Technical Handbook

Skill Industry 4.0

Contents

Introduction

The aim of this technical handbook is to help competitors who are preparing for Industry 4.0 competitions across all stages - from passive test to National Finals. In this document you will find various rules and guidelines that once followed, greatly increase your chances on becoming one of the "Nations best".

Career Pathway

To establish the use of Industry 4.0 technologies, within a company, the training and qualifications of its skilled workers must be adapted to meet the new requirements of this interdisciplinary approach. For example, service technicians not only need practical mechatronics experience but also knowledge of IT infrastructure, so that they can work at a high level to rectify machine standstills as quickly as possible.

Industry 4.0 means that the tasks to be carried out are becoming more demanding, in both technological and organisational terms. Interdisciplinary competencies are growing in importance, which is why it is necessary to adapt the skills and abilities that are taught for the various trades. As the boundaries between the different functional levels are becoming ever more fluid, the need to adapt affects all technical professions.

Currently, technologies covered by this competition doesn't directly link to individual profession as there is no such a profession as "Industry 4.0 Technician". Instead, we are preparing for factories of a future with **"Digital Production Systems Technicians"** who are able to combine knowledge from different trades to create and maintain highly advanced production systems, that combined together form Smart Factories.

Technologies included in Industry 4.0 competition are relevant to various careers

- Mechatronics engineer
- Electronics engineer (for automation technology)
- IT specialist (automation technology)
- IT specialist (application development)
- Industrial manager

Competition overview

The competition tests practical skills of its competitors who are able to apply their knowledge of Industry 4.0's core elements, such as:

- Cyber-Physical systems (CPS)
- Radio-Frequency Identification (RFID)
- Energy efficiency / monitoring
- Augmented Reality (AR)
- Digital Shadow
- Data Security & Cyber Security
- Open-Protocol Communication Unified Architecture (OPC UA)
- Industrial Internet of Things (IIoT)
- Manufacturing Execution System (MES)

During competition, skills listed above are tested in the form of tasks. Each task combines a different set of technologies, applied to a single module of a production system. Despite some of the core elements being more important than others, we are able to distinguish 6 major topics, that participants must demonstrate their skills in:

- Hardware and software update of production module
- Working with MES software
- Integration of Energy Monitoring system
- Integration of Cyber Security system
- Analysis, evaluation, and optimization reporting
- Creating of online dashboard that communicates with machine and/or MES system

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Note

All major topics apply to National Finals. During the passive test stage, and regional qualifiers, not all of them may be required.

Stage 1 – Registration

In order to take part in this competition, you must register your team using WorldSkills UK website. Upon successful registration, all competitors will receive a confirmation email. Each team signing up for Industry 4.0 competition must consist of two competitors.

While waiting for the next stage of the competition, you should start to prepare for challenges ahead. The **pre-competition activity** has been prepared to help you understand the tasks.

Stage 2 – Passive stage

A period of time between registration and national qualifiers is called a "passive stage". Once registration closes, each team that has successfully registered for I4.0 competition will be send an access link to an online task, prepared to test their skills. It is a mixture of multiple choice and open-ended questions.

Once everyone's scores have been calculated, competitor teams will be informed if they have progressed on to the next round, called the national qualifiers.

Stage 3 – National Qualifiers

Competitors who have successfully passed a passive stage will be invited to compete in national qualifiers. This event is a face-to-face competition, and all details would be emailed to you in advance.

National Qualifiers consist of similar tasks to those presented during National Finals; however, only a restricted number of technologies will be involved, mainly focusing on the basics.

National qualifiers are a one-day activity, typically involving three main topics (listed in competition overview). The top scoring teams meeting the minimum threshold from the national qualifiers will then go through to the next round, the National Finals.

Stage 4 – National Finals

The top teams in the UK will be invited to compete in the UK National Final which is the pinnacle of the UK national competition cycle.

Attend Pre-final training arranged by Festo & Didactic Services Ltd and virtual online training. These will take place well ahead of national competitions to make sure all teams have received the same amount of information and access to additional equipment.

Stage 5 – International Competitions

Beyond the national finals, there are a host of opportunities for competitors. Eligible competitors who show the highest skills, passion, and drive from the national finals will be given the opportunity to compete to train for the EuroSkills and WorldSkills International competitions. The winners from national final competitions who are not eligible for international competitions may join the Skills Champions programme, which allows continued involvement, including the opportunity to work with WorldSkills. Alternatively, if training is of interest to you, you could consider supporting WorldSkills UK with organising and training, and even helping to run the National Finals.

Core competencies

Please note the following are core competencies for the full set of Industry 4.0 competitions, that competitors will be assessed on. Not all competencies are covered at all stages and levels.

Core competencies and standards for WorldSkills UK Skills Competitions activities			Regional Qualifiers	National Finals	International Competition
Design, assembly, and commissioning	**Standards**	**The individual needs to know and understand:** • Principles and applications for the o Design o Assembly o Connectivity o Commissioning of hardware and peripherals to meet cyber-physical requirements • Principles and methods for integrating autonomous subsystems and components.	N	Y	Y
	Competency	**The individual shall be able to:** • Read and interpret instructions, • Select and apply sensors, communication technologies, and devices for motion control, position sensing, pressure testing and electronic communication • Test the performance of electrical, electronic, mechanical, and integrated systems and equipment, relative to their intended purpose • Integrate the equipment and sub-systems to ensure readiness for data capture, networking, exchange, and use. • Commission the system • Create and maintain project files.	N	Y	Y
Software design and implementation	**Standards**	**The individual needs to know and understand:** • Mathematics and their applications • Principles and applications of electronics • Computer capabilities, subject matter, and symbolic logic • Computer hardware and software, and their applications • The required standards for code conventions, style guides, user interface designs, managing directories, and files • Principles and applications of human-machine communication.	Y	Y	Y
	Competency	**The individual shall be able to:** • Write, analyse, review, and rewrite programs • Write, update, and maintain computer programs or software packages to handle specific jobs such as tracking inventory, storing, or retrieving data, or controlling other equipment • Investigate whether networks, workstations, the central processing unit of the system, or peripheral equipment are responding to a program's instructions.	Y	Y	Y

Networking and cyber security	**Standards**	**The individual needs to know and understand:** • The scale and nature of the organization's vulnerability to breaches in information security • The trends, nature, and intent of malicious breaches • Principles and methodologies for establishing and maintaining maximum information security and data integrity • Network protocols and topology • Network monitoring software	N	Y	Y
	Competency	**The individual shall be able to:** • Design and implement network protocols and topologies • Maintain levels of preparedness and the availability of preventative and defensive tools commensurate with risks and trends in malicious attacks • Encrypt data transmissions and set up firewalls to conceal confidential information when transmitted • Conduct tests of data processing systems to ensure safe functioning of data processing and security measures • Monitor the use of data files and regulate access to safeguard information • Document enabled security and emergency measures, policies, procedures and tests	N	Y	Y
Analysis, evaluation, and reporting	**Standards**	**The individual needs to know and understand:** • Principles and applications of critical thinking and complex problem-solving. • The uses and availability of self-monitoring equipment and tools • The bases, techniques, and tools for creating and using analytical models of performance, including: 　o Performance targets or specifications 　o Numerical and quantifiable parameters 　o Data requirements 　o Constraints and variables 　o Alternatives • How to conceptualize, define and evaluate problems referred to them, and to derive recommendations for solutions.	Y	Y	Y
	Competency	**The individual shall be able to:** • Take account of requirements for monitoring, review, and evaluation in the design of the system and sub-systems. • Optimize the use of self-monitoring equipment and tools to the extent feasible. • Design and apply an appropriate model for monitoring and evaluating performance relative to specification • Anticipate requests for feedback and reports and prepare accordingly on a data rational basis. • Prepare reports in appropriate formats for routine and exception reporting.	Y	Y	Y

Task overview – Regional Qualifiers

TASK A – PLC / HMI Programming

Technologies involved:
- PLC Programming
    - Device configuration of an existing system
    - Import/Export of PLC Tags
    - Sequential programming
    - Use of functions, function blocks, data blocks
- HMI Design
    - Single screen implementation
    - Configuration of PROFINET communication between PLC and HMI
    - Use of interactive components such as buttons, switches, graphs etc.
    - Use of animations
    - Use of events
    - HMI tags

Task A Involves programming a CP Lab base module according to a provided specification. Competitors focus on setting up a project, detecting or setting up configuration of PLC and HMI according to devices supplied and programming them.

The first part of Task A, involves writing a PLC program that enables station to follow specific sequence, specified in task description. The task description lists all requirements that will be marked by the judges. It is up to competitors to select a programming language and the way the system is being programmed; only system's final behaviour is marked.

The second part of Task A consists of developing a simple screen for HMI panel that will support a PLC Program. The communication between the two devices has to be established, and information/controls required to be displayed will be listed in task's description.

Judges will test functionality of HMI Panel, and system's abilities.

TASK B – SCADA

Technologies involved:
- PLC Programming
    - Device configuration of an existing system
    - Data blocks
    - Minor changes to program's behaviour
    - OPC UA server activation

- Node-RED
    - Single dashboard implementation
    - Use of basic palette
    - Use of OPC UA palette
    - Use of Dashboard palette
    - Use of external software to act as a OPC UA client (i.e. *UA Expert*)

The second task involves minor changes to an existing PLC program (different to the one created in Task A) that will allow for the PLC to run an OPC UA server with specific variables available. All the rules for server will be listed in task's description.

Next, competitors will be asked to create a browser dashboard using Node-RED package. The final outcome should display specific PLC data, received by establishing OPC UA communication (Server<->Client). A List of required Node-RED palettes is included in **Equipment Required / Qualifiers** section (page 15). Use of external software for OPC UA server browsing will be also tested – for example "UA Expert" software.

TASK C – MES offline configuration

Technologies involved:
- ■ MES4
  - o Creation/addition of:
    - ▪ Resources
    - ▪ Parts
    - ▪ Workplans
- ■ Report
  - o Completion of system's documentation
  - o Summary of work completed
  - o Explanation of different functions to end user

The final task of regional qualifiers involves an offline configuration of MES4 database. Teams will receive a specific configuration of multiple CP Lab stations, with a task to configure MES4 according to listed requirements. That will involve adding resources, new parts, and workplans with their parameters according to specification.

Completed configuration should be documented, with screenshots and descriptions included in a documentation. Template will be supplied to competitors in **.docx format**, which teams will fill in with materials gathered from completed MES4 configuration.

Marking overview – Regional qualifiers

The following is an example of the marking criteria for the Regional Qualifier.

Criteria	Task	Marks
A	PLC / HMI Programming	40
B	SCADA	30
C	MES offline configuration	30
	Total Marks	**100**

Task overview – National Finals

TASK A – System upgrade

Technologies involved:

- **PLC Programming**
  - Properties configuration
  - Updating system's PLC programs (download)
- **HMI Design**
  - Properties configuration
  - Updating system's HMI program (download)
- **MES4**
  - MES configuration
  - Creation/addition of:
    - Resources
    - Parts
    - Workplans
- **Node-RED**
  - Single dashboard implementation
  - Use of basic palette
  - Use of OPC UA palette
  - Use of Dashboard palette
  - Use of external software to act as a OPC UA client (i.e. *UA Expert*)

The first task of National Finals is based around "upgrading", an existing CP system. Given all required files and documentation, teams will perform an upgrade and later match it with correct configuration of MES4 software. Task A also includes development of a browser dashboard, used to support new configuration, and allow for remote access to a new system.

TASK B – SCADA

Technologies involved:
- **■ MES4**
    - o MES configuration
    - o Creation/addition of:
        - ▪ Resources
        - ▪ Parts
        - ▪ Workplans
- **■ Node-RED**
    - o Single dashboard implementation
    - o Use of basic palette
    - o Use of OPC UA palette
    - o Use of Dashboard palette
    - o Use of external software to act as a OPC UA client (i.e. *UA Expert*)

Task B is a continuation of Task A, with further upgrades added to a system. In this section, competitors will mostly focus on configuring MES4 software according to a task, as well as adding further functionalities to their node-RED dashboard, that will match requirements of this task.

TASK C – Cyber Security

Technologies involved:
- Networking
- Cyber Security implementation – Net lab kit
  - Use of industrial router Siemens S615
  - Use of managed switch Siemens XC208
- Network analysis using Wireshark software

With a system upgrade completed, Task C introduces cyber security to an Industry 4.0 system. It is vital to secure a CP Lab station from unwanted access and the potential harm it can cause. Using Festo Didactic's Net Lab kit, (See above) competitors will be asked to set up system's network and configure both router and switch, according to specification given.

Note

Net Lab system will be introduced to all teams who have been invited to National Finals prior to competition, during one of training camps.

TASK D – Energy Measurement Box

Technologies involved:
- Energy Measurements Box (EMB)
- Node-RED
  - Single dashboard implementation
  - Use of basic palette
  - Use of OPC UA palette
  - Use of Dashboard palette
  - Use of external software to act as a OPC UA client (i.e., *UA Expert*)

With the system successfully upgraded and its network secured, a further optimization is required by implementing an Energy Measurement Box that is used to keep track of energy and air consumption. Competitors will be asked to connect the EMB to an existing CP Setup, gain access to consumption data, and present it to an end-user using Node-RED dashboard.

Note

Energy Measurement Box system will be introduced to all teams who have been invited to National Finals prior to competition, during one of training camps.

TASK E – Augmented Reality

Technologies involved:
- Festo AR App
- Report
  - Completion of system's documentation
  - Summary of work completed
  - Explanation of different functions to end user

The final task of National Finals involves use of Festo Didactic AR App in conjunction with CP Lab module. With minor changes introduces to its functionality, teams will be asked to document their work, and present its functionalities.

The final report involves providing information on all work completed during National Finals and will provide user with a manual / report that is used as a proof of work that competitors have completed.

Marking overview − National Finals

The following is an example of the marking criteria for the National Finals.

Criteria	Task	Marks
A	System upgrade	25
B	SCADA	20
C	Cyber Security	20
D	Energy Measurement Box	20
E	Augmented Reality	15
	Total Marks	**100**

Equipment Required

Regional Qualifiers

1. Competition equipment is based on Festo Didactic Cyber-Physical Lab (CP Lab in short). This equipment is provided by the organisers.

2. All competitor teams will need to bring their own laptops / computers with installed software packages and valid licences for:
    a. TIA Portal V15.1 or higher (TIA Portal & WinCC Advanced licence)
    b. MES4 software
    c. UA Expert (or other OPC UA client software)
    d. Node-Red, with following palettes:
        i. node-red-contrib-opcua
        ii. node-red-dashboard

3. It is **compulsory** that teams have full administrator's rights on laptops they will be using.
    a. Teams may be disqualified, if they cannot complete tasks, due to user-restrictions

4. While it is not necessary, competitors may bring their own tools, screens etc. to aid their work.

National Finals

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2. All competitor teams will need to bring their own laptops / computers with installed software packages and valid licences for:
    a. TIA Portal V15.1 or higher (TIA Portal & WinCC Advanced licence)
    b. MES4 software
    c. Festo Netlab toolkit
    d. Wireshark
    e. Siemens Proneta
    f. UA Expert (or other OPC UA client software)
    g. Node-Red, with following palettes:
        i. node-red-contrib-opcua
        ii. node-red-dashboard

3. It is **compulsory** that teams have full administrator's rights on laptops they will be using.
    a. Teams may be disqualified, if they cannot complete tasks, due to user-restriction

3. Tablets to use with Festo AR app during task E will be provided by organisers.

4. While it is not necessary, competitors may bring their own tools, screens etc. to aid their work.

Judges Top Tips

1. **Pressure** – despite the stage of competition you will be taking part in, stress will be always involved. It is important to control your nerves and focus on the goal you are about to achieve. When managed, pressure can be good, increasing energy and performance potential.

2. **Time management** - The tasks are all against the clock. So, once you have had your task brief and know how long you have, then quickly plan your workload. Section the aspects of the task into time blocks.

3. **Practice before the competition** – use materials provided by organisers to prepare yourself the best way you can. Try timing yourself and competing with others. Ask for someone to watch and judge your work, while being super critical on your work quality, methods of work and approach.

4. **Think outside the box** – due to problem-solving nature of this competition, you will be asked to complete a task that may have more than just one solution. With the right knowledge of software and equipment, take into consideration all requirements of the task and find the most optimal and best way for you to solve it.

5. **Prepare** – before each stage, make sure you have all equipment and software required for the tasks ahead.

6. **Think of the marks** – each task involves multiple subsections, and some are worth more than others. When task is not going well and you are stuck with a problem, try covering as much as you can on other sections – it may give you those vital points and still secure you a good position.

Practice for Nationals

There are a number of competition test pieces available to download from the WorldSkills UK website.

This is labelled the pre-competition activity. Please ensure you make full use of these in preparing to attend the qualifiers and national finals.

Teams invited to attend national finals will be also given the opportunity to attend a training camp (TBC: August – September 2022). During training camp, competitors will be given an opportunity to use additional modules like Net Lab and Energy Measuring Box – a crucial part of National Finals.

Conclusion

Remember, the competition will be difficult but achievable. There will be a lot of 'self-pressure'. You need to learn how to control this and focus on the task in hand. Once a task is complete, you cannot change the outcome good or bad, start the next task afresh and with positivity. Drink plenty of water throughout the competition, staying hydrated will help with your concentration, focus, and will reduce stress and headaches.

We wish you the best of luck in your competition journey,

Competition Organising Partner

Lead Competition Supplier