MANUFACTURING AND ENGINEERING TECHNOLOGY

Electronics

Technical Description

 TD16 v8.0 WSC2021

worldskills

WorldSkills International, by a resolution of the Competitions Committee and in accordance with the Constitution, the Standing Orders, and the Competition Rules, has adopted the following minimum requirements for this skill for the WorldSkills Competition.

The Technical Description consists of the following:

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1 Introduction

1.1 Name and description of the skill competition

1.1.1 The name of the skill competition is

Electronics

1.1.2 Description of the associated work role(s) or occupation(s).

The electronics industry is very diverse and has evolved into several specialisms. Some Engineering Technicians/Technologists will work across many aspects of electronics but increasing specialization and technical developments means that specialist Engineering Technician/Technologist are widely employed.

The key areas of specialism which can be seen as careers in their own right include the assembly and wiring of electronic products; the designing of prototype circuits to specifications and/or to solve specified technical problems; the installation and commissioning of equipment including the provision of customer support; service and maintenance which includes service at customer/repair/service-depot locations and remotely; and monitoring and testing to specifications: circuits, sub-assemblies and systems. Approving: circuits, sub-assemblies, systems as fit-for-purpose or meeting government regulations.

Electronics Engineering Technician/Technologists also rely on Schematic Capture and Layout software to create/verify/simulate schematic circuits and printed circuit boards. This is a specialised occupation in its own right, and also involves the creation of production documents such as Bills of Material, Gerber Files and Excellon drill files, and other automated equipment files.

Electronics specialists work in a wide range of industries supported by highly technical specialist equipment. Almost every aspect of today's world relies on, or directly uses, electronics technology. It can be said that all technologies today use Electronics in one form or another.

Electronics Engineering Technician/Technologists must work with a high degree of accuracy and precision, conforming to detailed specifications and international quality standards and demonstrating extensive technical ability. Due to the constant developments in technology, the electronics Engineering Technician/Technologist needs to be proactive in ensuring that his/her skills and knowledge are up-to-date and meet industry standards and expectations.

The Engineering Technician/Technologist may work directly with clients and will therefore need to demonstrate excellent customer service and communication skills and work effectively to time schedules. When working with clients, the Engineering Technician/Technologist may have to explain elements of complex electronics principles to assist the client to use equipment correctly. Often the nature of the establishment in which the electronics Engineering Technician/Technologist works will require them to respect confidentiality in relation to highly commercially sensitive information and to demonstrate integrity, honesty, and a strong ethical sense.

The electronics specialist will work with a wide range of tools. These tools are often specialized and include measurement test equipment. Computers and specialist software development tools are used to create programs for embedded systems, programmable devices, and desktop systems. In addition, tasks will also require the use of specialist hand tools for the assembly and maintenance and rework of circuits. Surface mounted technology (SMT) is the dominant technology.

Industry also relies on Engineering Technician/Technologists to implement software solutions used to address manufacturing requirements. Engineering Technician/Technologists may also setup, configure and tune automated assemblies, circuits, systems, and processes.

Embedding microcontroller units (MCUs) into systems forms the basis for Embedded Systems Engineering and is another electronics specialism. Embedded System design involves interfacing MCUs to the outside world via sensors/communication interfaces. It also involves the writing of quality software to perform required tasks.

1.1.3 Number of Competitors per team

Electronics is a single Competitor skill competition.

1.1.4 Age limit of Competitors

The Competitors must not be older than 22 years in the year of the Competition.

1.2 The relevance and significance of this document

This document contains information about the standards required to compete in this skill competition, and the assessment principles, methods and procedures that govern the competition.

Every Expert and Competitor must know and understand this Technical Description.

In the event of any conflict within the different languages of the Technical Descriptions, the English version takes precedence.

1.3 Associated documents

Since this Technical Description contains only skill-specific information it must be used in association with the following:

- WSI – Code of Ethics and Conduct
- WSI – Competition Rules
- WSI – WorldSkills Occupational Standards framework
- WSI – WorldSkills Assessment Strategy
- WSI online resources as indicated in this document
- WorldSkills Health, Safety, and Environment Policy and Regulations.

2 The WorldSkills Occupational Standards (WSOS)

2.1 General notes on the WSOS

The WSOS specifies the knowledge, understanding, and specific skills that underpin international best practice in technical and vocational performance. It should reflect a shared global understanding of what the associated work role(s) or occupation(s) represent for industry and business (www.worldskills.org/WSOS).

The skill competition is intended to reflect international best practice as described by the WSOS, and to the extent that it is able to. The Standard is therefore a guide to the required training and preparation for the skill competition.

In the skill competition the assessment of knowledge and understanding will take place through the assessment of performance. There will only be separate tests of knowledge and understanding where there is an overwhelming reason for these.

The Standard is divided into distinct sections with headings and reference numbers added.

Each section is assigned a percentage of the total marks to indicate its relative importance within the Standards. This is often referred to as the "weighting". The sum of all the percentage marks is 100. The weightings determine the distribution of marks within the Marking Scheme.

Through the Test Project, the Marking Scheme will assess only those skills that are set out in the Standards Specification. They will reflect the Standards as comprehensively as possible within the constraints of the skill competition.

The Marking Scheme will follow the allocation of marks within the Standards to the extent practically possible. A variation of up to five percent is allowed, provided that this does not distort the weightings assigned by the Standards.

2.2 WorldSkills Occupational Standards

Section		Relative importance (%)
1	**Work organization and management**	**10**

The individual needs to know and understand:

- Creativity in the design of circuits, PCB layout, and programming
- Critical thinking in the design of circuits, PCB, fault-finding, and programming
- Honesty and integrity
- Self-motivation
- Problem-solving
- Effective working under pressure
- Health and safety legislation
- Best practices in relation to skills
- The importance of continuing personal development
- Company cultures and procedures and potential variations dependent on national practice

The individual shall be able to:

- Work professionally in relation to the environment and others
- Work with colleagues and teams both in the local environment and remotely
- Present ideas to teams and clients
- Exercise care in the workplace for personal and other's safety
- Take appropriate preventative action to minimize accidents and their impact
- Proactively engage in continuing professional development
- Develop effective record keeping practices to facilitate traceability for future development and maintenance and to comply with international standards
- Interpret and recognise international symbols, diagrams and languages used by other International Standards Institutes Source and purchase components and test equipment to meet specifications and be cost effective
- Write reports and record data about testing techniques, laboratory equipment and specifications to assist engineers
- Communicate effectively with customers
- Train others on the use of installations
- Keep up to date with changes in technology
- Act professionally on clients' premises
- Initiate records for on-going maintenance policy
- Establish maintenance contracts where appropriate

Section		Relative importance (%)
2	**Application of electronics in practice**	**15**

The individual needs to know and understand:

- The various electronics specialisms within specific industries
- Commonly used and International industry standard symbols
- Commonly used units of distance measurement (mils and mm)
- The business environment of the client
- materials and tools of the electronics industry in ordinary servicing, installation, and repair tasks (Electronic Circuit Component Specifications
- Analogue and digital logic circuit and sensor circuit
- AC and DC technology
- Power
- Wire and cables
- Connectors
- Displays
- Circuit Design
- Analysis, of electrical circuits, electronic circuits, digital logic circuits and sensor circuits
- Inductive and capacitive reactance
- Capacitor and inductor characteristic charging and discharging behaviour
- Capacitor selection and suitability to application
- Passive and Active Filters
- Oscillators (RC, Crystal, PLL)
- Multistage Circuits
- Basic amplifier circuits (AC, DC, and power amplifiers)
- Basic Op Amp circuits
- Practical Operational Amplifier considerations. PID Control and servo systems
- Generators and pulse shapers
- Generators for sine wave voltage: RC, quartz, LC oscillators, Wien bridge generator, phase generator
- Pulse shaper: Schmitt trigger, differentiator, and integrator
- Race Conditions
- Truth tables, timing diagrams, karnaugh mapping, boolean algebra, combinational logic, combinational logic applications
- Number systems
- Properties of basic gates AND, OR, NOT, NAND, NOR, EXCLUSIVE OR EXCLUSIVE NOR
- Procedures for substituting basic NAND or NOR gates for basic gates
- Methods for creating digital logic to perform specified operations
- Digital logic equation/functions from given circuits.
- Industry standard waveform measurement characteristics Combinational and sequential logic circuits.
- EMI Shielding techniques
- Electrostatic Discharge (ESD) best practices

Section		Relative importance (%)

	The individual shall be able to:
	• Identify and analyse the appropriate principle for the task
	• Apply cognitive skills as appropriate to the task
	• Use computers as a tool to perform
	  • circuit design, PCB Layout and Simulation
	  • programming of embedded devices
	  • test and measurement of components and circuit operation to given specifications
	  • The control of circuit boards and production machinery
	• Create communication links typically used in embedded systems.
	• Interface MCUs to external devices.
	• Read and interpret engineering drawings, wiring diagrams, schematic drawings, technical manuals, and engineering instructions
	• Install equipment, components, units, upgrades, or refurbished equipment into service	

3	**Prototype hardware design**	**25**
	The individual needs to know and understand: • The application of electronic principles • Specialist (PCB design) software • Design that is fit for purpose • The process of converting a design into actuality	
	The individual shall be able to: • Calculate and select component values that are fit-for-purpose • Implement heatsinking principles • Design modifications to given basic electronics blocks • Design circuits that meet specification and are fit for purpose. • Use computer circuit simulation software to test that circuit designs are fit for purpose. Discuss and interpret design briefs and specifications • Draw schematic circuits using schematic capture and PCB layout software • Use the 3D capabilities of PCB Layout software. • Lay out PCBs using industry best practices • Generate fit-for-purpose PCB manufacturing data. • Assemble components onto PCBs to create functional circuits • Test prototypes and adjust as required • Implement rework and repair mistakes in design to industry standards	

Section		Relative importance (%)
4	**Embedded systems programming**	**25**

The individual needs to know and understand:

- Embedded Systems
- Microcontrollers
- Microcontroller Development Tools
- Integrated Software Development Environments commonly used in industry
- Device Programming methods.
- Programming embedded systems using the C-language and industry best practices
- The application of microcontroller interfacing principles
- Common MCU peripherals Programming and interfaces to external peripherals Power management techniques Watch-dog timers
- Interrupt handling (ISRs) and resets

The individual shall be able to:

- Locate, correct and re-compile syntax errors
- Write, compile, upload, test, and debug C-code that performs to specification.
- Use common C functions
- Use supplied functions
- Write functions to perform a specified task
- Open, compile and upload pre-written code onto embedded systems.
- Modify, debug, download, verify/test pre-written codes on embedded systems
- Design, write, debug, download/upload, and verify/test programs to solve/perform specified tasks
- Use and/or write interrupt handlers (ISRs) and/or polling techniques where appropriate
- Use generally accepted best practices when writing code
- Use pre-written code and/or design and write code that implements power management techniques

Section		Relative importance (%)
5	**Fault finding and repair**	**15**

The individual needs to know and understand:

- The application of electronic principles
- Contexts in which the function of fault finding, testing, repair and measurement takes place. The limitations and applications of test equipment
- Implications of unreliable equipment on business and preventative maintenance
- Techniques used to isolate faults
- Techniques used to make measurements on practical circuits
- Software techniques used in troubleshooting embedded systems
- How to work safely with high voltage and high currents
- Effects of ESD and working safely with ESD sensitive devices
- When to adopt safe and appropriate alternatives, shortcuts, and solutions

The individual shall be able to:

- Check the functionality and calibration of test equipment.
- Select the appropriate equipment to perform measurements.
- Take measurements to test, set, adjust, and measure electronic components, modules, and equipment using measurement equipment that can measure and analyse voltage, currents, and waveforms.
- Determine causes of operating errors and the required action to repair.
- Isolate faults to the component level.
- Adjust/replace/upgrade defective or improperly functioning circuitry and/or electronics components, using hand-tools and through-hole and surface mount soldering techniques
- Test electronics units and components, using standard test equipment
- Analyse results to evaluate performance against specification and determine the need for adjustment
- Record evidence of successful repair
- Collect and analyse the evidence both manually and remotely
- Complete repair reports that record the nature, evidence, cause, and repairs performed on faulty units
- Support the development of preventative maintenance schedules
- Perform preventative maintenance and calibration of equipment and systems
- Use automatic test equipment
- Use digital documentation
- Measure specific electrical parameters with precision and/or plotting variations over time in order to determine correct circuit functionality
- Determine if an electronic component meets specification
- Design and implement test strategies to localize/find faults
- Use computers as a tool to perform test routines, implement test strategies and collect and analyse test data
- Replace components and perform rework to industry standards

Section		Relative importance (%)
	• Replace components or modules with ones not originally designed or intended for use in a PCB or System, to obtain temporary functionality or for use in prototypes	
6	**Assembly and Measurement**	**10**
	The individual needs to know and understand: • Relevant industry standards. • The application of electronic principles • The purposes and functions of components to fulfil required tasks • Typical tools used in electronic assembly • Safe working practices • ESD safe working practices • How to make, save and print accurate DSO measurements	
	The individual shall be able to: • Identify and assemble and use electro-mechanical parts. • Identify and assemble common sensors. Assemble mechanical parts to form working units • Wire and form cables harnesses • Identify, assemble, and use various types of parts and surface mounted device parts • Work to correct sequences and tolerances • Solder components using lead free solder to comply with industry standards • Install, test, and calibrate a completed assembly to customer specifications	
	Total	**100**

3 The Assessment Strategy and Specification

3.1 General guidance

Assessment is governed by the WorldSkills Assessment Strategy. The Strategy establishes the principles and techniques to which WorldSkills assessment and marking must conform.

Expert assessment practice lies at the heart of the WorldSkills Competition. For this reason, it is the subject of continuing professional development and scrutiny. The growth of expertise in assessment will inform the future use and direction of the main assessment instruments used by the WorldSkills Competition: the Marking Scheme, Test Project, and Competition Information System (CIS).

Assessment at the WorldSkills Competition falls into two broad types: measurement and judgement. For both types of assessment, the use of explicit benchmarks against which to assess each Aspect is essential to guarantee quality.

The Marking Scheme must follow the weightings within the Standards. The Test Project is the assessment vehicle for the skill competition, and therefore also follows the Standards. The CIS enables the timely and accurate recording of marks; its capacity for scrutiny, support, and feedback is continuously expanding.

The Marking Scheme, in outline, will lead the process of Test Project design. After this, the Marking Scheme and Test Project will be designed, developed, and verified through an iterative process, to ensure that both together optimize their relationship with the Standards and the Assessment Strategy. They will be agreed by the Experts and submitted to WSI for approval together, in order to demonstrate their quality and conformity with the Standards.

Prior to submission for approval to WSI, the Marking Scheme and Test Project will liaise with the WSI Skill Advisors for quality assurance and to benefit from the capabilities of the CIS.

4 The Marking Scheme

4.1 General guidance

This section describes the role and place of the Marking Scheme, how the Experts will assess Competitors' work as demonstrated through the Test Project, and the procedures and requirements for marking.

The Marking Scheme is the pivotal instrument of the WorldSkills Competition, in that it ties assessment to the standard that represents each skill competition, which itself represents a global occupation. It is designed to allocate marks for each assessed aspect of performance in accordance with the weightings in the Standards.

By reflecting the weightings in the Standards, the Marking Scheme establishes the parameters for the design of the Test Project. Depending on the nature of the skill competition and its assessment needs, it may initially be appropriate to develop the Marking Scheme in more detail as a guide for Test Project design. Alternatively, initial Test Project design can be based on the outline Marking Scheme. From this point onwards the Marking Scheme and Test Project should be developed together.

Section 2.1 above indicates the extent to which the Marking Scheme and Test Project may diverge from the weightings given in the Standards, if there is no practicable alternative.

For integrity and fairness, the Marking Scheme and Test Project are increasingly designed and developed by one or more independent people with relevant expertise. In these instances, the Marking Scheme and Test Project are unseen by Experts until immediately before the start of the skill competition, or competition module. Where the detailed and final Marking Scheme and Test Project are designed by Experts, they must be approved by the whole Expert group prior to submission for independent validation and quality assurance. Please see the Rules for further details.

Experts and Independent Assessors are required to submit their Marking Schemes and Test Projects for review, verification, and validation well in advance of completion. They are also expected to work with their Skill Advisor, reviewers, and verifiers, throughout the design and development process, for quality assurance and in order to take full advantage of the CIS's features.

In all cases a draft Marking Scheme must be entered into the CIS at least eight weeks prior to the Competition. Skill Advisors actively facilitate this process.

4.2 Assessment Criteria

The main headings of the Marking Scheme are the Assessment Criteria. These headings are derived before, or in conjunction with, the Test Project. In some skill competitions the Assessment Criteria may be similar to the section headings in the Standards; in others they may be different. There will normally be between five and nine Assessment Criteria. Whether or not the headings match, the Marking Scheme as a whole must reflect the weightings in the Standards.

Assessment Criteria are created by the person or people developing the Marking Scheme, who are free to define the Criteria that they consider most suited to the assessment and marking of the Test Project. Each Assessment Criterion is defined by a letter (A-I). *The Assessment Criteria, the allocation of marks, and the assessment methods, should not be set out within this Technical Description. This is because the Criteria, allocation of marks, and assessment methods all depend on the nature of the Marking Scheme and Test Project, which is decided after this Technical Description is published.*

The Mark Summary Form generated by the CIS will comprise a list of the Assessment Criteria and Sub Criteria.

The marks allocated to each Criterion will be calculated by the CIS. These will be the cumulative sum of marks given to each Aspect within that Assessment Criterion.

4.3 Sub Criteria

Each Assessment Criterion is divided into one or more Sub Criteria. Each Sub Criterion becomes the heading for a WorldSkills marking form. Each marking form (Sub Criterion) contains Aspects to be assessed and marked by measurement or judgement, or both measurement and judgement.

Each marking form (Sub Criterion) specifies both the day on which it will be marked, and the identity of the marking team.

4.4 Aspects

Each Aspect defines, in detail, a single item to be assessed and marked, together with the marks, and detailed descriptors or instructions as a guide to marking. Each Aspect is assessed either by measurement or by judgement.

The marking form lists, in detail, every Aspect to be marked together with the mark allocated to it. The sum of the marks allocated to each Aspect must fall within the range of marks specified for that section of the Standards. This will be displayed in the Mark Allocation Table of the CIS, in the following format, when the Marking Scheme is reviewed from C-8 weeks. (Section 4.1 refers.)

		CRITERIA								TOTAL MARKS PER SECTION	WSSS MARKS PER SECTION	VARIANCE
		A	B	C	D	E	F	G	H			
STANDARDS SPECIFICATION SECTION	1	5.00								5.00	5.00	0.00
	2		2.00					7.50		9.50	10.00	0.50
	3								11.00	11.00	10.00	1.00
	4			5.00						5.00	5.00	0.00
	5				10.00	10.00	10.00			30.00	30.00	0.00
	6		8.00	5.00				2.50	9.00	24.50	25.00	0.50
	7			10.00				5.00		15.00	15.00	0.00
TOTAL MARKS		5.00	10.00	20.00	10.00	10.00	10.00	15.00	20.00	100.00	100.00	2.00

4.5 Assessment and marking

There is to be one marking team for each Sub Criterion, whether it is assessed and marked by judgement, measurement, or both. The same marking team must assess and mark all Competitors. Where this is impracticable (for example where an action must be done by every Competitor simultaneously, and must be observed doing so), a second tier of assessment and marking will be put in place, with the approval of the Competitions Committee Management Team. The marking teams must be organized to ensure that there is no compatriot marking in any circumstances. (Section 4.6 refers.)

4.6 Assessment and marking using judgement

Judgement uses a scale of 0-3. To apply the scale with rigour and consistency, judgement must be conducted using:

- benchmarks (criteria) for detailed guidance for each Aspect (in words, images, artefacts or separate guidance notes)
- the 0-3 scale to indicate:
  - 0: performance below industry standard
  - 1: performance meets industry standard
  - 2: performance meets and, in specific respects, exceeds industry standard
  - 3: performance wholly exceeds industry standard and is judged as excellent

Three Experts will judge each Aspect, normally simultaneously, and record their scores. A fourth Expert coordinates and supervises the scoring, and checks their validity. They also act as a judge when required to prevent compatriot marking.

4.7 Assessment and marking using measurement

Normally three Experts will be used to assess each aspect, with a fourth Expert supervising. In some circumstances the team may organize itself as two pairs, for dual marking. Unless otherwise stated, only the maximum mark or zero will be awarded. Where they are used, the benchmarks for awarding partial marks will be clearly defined within the Aspect. To avoid errors in calculation or transmission, the CIS provides a large number of automated calculation options, the use of which is mandated.

4.8 The use of measurement and judgement

Decisions regarding the choice of criteria and assessment methods will be made during the design of the competition through the Marking Scheme and Test Project.

4.9 Skill assessment strategy

WorldSkills is committed to continuous improvement. This particularly applies to assessment. The SMT is expected to learn from past and alternative practice and build on the validity and quality of assessment and marking.

1. Hardware Design module – 50 marks

   (a) Phase 1: Development of circuit(s) – 15 marks
   (b) Phase 2: Design of PCB-board layout – 15 marks
   (c) Phase 3: Production and assembly of PCB – 10 marks
   (d) Functionality of PCB prototype to specification – 10 marks

2. Embedded Systems Programming module – 30 marks

   (a) Functionality – 30 marks

3. Fault Finding and Repair module – 20 marks

   (a) Finding faults and evidence – 15 marks
   (b) Repairing to Rework standard (IPC-7711A/7721A) – 5 marks

4.10 Skill assessment procedures

Assessment and marking are an intense process that depends upon skilful leadership, management, and scrutiny.

Groups of Experts are formed for each of the three (3) modules to be assessed.

- Chief Expert allocates four (4) Experts for each sub criteria to assess
- Chief Expert nominates an assessment team leader for each sub criteria. The assessment team leader is responsible for the recording of results.
- One Expert in each marking group needs to be fluent in English;
- The Independent Test Project Designer proposes the outline of the marking standard to the project marking group;
- Experts start marking after the end of each module. Each Expert marking group can organize the marking schedule after consultation with the Chief Expert.
- Experts may not mark their compatriot Competitor. In this case, the assessment team leader will perform this role.
- Assessment is completed each day (if possible).
- Only the Expert marking group for a specific sub criterion assesses the sub criteria. All other Experts may leave the Competition site if they are not involved in assessment. Modules are assessed in the Expert room.
- Where functionality of hardware/PCB is marked, the functionality must be assessed at the workbench of the Competitor. The functionality must be demonstrated by the Competitor.

5 The Test Project

5.1 General notes

Sections 3 and 4 govern the development of the Test Project. These notes are supplementary.

Whether it is a single entity, or a series of stand-alone or connected modules, the Test Project will enable the assessment of the applied knowledge, skills, and behaviours set out in each section of the WSOS.

The purpose of the Test Project is to provide full, balanced, and authentic opportunities for assessment and marking across the Standards, in conjunction with the Marking Scheme. The relationship between the Test Project, Marking Scheme, and Standards will be a key indicator of quality, as will be its relationship with actual work performance.

The Test Project will not cover areas outside the Standards, or affect the balance of marks within the Standards other than in the circumstances indicated by Section 2. This Technical Description will note any issues that affect the Test Project's capacity to support the full range of assessment relative to the Standards. Section 2.1 refers.

The Test Project will enable knowledge and understanding to be assessed solely through their applications within practical work. The Test Project will not assess knowledge of WorldSkills rules and regulations.

Most Test Projects (and Marking Schemes) are now designed and developed independently of the Experts. They are designed and developed either by the Skill Competition Manager, or an Independent Test Project Developer, normally from C-12 months. They are subject to independent review, verification, and validation. (Section 4.1 refers.)

The information provided below will be subject to what is known at the time of completing this Technical Description, and the requirement for confidentiality.

Please refer to the current version of the Competition Rules for further details.

5.2 Format/structure of the Test Project

The Test Project is a series of three (3) standalone or integrated modules.

5.3 Test Project design requirements

Modules may consist of PC boards that include conventional and surface mount components. Wiring, mechanical assembly, subunits may also be included.

Fault Finding and Repair module

Final module is presented at the competition. The block diagram of the module is circulated two (2) months prior to the competition.

The boards may be conventional Through Hole (TH), Surface Mount Technology (SMT), or mixed

technology boards. Surface Mount Devices (SMD) shall have no less than 0.5 mm of pin pitch. And all surface mounted passive devices shall not be smaller than 0805 footprint.

The Independent Test Project Designer will supply at least one working project. The Independent Test Project Designer will demonstrate a functioning project to Experts and Competitors at the competition.

Replacement components for every component in the project is available during the competition. All boards are pre-built prior to the competition. Each board will have a minimum of five (5) faults.

All electronic parts brought to the Competition should be in anti-static bags. Integrated Circuits to be brought in anti-static boxes inserted in anti-static foam.

Hardware Prototype Design module

This module involves three (3) phases.

During phase one the Competitor must design a complete or partial circuit. The circuit(s) may be tested through simulation.

During phase two the Competitor is given a reference schematic design. This circuit schematic is used by the Competitor and a double-sided Printed Circuit Board (PCB) is designed. The Competitor must prepare manufacturing documents: Gerbers, drills files, pdfs, Bills of Material (BOM), etc. The Competitor is given a component library that contains the schematic symbols and footprints needed to complete the PCB except for one or two components. The Competitor is expected to create the schematic symbol, and footprint for these one or two components. The Competitor may use their country's schematic drawings conventions.

All Competitors have to use same CAD programme. The Skill Management Team will select the programme 12 months prior to the Competition after researching suitable programmes.

During phase three the prototype PCB is assembled and tested. If problems/errors in design are recognized at this stage they may be repaired.

The board will primarily use Surface Mount Technology. ICs must have 0.5 mm of pin pitch or greater. All surface mounted passive devices shall have an 0805 footprint or bigger.

Competition time for this module is 9 hr: Phase one 3 hr, Phase two 3 hr, and Phase three 3hr.

The Independent Test Project Designer will bring a functioning sample and all components (with extras). The individual will have a selection of components to choose from in their design. All complex components that may be used have to be identified (along with their datasheets) in the WorldSkills Discussion Forum.

Common fundamental components:

- Op amps and comparators;
- Logic gates (AND, NAND, counters, shift registers, monostables, etc.);
- Passive components (resistors, capacitors, etc.) ;
- Discrete semiconductors (transistors, diodes, zeners etc);
- Opto components (optocouplers, slotted optos, 7 segment displays, etc.); Will not have their data sheets provided in advance.

The PCB design rules are supplied during the competition.

The PCB is manufactured at the competition by the Competition Organizer between Competition Day 2 (C2) and the afternoon of Competition Day 3 (C3).

The Hardware Design may contain analogue, digital, and microcontroller(s), or a mixture of such components.

Embedded Systems Programming module

This module has the individual write C code for an embedded system. The embedded MCU is an ARM Cortex M0+: STM32L052.

All Competitors have to use same IDE program (ex. STM32Cube IDE or Keil uVision5). The Skill Management Team will select the programme 12 months prior to the Competition after researching suitable programmes.

The device Programmer is the ST-LINK/V2 or newer.
https://www.st.com/content/st_com/en/products/development-tools/hardware-development-tools/hardware-development-tools-for-stm32/st-link-v2.html

The Independent Test Project Designer may prepare a custom PCB with a connector for the ST-LINK. The Competition Organizer will supply the custom PCB and ST-LINK programmer.

The programme is in C only. Interrupts and Interrupt Service Routines (ISRs) may be used. In-line assembly is not allowed.

If the module includes a complex external component, then the datasheet and software library is provided two (2) months prior to the competition via the WorldSkills Discussion Forum.

Time allowed: 16 hours

MODULE	TIME ALLOWED	SUGGESTED DAY
Hardware Design module	9 hr (3 hr A1, 3 hr A2, 3 hr A3)	A1 and A2 on C1 and A3 C4
Fault Finding and Repair	3 hr	C2
Embedded Systems Programming	4 hr	C3

General notes on modules

Each Independent Test Project Designer of modules will:

- Meet the Test Project design requirements;
- Supply documents that use a minimum number of words;
- Supply a small project brief;
- Supply parts lists; circuit diagrams, data sheet packs.

Project documentation is brought to the Competition on CD/DVD or memory stick in Microsoft Word. The Independent Test Project Designer is encouraged to use illustrations, diagrams, and videos to reduce the amount of text that requires translation.

The Independent Test Project Designer will use MS office tools or software used in the competition to create documentation.

Where possible, circuit diagrams, photographs, line drawings, etc. are used for all modules and wording should be as brief as possible.

Specifications for Test Project modules

All Test Project modules must be powered by +/- 24V or less. Test Projects must be possible to complete using equipment on the IL.

All Test Project modules should be designed to be completed in the time allotted. Any HF, VHF, or higher frequency design or communications must be module based (e.g. Zigbee, 802.11, etc.)

5.4 Test Project development

The Test Project MUST be submitted using the templates provided by WorldSkills International (www.worldskills.org/expertcentre). Use the Word template for text documents and DWG template for drawings.

5.4.1 Who develops the Test Project or modules

The Test Project/modules are developed by an Independent Test Project Designer in collaboration with the Skill Competition Manager.

5.4.2 When is the Test Project developed

The Test Project/modules are developed according to the following timeline:

Time	Activity
At least twelve (12) months prior to the Competition	CAD Programme is released. IDE programme is released.
Two (2) months prior to the first Competition preparation day	If the SD task includes a complex external component, then the datasheet and software library are provided. The fault-finding block diagram is presented.
One (1) month prior to the Competition	The Test Project is sent to the WorldSkills International Skills Competitions Administration Manager.
At the Competition	The Test Project is presented to Experts and Competitors during the briefing at the beginning of each module.

5.5 Test Project initial review and verification

The purpose of a Test Project is to create a challenge for Competitors which authentically represents working life for an outstanding practitioner in an identified occupation. By doing this, the Test Project will apply the Marking Scheme and fully represent the WSOS. In this way it is unique in its context, purpose, activities, and expectations,

To support Test Project design and development, a rigorous quality assurance and design process is in place (Competition Rules sections 10.6-10.7 refer.) Once approved by WorldSkills, the Independent Test Project Designer is expected to identify one or more independent, expert, and trusted individuals initially to review the Designer's ideas and plans, and subsequently to verify the Test Project, prior to validation.

A Skill Advisor will ensure and coordinate this arrangement, to guarantee the timeliness and thoroughness of both initial review, and verification, based on the risk analysis that underpins Section 10.7 of the Competition Rules.

5.6 Test Project validation

The Skill Competition Manager coordinates the validation and will ensure that the Test Project/modules can be completed within the material, equipment, knowledge, and time constraints of Competitors.

5.7 Test Project selection

The Test Project/modules are selected by the Skill Competition Manager.

5.8 Test Project circulation

If applicable, the Test Project is circulated via the website as follows:

The Test Project/modules are not circulated prior to the Competition. The Test Project/modules are presented to Experts and Competitors during the briefing at the beginning of each module.

5.9 Test Project coordination (preparation for Competition)

Coordination of the Test Project/modules is undertaken by the Skill Competition Manager.

5.10 Test Project change

There is no 30% change required to be made to the Test Project/modules at the Competition. Exceptions are amendments to technical errors in the Test Project documents and to infrastructure limitations.

5.11 Material or manufacturer specifications

Specific material and/or manufacturer specifications required to allow the Competitor to complete the Test Project will be supplied by the Competition Organizer and are available from www.worldskills.org/infrastructure located in the Expert Centre. However, note that in some cases details of specific materials and/or manufacturer specifications may remain secret and will not be released prior to the Competition. These such items may include those for fault finding modules or modules not circulated.

This list is continuously updated by the Competition Organizer as new information is available. As it is the policy to not publish details about manufacturer, model, etc. until the Competition Organizer has a signed contract with their sponsor/supplier it is recommended that Experts periodically look at the IL to ensure they don't miss any critical information.

However, the Independent Test Project Designer is expected to identify all tools and equipment needed to complete their Test Project on the Infrastructure List.

6 Skill management and communication

6.1 Discussion Forum

Prior to the Competition, all discussion, communication, collaboration, and decision making regarding the skill competition must take place on the skill specific Discussion Forum (http://forums.worldskills.org). Skill related decisions and communication are only valid if they take place on the forum. The Chief Expert (or an Expert nominated by the Chief Expert) will be the moderator for this Forum. Refer to Competition Rules for the timeline of communication and competition development requirements.

6.2 Competitor information

All information for registered Competitors is available from the Competitor Centre (www.worldskills.org/competitorcentre).

This information includes:

- Competition Rules
- Technical Descriptions
- Mark Summary Form (where applicable)
- Test Projects (where applicable)
- Infrastructure List
- WorldSkills Health, Safety, and Environment Policy and Regulations
- Other Competition-related information

6.3 Test Projects [and Marking Schemes]

Circulated Test Projects will be available from www.worldskills.org/testprojects and the Competitor Centre (www.worldskills.org/competitorcentre).

6.4 Day-to-day management

The day-to-day management of the skill during the Competition is defined in the Skill Management Plan that is created by the Skill Management Team led by the Skill Competition Manager. The Skill Management Team comprises the Skill Competition Manager, Chief Expert, and Deputy Chief Expert. The Skill Management Plan is progressively developed in the six months prior to the Competition and finalized at the Competition by agreement of the Experts. The Skill Management Plan can be viewed in the Expert Centre (www.worldskills.org/expertcentre).

6.5 General best practice procedures

General best practice procedures clearly delineate the difference between what is a best practice procedure and skill-specific rules (section 9). General best practice procedures are those where Experts and Competitors CANNOT be held accountable as a breach to the Competition Rules or skill-specific rules which would have a penalty applied as part of the Issue and Dispute Resolution procedure including the Code of Ethics and Conduct Penalty System. In some cases, general best practice procedures for Competitors may be reflected in the Marking Scheme.

Topic/task	Best practice procedure
Best practice	• Competitors during their work and Experts during the assessment need to follow the Best practices for PCB design document
Standards	• Competitors during their work and Experts during the assessment need to follow the Recording Faults and Repairs document • Experts during the assessment need to follow the WorldSkills Standards for assessment
Tools/infrastructure	• Competitors and Experts must wear ESD straps when handling PCBs and components.

7 Skill-specific safety requirements

Refer to WorldSkills Health, Safety, and Environment Policy and Regulations for Host country or region regulations.

Task	Sturdy shoes with closed toe and heel with	Safety glasses with both protective sides	Dusk mask	Protective Gloves (with no breakage)	ESD robe
General PPE for safe areas	√				
At the workbench	√	Optional			√
Soldering, cutting, machining	√	√	√		√
Work with hazardous substances (e.g. cleaning)	√	√	√	√	√

8 Materials and equipment

8.1 Infrastructure List

The Infrastructure List details all equipment, materials, and facilities provided by the Competition Organizer.

The Infrastructure List is available at www.worldskills.org/infrastructure.

The Infrastructure List specifies the items and quantities requested by the Skill Management Team for the next Competition. The Competition Organizer will progressively update the Infrastructure List specifying the actual quantity, type, brand, and model of the items. Note that in some cases details of specific materials and/or manufacturer specifications may remain secret and will not be released prior to the Competition. These such items may include those for fault finding modules or modules not circulated.

At each Competition, the Skill Management Team must review and update the Infrastructure List in preparation for the next Competition. The Skill Competition Manager must advise the Director of Skills Competitions of any increases in space and/or equipment.

At each Competition, the Technical Observer must audit the Infrastructure List that was used at that Competition.

The Infrastructure List does not include items that Competitors and/or Experts are required to bring and items that Competitors are not allowed to bring – they are specified below.

8.2 Competitors toolbox

Competitors are not allowed to send a toolbox to the Competition. All tools are provided by the Competition Organizer.

8.3 Materials, equipment, and tools supplied by Competitors

It is not applicable for the Electronics skill competition for Competitors to bring materials, equipment, and tools to the Competition.

However, Competitors are required to supply their own Personal Protective Equipment as specified in section 7 skill-specific safety requirements.

Competitors are allowed to bring:

- Competitors can bring their own non-programmable standard keyboard.
- Music data files which are made available to all Competitors for the Competition days.

Native language to English translation dictionary

- Competitors can use a commonly available English to native language dictionary during the Competition. They cannot use custom or subject specific dictionaries.
- The dictionary must be in paper form, electronic dictionaries are not allowed if it is not provided by the Competition Organizer.

8.4 Materials, equipment, and tools supplied by Experts

Experts are not required to bring materials, equipment, or tools. All is supplied by the Competition Organizer.

Experts are required to supply their own Personal Protective Equipment as specified in section 7 skill-specific safety requirements.

8.5 Materials and equipment prohibited in the skill area

Competitors and Experts are prohibited to bring any materials or equipment not listed in section 8.3 and section 8.4 .

Materials, equipment, and tools supplied by Competition Organizer

The Competition Organizer will supply all the items on the IL.

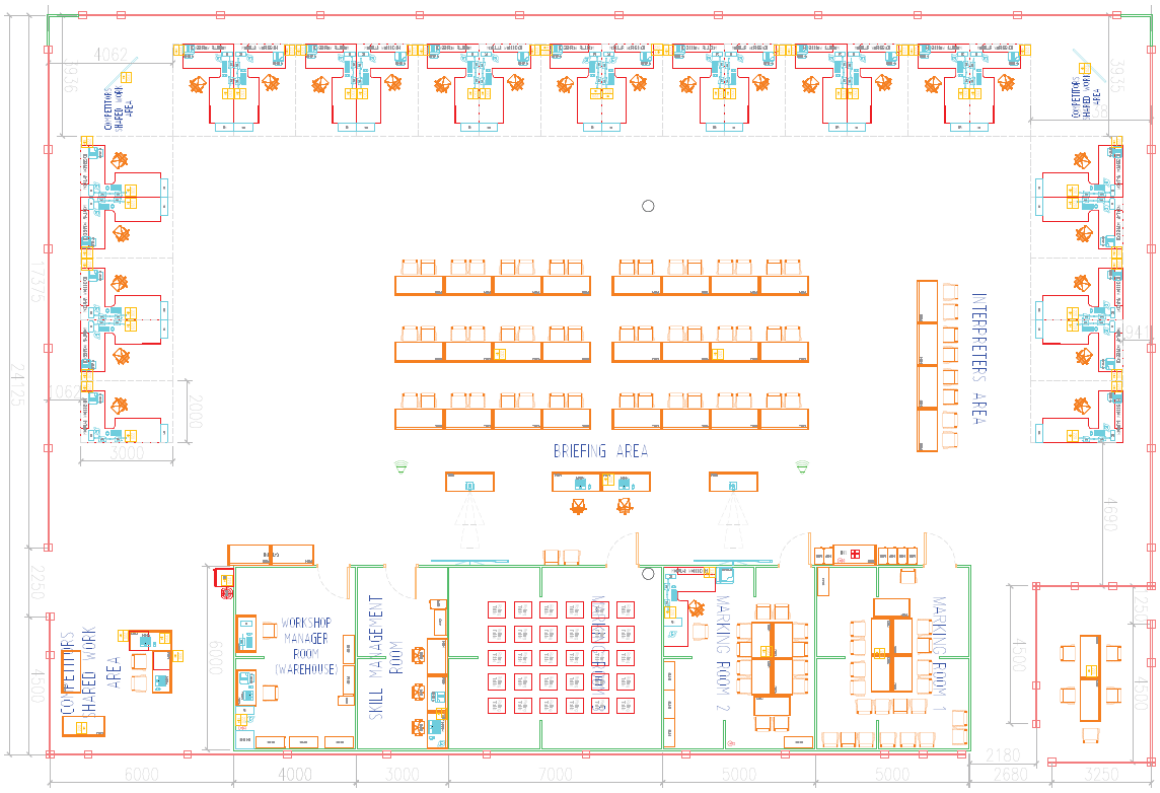
Computers supplied by the Competition Organizer will use the current version of Windows capable of supporting software used in the competition. Windows to be installed and use of English language. The Competition Organizer will install the software required for the competition and use the English language version.

If the Competitor does not bring their own keyboard a standard US layout keyboard is used. Competitors are allowed to change keyboard language to their personal preference. Competitors are allowed to place stickers on keys.

8.6 Proposed workshop and workstation layouts

Workshop layouts from previous competitions are available at www.worldskills.org/sitelayout.

Example workshop layout



9 Skill-specific rules

Skill-specific rules cannot contradict or take priority over the Competition Rules. They do provide specific details and clarity in areas that may vary from skill competition to skill competition. This includes but is not limited to personal IT equipment, data storage devices, Internet access, procedures and workflow, and documentation management and distribution. Breaches of these rules will be solved according to the Issue and Dispute Resolution procedure including the Code of Ethics and Conduct Penalty System.

Topic/task	Skill-specific rules
Use of technology – USB, memory sticks	• Competitors, Experts, and Interpreters are only allowed to use memory sticks provided by the Competition Organizer. No other memory sticks are to be inserted into the Competitor computers. • Competition memory sticks or any other portable memory devices must not be taken outside the workshop. • Competition memory sticks or other portable memory devices must be submitted to the Chief Expert at the end of each day for safe keeping. • Note: The Competition Organizer may use specific software to check that the three previous rules are strictly followed. • The Chief Expert, Deputy Chief Expert, and Skill Competition Manager are exempt from this rule.
Use of technology – personal laptops, tablets, and mobile phones	• Competitors, Experts, and Interpreters are not allowed to bring personal laptops, tablets, or mobile phones into the workshop from C-4 until C4. • If Competitors, Expert, and Interpreters do bring these items into the workshop they must place them in their locker. They can use them at break times and take at the end of each day.
Use of technology – personal photo and video taking devices	• Competitors, Chief Expert, Deputy Chief Expert, Experts, Workshop Manager, and Interpreters are not allowed to use personal photo and video recording devices in the workshop before the competition modules begin and during the translation and presentation of the module by the independent designer. • Once competition begins Competitors may not use photo and video recording devices. • Competitors, Experts, Interpreters, Workshop Manager, and visitors should obtain the consent of one of the Skill Management Team and those they wish to photograph.

10 Visitor and media engagement

Following is a list of possible ways to maximize visitor and media engagement:

- Try-a-Skill;
- Display screens outlining the tasks being performed;
- Test Project descriptions;
- Competitor profiles;
- Career opportunities;
- Daily reporting of Competition status;
- Display of interesting electronic project;
- Display of past Test Projects;
- Electronic Game visitors can play;
- Encourage Independent Test Project Designer to develop Test Projects that are visually interesting and exciting;
- Encourage Independent Test Project Designer to allow open-ended solutions to tasks;
- Sponsor install a mini working electronic production line close to the competition area

11 Sustainability

This skill competition will focus on the sustainable practices below:

- Recycling;
  - Using project from previous competition for different tasks;
  - Encourage use of industry donated components;
  - Use datasheets in PDF form
- Use of "green" materials – e.g. lead-free solder is used;
- Competition tasks Host Country funding;
- Use of components available from global suppliers;
- Ensure that all items on IL are used

12 References for industry consultation

WorldSkills is committed to ensuring that the WorldSkills Occupational Standards fully reflect the dynamism of internationally recognized best practice in industry and business. To do this WorldSkills approaches a number of organizations across the world that can offer feedback on the draft Description of the Associated Role and WorldSkills Occupational Standards on a two-yearly cycle.

In parallel to this, WSI consults three international occupational classifications and databases:

- ISCO-08: (http://www.ilo.org/public/english/bureau/stat/isco/isco08/) ILO 3114
- ESCO: (https://ec.europa.eu/esco/portal/home)
- O*NET OnLine (www.**onet**online.org/)

This WSOS (Section 2) appears most closely to relate to a *Microelectronics Engineering Technician*: http://data.europa.eu/esco/occupation/0ea36a48-a27d-4515-b61f-3cab395cf60f

and/or *Electronics Engineering Technicians:* https://www.onetonline.org/link/summary/17-3023.01.

These links can also be used to explore adjacent occupations.

The following table indicates which organizations were approached and provided valuable feedback for the Description of the Associated Role and WorldSkills Occupational Standards in place for WorldSkills Shanghai 2021.

Organization	Contact name
National Instruments (Global)	Ilya Stepanenko, Engineering Project Manager
«Rosenergoatom» Joint Stock Company (Electric Power Division of Rosatom) (Global)	Vadim Tukmachov, Chief of the Industry Skill Center