (C1)

The Basic Task is to simulate the Automation of the Tote loading:



But instead of multiple robots, we will use only one robot.

The Basic Task starts with the Totes Stacked tightly together on one Pallet:



The Robot starts and ends the task at a Home position. It should not start the task unless it is at Home.

The Totes must be Unloaded from the Input Pallet [1] and Loaded onto one end of the Conveyor [2]. Then the Tote must be moved [3] to the other end of the Conveyor. When it reaches the end of the Conveyor the Packages [4] must be loaded into the Tote. When the Packages are loaded into the Tote it must be Picked [5] from the end of the Conveyor and Placed on to the Output Pallet [6].

This sequence must be strictly followed.

Note that on the Output Pallet the Totes are stacked with alternating orientation.

Sensors mounted on the Conveyor and on the Magazines must be used to check that the system is operating correctly.

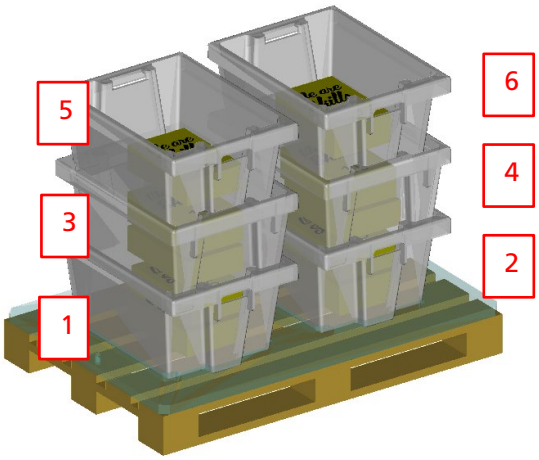
Because only one robot is used, the layout will have to be chosen so that both pallets and the conveyor are inside the robot envelope.

Note that sensors are provided for both ends of the conveyor and should be used to ensure the reliable operation of the system.

Instructions – Numbering/Sequence (C1) - Example

The Tote Numbering is as shown below.

The Totes should be placed on the Pallet according to the numbering sequence shown:



For the Basic Task the Packages should be loaded into the Totes according to a table as shown below. Some Totes have one package in, some Totes have two packages:

TOTE #	NUMBER TO LOAD	
	Package 16	**Package 19**
1	2	0
2	1	1
3	0	2
4	1	0
5	1	1
6	0	1
Total	5	5

Note that this is just Example Table – Actual table will be provided to Competitors one hour before Marking/Assessment. Competitors should prepare and test all possible combinations.

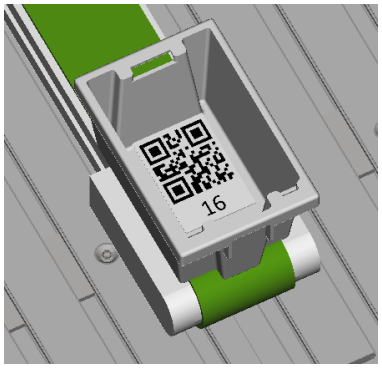
Test Run Conditions: six totes, three attempts, total ten minutes

Instructions – Extension Task 1 (C3) QR Codes

In the Basic Task, the number of packages to be loaded in each Tote is given in a table

For Extension Task 1, the number of packages to be loaded into each Tote must be automatically allocated according to a QR Code placed in the bottom of each Tote and detected by the Camera.

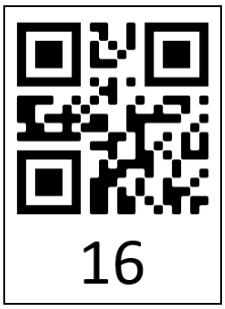
The rest of the sequence should be the same as in the Basic Task, but updated (e.g., HMI) for the QR codes

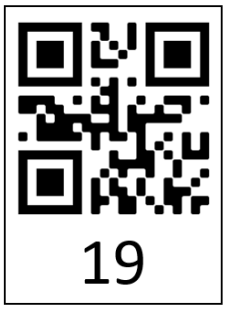


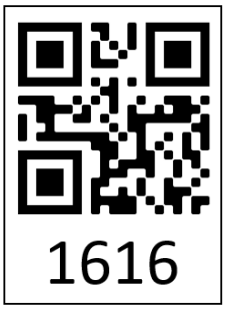
The codes are printed on laminated cards as shown below.

Only these five codes are used. Any other code should be handled as invalid, the operator informed, and appropriate action taken.

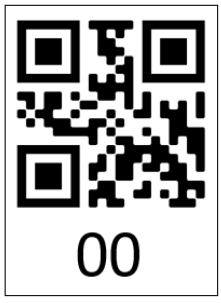
For Marking, the Experts will insert the cards randomly into the Totes at the beginning of the Cycle







Example of invalid code:



QR Code	Meaning
16	Load 1 x package 16
19	Load 1 x package 19
1616	Load 2 x package 16
1919	Load 2 x package 19
1619	Load 1 x package 16 & 1 x package 19
Any other code	Error

For information on the QR code function, please refer to
R-30iB_Plus_iRVision_reference_operator_manual_[B-83914EN_05], section 4.15 2-D BARCODE TOOL

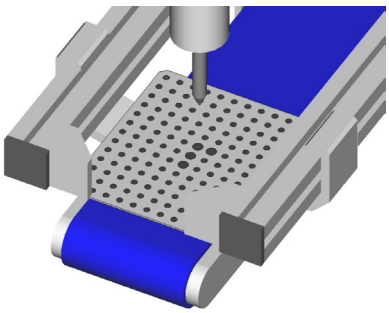
Test Run Conditionn: six totes, three attempts, total ten minutes

Instructions – Extension Task 2 (C4) Tote

In the Basic Task, the Totes are placed on one end of the conveyor and picked off the other end by the robot, so the orientation of the totes should not change.

However, in the real world, the totes may fall off or be taken off the conveyor for various reasons and placed back in a different orientation.

Extension Task 2 requires using iRVision to check the actual orientation of the totes before they are picked from the end of the conveyor, and taking appropriate action to stack them correctly without operator intervention.

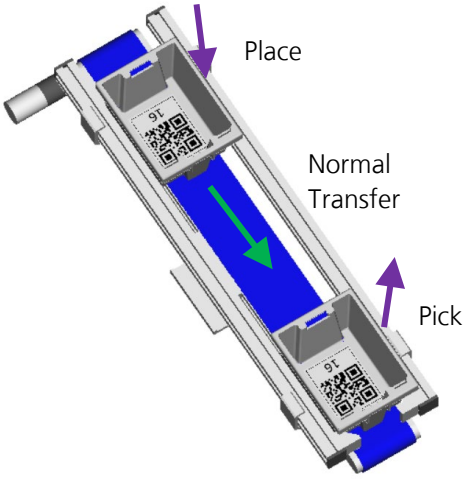


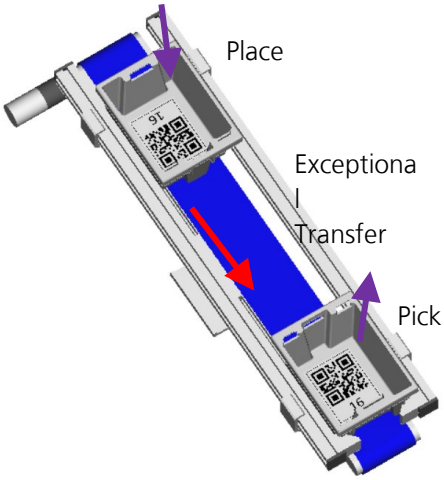
The orientation can possibly be detected without calibrating iRVision, but extra marks will be awarded for doing Calibration using the Calibration Grid provided.

Please refer to: R-30iB_Plus_iRVision_reference_operator_manual_[B-83914EN_05], section 2.1.2 Grid Pattern Calibration

Competitors can assume that the QR code cards will also be used for this task, and that the QR codes will always be placed in the same orientation inside the totes:

Normal Transfer – Orientation does not change: Exceptional Transfer – Orientation changed by Experts manually:





Test Run Conditions: six totes, three attempts, total ten minutes. The Experts will have to manually interrupt the cycle in order to test the orientation check– so cycle time will not be tested.

Instructions – Working Style and Safety (F)

Throughout the Competition, Competitors will be expected to work as if they are in a real Industrial setting – installing and setting up a Robot System at a Customer site.

This means always working professionally and taking all normal precautions against events which may occur in a real industrial situation.

Instructions – Test Running (F)

During Marking, the Competitors will be asked to test run the different Tasks that have been set. As in industry, Reliability and Cycle Time are both important

The number of completed cycles and the cycle time will be marked separately. Marks will be given for cycle time only if all required cycles are completed.

The Competitors can choose Auto/T1/T2 mode and Override % and change during test run if desired.

During marking the Competitors have THREE attempts ONLY to demonstrate the full number of cycles.

The first successful attempt ends the marking, and the cycle time for that attempt will be used for the cycle time marking.

Competitors may change whatever programs, data, settings they want to in between attempts, but the maximum time allowed for all test runs will be set for each task, for example five minutes.

Please note that changing between test runs is a risky activity and competitors are encouraged to make sure that their systems are reliable and will run correctly first time.

Instructions - Roboguide/Digital Twin (F)

Simulation plays an important role in this skill.

- Planning the layout of the cell
- Creating the basic task program structure while the equipment is being installed according to the layout
- Creating the extension task program structure while the basic task structure is being installed and tested

It is also important that any changes that are found during installation and testing are implemented in the Simulation as well as on the real cell – so that there is a Digital Twin of the actual cell – the layout, the programs – all aspects of the cell.

During marking it will be checked if the Roboguide simulation is really a Digital Twin of the real cell.

Remember also to make the Teach Pendant display as realistic as possible – for example with the 4D Graphics function, and to work professionally with the Laptop as well as with the Robot.

Instructions –Documentation (F)

When you have finished the task, you should hand over a documentation package to the end customer. This documentation should contain all the information necessary to run, maintain and troubleshoot the cell after you leave site.

You have been provided with a template document in English for the documentation package.

The contents by the Competitors do not need to be in English, but it would help the Marking Teams if at least the titles of the different sections of the documentation could be in English and own language.

Equipment, machinery, installations, and materials required

It is expected that all Test Projects can be done by Competitors based on the equipment and materials specified in the Infrastructure List*, except as detailed below.

Materials, Equipment, and tools supplied by competitors (F)

The Competitor PCs are equipped with US International standard Keyboards and basic mouse.

Competitors may bring their own keyboard and mouse to connect to the PC if they prefer. Hard-wired USB connections are recommended.The installation and functioning of these devices is the responsibility of the Competitors. It is permitted to install additional drivers, if necessary, after approval by SMT.

Neither WorldSkills nor the Global Partner or PC supplier can guarantee the compatibility or functioning of the Competitor supplied devices.

The competitors may also bring a paper dictionary. The dictionary may not have been modified in any way – handwriting, additional papers etc. It will be checked on C-1.

There should be no other tools or equipment required to complete the Test Project – these are all provided in the Test Project Kit and Tool Trolley, and competitors are prohibited from bringing other tools and equipment.

Materials, equipment, and tools prohibited in the skill Area (F)

PERSONAL LAPTOPS – USB – MEMORY STICKS– MOBILE PHONES
Competitors are only allowed to use memory sticks provided by the Competition Organizer.

Memory sticks or any other portable memory devices cannot be taken outside the workshop.

Memory sticks or other portable memory devices are to be submitted to the Chief Expert or to the Deputy Chief Expert at the end of each day for safe keeping.

Experts are allowed to use personal laptops, tablets, and mobile phones in the Expert room only.

Competitors are not allowed to bring personal laptops, tablets, or mobile phones into the workshop.

PERSONAL PHOTO CAMERAS – VIDEO TAKING DEVICES
Competitors and Experts are allowed to use personal photo and video taking devices in the workshop at the conclusion of the competition only.

Marking Scheme (C1)

A	Day 1 AM: Setup Robot and Gripper (Payload, Input/Output etc) Home/Reference Positions and DCS. Demonstrate Running Gripper Test Program. Import CAD, Create Cell Layout, Tools, Uframes. Demonstrate Reachability of key components.	12.50
A1	Create Pick and Place Demo program to show proper robot and gripper setup. Run in Auto or T2.	3.00
A2	Setup Gripper : Mechanical, Cable, Electrical, Input/Output, Macro etc	2.65
A3	Setup Tool(s) / Payload(s) : TCP Coordinates, Payload Values, etc	1.25
A4	Setup Reference Positions - Quick Master & Home. Setup DCS	1.30
A5	Import CAD and Setup Roboguide Cell to match actual Cell layout accurately	0.80
A6	Create missing CAD using Roboguide Modeller	1.00
A7	Check Reachability & access to of key cell components in Roboguide - create Roboguide demo program to demonstrate access to Pallets, etc.	2.50
B	Day 1 PM: Install Equipment according to Roboguide Layout. Connect and setup Input/Output and Macros. Setup User Frame(s). Offline Program Basic Task, Connect Ethernet, set R[], Input/Output Comments from PC.	12.90
B1	Complete all Mechanical/Electrical Installation according to Roboguide Layout. Label Cables, Frames etc	2.40
B2	Complete Input/Output Setup, Comments, Macros, etc for all Electrical Equipment	1.50
B3	Teach User Frame(s) - be prepared to show how this was done	0.75
B4	Create Offline Programs for Basic Task - Program Structure will be checked	2.50
B5	Create Offline Programs for Basic Task - Gripper control, Home check, Robot Pick/Place Motion will be checked	2.25
B6	Setup Host Comm according to Instructions, Set Comments for Registers - R[], PR[] etc from PC	1.25
B7	Follow correct Working Style and Safety	2.25

C	Day 2 Install, Test Offline Programs. Demonstrate running Basic Task.	22.00
C1	Demonstrate Basic Task running, measure cycle time. With Error Handling and Teach Pendant User Interface. Auto or T2	11.50
C2	Check peripheral equipment control and error handling	6.0
C3	Demonstrate Home Check UIF	2.0
C4	Follow correct Working Style and Safety	2.50

Marking Scheme (C3)

D	Day 3: Demonstrate Running System with BOTH Basic and Extension Task 1. Create and demonstrate User Interface. Create User Documentation & Simulation "Digital Twin"	24.75
D1	Demonstrate BOTH Basic Task and Extension Task 1 running	11.00
D2	Demonstrate Teach Pendant User Interface Setup and Display	6.85
D3	Review Teach Pendant Program Internal User Commenting: Headers, Logic, Positions, etc	4.40
D4	Follow correct Working Style & Safety	2.50

Marking Scheme (C4)

E	Day 4: Demonstrate Running System with Basic, Extension Task 1 and Extension Task 2. Finalize, Demonstrate Documentation and Simulation - "Digital Twin"	27.85
E1	Demonstrate Basic, Extension Task 1 and Extension Task 2 running system	6.80
E2	Check iRVision Calibration and Setup	2.40
E4	Review User/Customer Documentation - Instructions and Reference Information	8.00
E5	Review Roboguide "Digital Twin" - how realistic it is compared to real cell	8.15
E6	Follow correct Working Style & Safety	2.50