Agreed by /*Signature*/

Skill Competition Manager: T.Yu. Karpova
Date September 1, 2019

Test Project

Skill

UAV OPERATION

Age group 14–16 years old

Number of hours allotted for the test project	*Number of modules*	*Number of competition days*
12 hours	5 modules	**3** days

The Test Project includes the following sections:

1. INTRODUCTION. COMPETITION FORMATS
2. TEST PROJECT MODULES AND TIME REQUIRED
3. UAV COMMISSIONING
4. TEST PROJECT DESCRIPTION BY MODULE
5. ANNEXES

Expert and Competitor must read and understand this Test Project prior to the start of the competition.

1. INTRODUCTION

1.1 RELATED DOCUMENTS:

The Test Project is a part of the general package of technical documentation for the skill. It contains only specific information on the Test Project implementation.

The Test Project document must be used together with the following documents:

- WSI, WSR — Regulatory documentation for holding competitions, internet resources;
- WSI, WSR — policy and statutory regulations;
- Code of Ethics and Conduct;
- WSSS — WorldSkills Standards Specification;
- Equipment instructions with technical characteristics;
- Industry-specific sanitary standards and Labor Safety and OHSE requirements adopted in the Russian Federation;
- OHSE instructions for the skill, taking into account the specifics of each age group;
- Recommended competition documentation, 2019–2020;
- Technical Description of the skill.

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1.2 FORMS OF PARTICIPATION IN THE COMPETITION

1.2.1 Competitor form of participation: **Individual — 1 person.**

1.3 Professional skill name:

UAV Operation

1.4 Unmanned aerial vehicles are at the peak of technological trends.

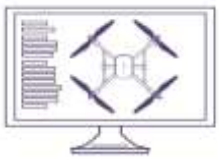
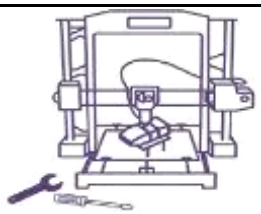
This profession combines an operational component with a high-tech one. There is clearly a trend towards digital. The modern-day UAV specialist shall have a wide range of knowledge in the areas covered by the WSSS sections:

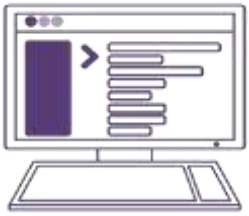
- Organization of activities and safety.
- Communication and work with people.
- Work with equipment, tools and materials.
- Process development / management and creativity.
- Supporting and regulatory documents.

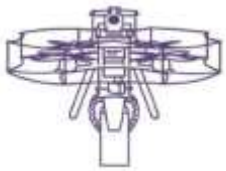
The future UAV operator should understand the peculiarities of the profession and improve their basic skills:

- Designing and modeling new modifications and specific units of UAVs, including the multirotor type systems;
- Methods for manufacturing them using digital equipment;
- Maintenance of UAV, installation of individual components, assembly, diagnostics, upkeep/repairs of UAV;
- The purpose and use of payload for performing specific flight missions;
- Piloting in all conditions, visual, FPV;
- Air cargo transportation methods;
- Automatic adjustment of all systems;
- Autonomous flight programming;
- Promotion of new unmanned technologies.

2. TEST PROJECT MODULES AND TIME REQUIRED

Module		Task description	Time:	Points
B	 **FPV guidance**	Installation and configuration of a video camera and video transmitter	***1 h***	**12**
		Test flight		
		Accuracy and speed when passing along the route in FPV mode		
		De-installing the video camera and the video transmitter, assembling the copter to the standard form		
C	 **Copter unit modeling**	Modeling of separate quadcopter parts and units, fasteners and payload elements	***2 h***	**12**
		Preparation of models for manufacturing		
G	 **Copter unit manufacturing**	***3D printer operation time will not be counted in the competition time***	***2 h***	**8**
		Unit manufacturing, finishing		
		Assembly, configuration of the copter unit		
		Demonstration and testing of the unit		

F	 **Autonomous flight programming**	Modifying the copter design, installation of additional equipment	***4 h***	**18**
		Programming an autonomous UAV flight in a confined space		
		Flight through check points		
		Safe and accurate UAV landing		
		Equipment dismantling; copter assembly to its standard form		

H	 **Operation with payload**	Modifying the copter design, installation of external payload	***2 h***	**12**
		Setting up an external payload		
		Test flight		
		Performing tasks with payload (capture and transfer of cargo / delivery / moving items)		

The Competitor has the right to complete or deliver the module before the allotted time

5 modules	*3 competition days*	***12*** *hours*	***62*** *points*

3.4 The following general rules apply to performance of the Test Project

Permitted actions	Forbidden actions	Penalties
Use the built-in reference information	Use the Internet (if it is not specified in the Test Project for a specific module)	Points scored by the competitor for this module are nullified in case of unauthorized use of the Internet resources
Use instructions from the Skill Management Team	Use own storage media, notes, and instructions	Penalty according to the Technical Description
Make notes in the Test Project files that the competitors receive	Installation of prepared programs and finished codes on the competitor's laptop and their use in the competition	In case of violation of this rule, points scored by the competitors for flight programming are nullified

3. UAV COMMISSIONING

3.1 Before switching on, the unit shall meet the safety standards and have a certificate of conformity.

3.2 The following UAVs are cleared for flight in any part (module) of the Test Project:

- Fully functional UAVs.
- All structural elements are securely fastened.
- Wire insulation and structural integrity are not compromised.
- Units with a valid battery charge.
- No part of the UAV shall be exposed to the propeller rotation range.

!!! THE FOLLOWING IS FORBIDDEN:
Powering up the UAV with installed propellers outside of the flight zone!

3.3 If a hardware part of the UAV is changed during performance of the Test Project, in order for it to receive clearance for take-off, the competitor must:

- Perform pre-flight preparation, specifying the actions taken on the pre-flight sheet.
- Ensure that the pre-flight sheet is signed by an expert.

4. TEST PROJECT DESCRIPTION BY MODULE

4.1 *Module B* FPV guidance

4.1.1 Completion time: 1 hour.

4.1.2 Assessment: measurement, judgment aspects.

4.1.3 Test Project:

No.	Task	Time:	Assessment
1	Installation and configuration of equipment for FPV flights	30 min	measurement
2	Pre-flight preparation	20 min	measurement
	— Visual UAV inspection, calibration		
	— Check of integrity of the units and the reliability of attachments		
	— Video transmission system check, VTX channel configuration, testing in the flight zone		
3	Entry into the flight zone, checking of the video transmission system, test take-off/landing Passage of the route in FPV mode. To be assessed: accuracy, speed, trajectory calculation and tactics elaboration, UAV integrity at the end of the flight	10 min	measurement, judgement
4	De-installing the video camera and the video transmitter, assembling the copter to the standard form	20 min	Performed outside the competition time, not evaluated
	Total module performance time	**1 hour**	

4.2.4 Equipment used:	
	Training quadcopter kit for the UAV Operation skill, COEX Klever 4 WorldSkills Russia
	FPV equipment - *camera, VTX, FPV headpiece/glasses* from the competitor's toolbox according to the skill TD
	Tool kit
	Software: QgroundControl, Arduino IDE

4.2.5 Mystery challenge: Route, obstacles and nature of the cargo.

4.2.6 Module performance conditions:

- FPV headpiece/glasses shall be fixed on the pilot's head during the flight. The use of a separate screen is not allowed.
- The competitors are situated in specially designated pilot zones.
- The competitors must set up the video transmission channel specified before the start of the module.
- Several competitors are allowed to fly along the route at the same time.

4.2.7 Flight timing

Experts control the priority and access to the flight zone.
Any actions may be performed only with the permission and under the control of an expert

- Test flights may be performed for the duration of the Test Project performance time (1 hour 10 minutes). The number of attempts is not limited within the total competition time of the module and the sequence.
- The test flight time is 2 minutes from the moment of entering the flight zone. In the absence of a queue, it is allowed to repeat the test flight (up to 2 minutes).
- Pre-flight preparation time before the test flight is 2 minutes (flights are allowed only within the take-off and landing zone). Flying through obstacles is prohibited. In case of flying through an obstacle, the competitor is deprived of the right to further testing before the scoring attempt.
- The time of the scoring flight is 3 minutes.
- The time is not stopped for elimination of any breakdowns which occur or are discovered during performance of the scoring attempt.
- The competitor is allowed to enter the flight zone during the scoring flights to repair / turn over / put the copter on the ground in accordance with the safety regulations. The timer does not stop.
- At the end of the assigned time (60 minutes), the scoring flights will be carried out in a random order according to the degree of preparedness of the Competitors.

4.2.8 Expected module performance result:

- FPV equipment is installed on the UAV.
- The video transmission channels are set up and the equipment is functioning.
- The competitor has checked the efficiency of the equipment at the polygon.
- UAV made 2 laps along the route in FPV mode in the shortest time.
  The lap is considered completed when all obstacles have been passed according to the route layout. Points are awarded for passing each element in the prescribed manner. No points are awarded for skipping or flying over an obstacle on the wrong side.
- During the flight, the UAV did not touch the grid, the floor, or elements along the route.
  The Competitor is required to specify the STOP point to check the video transmission system operability before the first ACC connection.

4.2.10 Counting penalties for the module:

- If the competitor is not able to complete the task on his/her own, the installation and adjustment shall be performed by the compatriot expert or the technical expert on his/her behalf.
- In this case, the competitor will be charged with a penalty to the amount of 25% of the points he/she gained for this module.
- Points for the equipment installation and adjustment will also not be awarded.

Task	Expert signature		
FPV camera is installed on the UAV			
Video transmitter (VTX) is installed on the UAV			
Video transmitter antenna is installed			
Video stream output to FPV headpiece/glasses has been demonstrated			
Video transmission channel (specify _____)			
The transponder is mounted on the copter			
Demonstration of the transponder operation			

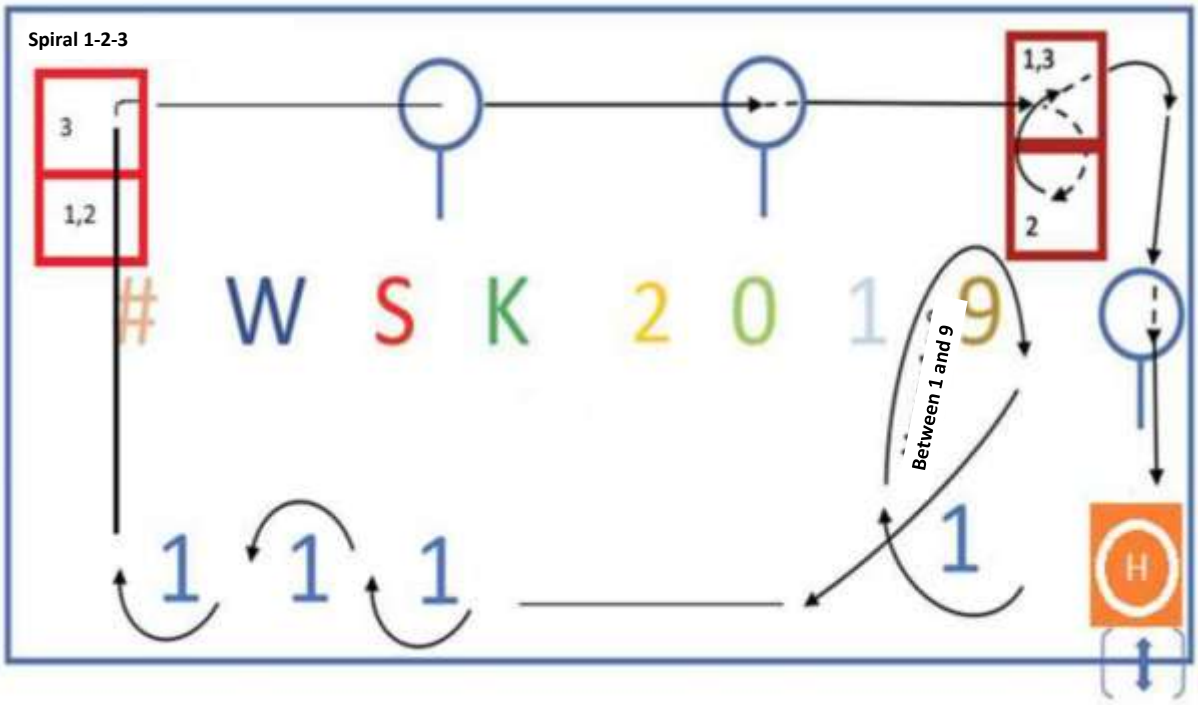
4.2.11 Obstacle course / route:

Take-off and landing area, flight direction indicators, arched gate, turning flags, single or double level gate, penta gate, suspension hoops/windows and other elements (lighting, flight direction arrows, flyover sensors, action cams)

*The track simulates a closed unexplored space — a maze. In the maze, the competitor must find an item (cargo) using the camera, grab it and carry it out of the boundaries of the limited space. Grabbing is performed with **the gripper** developed in the Modeling module.*

4.2.12 Example of a polygon with the mission description:

Fly 2 laps within 3 minutes as fast as possible without missing the obstacles and without touching the grid, floor, or route elements.



4.3 *Module C* Copter unit modeling

4.3.1 Completion time: 3 hours.

4.3.2 Assessment: measurement, judgment aspects.

4.3.3 Test Project:

No.	Task	Time:	Assessment
1	Development of the correct scheme of the unit and mechanism operation (a circuit diagram for the use of electronic components)	30 min	measurement, judgement
2	Unit modeling, drawing preparation, and visualization	100 min	measurement
3	Preparation of files for 3D printing. Preparation of an explanatory note. Preparation of documentation for handing in to experts.	50 min	measurement
4	Printing of a test sample (stays with the competitor)		
	Total module performance time	**3 hrs**	

4.3.4 Equipment used:

Copter, electronic components (sensors, resistors, transistors, diodes, etc.), computer, microcomputers and microcontrollers, measuring instruments.

4.3.5 Mystery challenge:

The competitors have to develop a unit that is unknown to the competitors (for example: a unit for determining the distance to objects and collision avoidance that stabilizes the suspension for the camera).

4.3.6 Within this module, the competitors shall:

- Use the software to make sure whether it is possible to manufacture the developed unit using the provided equipment and expendables within the time allotted for printing (3 hours);
- Proceeding from the conditions of the Test Project, define a list of equipment required for developing and manufacturing the unit;
- Build an editable computer model suitable for subsequent manufacturing.
- Check if the simulated unit can be printed using specialized software (perform model slicing).

4.3.7 Module performance conditions:

- During the testing of the equipment in C-1, the competitor tests the printing on the 3D printer which will be used for manufacture (maximum 30 minutes).

  In the first 30 minutes of the module, the competitor may perform test printing on the 3D printer which will be used for manufacture (**maximum 30 minutes**). The manufactured sample will be handed out to the competitor **40 minutes** prior to the module completion. The competitor may hand over an STL (a few parts) or a file with the print parameters in .plgx format for test printing, but the total printing time shall be no more than 30 minutes per competitor.

Competitor	Expert
May use any slicer program to generate gCode. (PolygonX)	Save the file prepared by the competitor for printing on a flash drive
Preparation of STL files	Finally, the print file is created by the expert responsible for 3D printing, (based on the competitor's file)
Demonstrate the folder with the Test Project execution files	**Register the list of files (PrintScreen).** The PrintScreen shall display the following: a. *Folder path* b. *File names* c. *File type (format)* d. *File modification date*
	Save the files and printscreens of the competitor to a flash drive
As a result of the module, two sets of the manufactured parts will be created:	
Set A: Competitor's printing settings have been used	***Set B***: Technical Expert's printing settings have been used

4.3.7. Specifications of the built polygonal model:

- The computer model built by the competitor shall be:
  - - Three-dimensional, fully integrated and editable
  - - Model elements must be interconnected
- The model must allow for subsequent work to determine its parameters and make changes
- The model can be simulated in assembly format (consisting of several parts). Number of parts in final assembly (5 maximum)
- Units of measurement: linear: mm; angular: degrees
- Approximate printing time (maximum 3 hours) when filling at least 30%, layer thickness at least 0.2 mm, 45 mm/sec
- Wall thickness of the part is at least 1 mm
- Dimensions of parts available for printing are maximum 200x200x200

4.3.8 Subject to assessment

- Visualization available
- Model functionality
- Aesthetics and ergonomics
- Demonstration of the place where the modeled part interfaces with the copter unit
- Drawing of the developed unit
  - *(Indication of overall dimensions of the developed unit,*
  - *Mounting holes of the mating parts of the developed unit,*
  - *Filling in the title block,*
  - *View arrangement,*
  - *General total readability of the drawing, presence of isometric drawings)*

Permitted actions	Forbidden actions	Penalties
Internet is only allowed for ***Autodesk Fusion***	*Use the Internet resources, except as indicated*	Points scored by the competitors for the module are nullified for violation of said rules
The competitor may create paper sketches within the competition time, which will serve as a basis for the three-dimensional modeling of components or units.	*It is forbidden to bring any ready-made sketches or drawings (hard or soft copy) to the competition area which could serve as the basis for three-dimensional modeling of components or units*	

4.3.8 Expected module performance result:

#	Document	Comment
1	Source document of the 3D model *compNassem1 - assembly* *compNpart1 - detail 1* *compNpart2 - detail 2*	3D model of the developed part in the source format. - Names of additional parts may be saved in any form (servo, Arduino, camera, etc.)
2	STL documents *compNassem1.STL;* *compNpart1.STL;* *compNpart2.STL*	3D model of the developed part (and its individual elements) in .stl format Saving individual elements of the part in STL format and compiling them in a single document.
3	Visualization *compNnodeRender.jpg*	Render of the developed part or toned axonometric projection
4	Drawing of the designed unit (.pdf; .jpg; .png) *compNdrawing1.pdf* The drawing shall reflect the following aspects:	**3 projections**: *(additional projections are allowed, provided they contain any information important and necessary for understanding)*
		Isometric projection
		Entering the data into the title block of the drawing *Performed by, Scale, Date, Unit name, Material, Skill)*
		Dimensions
		Mounting holes for mating parts including the frame of the drone or the landing area (runway)
		Plane of symmetry
5	Screenshot of the attachment *compNscreenshotJoin.jpg*	Screenshot of the connection point of the developed part with the drone (.jpg; .png)
6	Unit diagram, *compNschematic.png (jpg)*	Diagram of the unit(s) which shows the operation of the mechanisms
7	Screenshot of the arrangement of parts *compNscreenshotSlice.jpg*	Screenshot of the part arrangement diagram with indication of the print time (.jpg or .png)
8	Explanatory note *compNDescription* *(txt, docx, pptx)*	Information about additional functionality of the developed unit and its general description in a free form (maximum 700 characters). It is allowed to insert any images, diagrams and other materials necessary for clarity and understanding.
9	Document for printing *compNprint.plgx*	The document for printing makes it possible to manufacture the parts according to the competitor's settings.
10	The competitor's work results shall be saved on the desktop: ***C:/Users/USER NAME/Desktop/Competitor No. (COMPETITOR'S NUMBER) Full Name /Module C***	
11	Print file *compNprint.plgx*	Print file makes it possible to manufacture the developed unit strictly according to the preferences of the contestant.

4.3.9 Counting penalties for the module:

If the finished 3D model has critical errors that prevent manufacturing, the competitor is given the opportunity to correct the errors. The correction time is limited to 30 minutes.
The competitor does not receive any points for printing time, module execution time, uploading to STL, creation of .plgx printing file, 25% penalty on points earned for the module.
All other uploaded files will be evaluated before the corrections begin.
The Technical Expert may provide a template blank to switch to the Manufacturing module. In this case, the penalty is initially imposed on the points acquired in the Manufacturing module. The penalty amount is at the experts' discretion.

4.3.10 Technical assignment. *Example:*

Model the copter unit which allows one to determine the distance to the object in two planes with demonstration of light indication.

Technical assignment to be performed

- Rotation angle of the servodrive is 0 to 90 degrees.
- *(0 degrees: distance meter board is parallel to the horizontal plane,*
- *90 degrees: distance meter board is perpendicular to the horizontal plane)*
- The servodrive controls the rotation of the distance meter housing.
- Indication
  - *Green LED: indication of extreme sonar positions*
  - *Red LED: indication of critical distance = 30 cm*
- All components shall be integrated into the housing.
- Compact wire arrangement.
- Possibility for emergency replacement of the distance meter.
- The distance meter shall have protective housing.
- Place of attachment of the developed unit: bottom frame or center frame.
- Type of unit attachment: screw connection.
- Capability to connect the unit to the copter.
  (flight controller, receiver or other).

Unit name	FPV camera housing
General description	**Develop** a device for installing FPV cameras which can help change the rotation angle of the camera using a servodrive
Elements used:	FPV camera, VTX (video transmitter), servodrive
Specification	The servodrive controls the camera rotation angle (0 to 90 degrees)
	Capability of emergency replacement of the camera (maximum 30 sec)
	Capability to adjust the focus
	Capability to change VTX channels
	Components (video transmitter, camera, servodrive) shall have proper holders (seats)
	Point of attachment for the developed element: bottom/top frame
	Mounting type: bolt/screw connection

4.4 *Module G* Installation of the manufactured copter unit

4.4.1 Completion time: 2 hours.

4.4.2 Assessment: measurement, judgment aspects.

4.4.3 Test Project:

No.	Task	Time:	Assessment
1	Unit manufacturing, surface finishing	40 min	measurement, judgement
2	Assembly, installation, configuration of the copter unit	40 min	measurement
3	Installation of the unit onto the UAV	30 min	measurement
4	Demonstration and testing of the unit	10 min	measurement, judgement
	Total module performance time	**2 hrs**	

Printing/milling/cutting time **is not included** in the project performance timing.
The time spent on manufacturing is limited to **3 hours**.

4.4.4 Technology for task performance: 3D printing

Manufacturing of the parts on a 3D printer is carried out and controlled by the technical (process) expert.

4.4.5 Equipment used:

3D printer, copter, computer, microcomputers and microcontrollers, electronic components (sensors, resistors, transistors, diodes, etc.). Some additional equipment like servomotors / stepper motors, electromagnetic gripper, etc. may be provided to the competitors for development of the unit.

4.4.6 Specific features of the Test Project:

The unit is developed as a part of the Copter Unit Modeling module. The Manufacturing module involves finishing, assembly, and installation of the unit onto the copter.

4.4.7 Test Project description:

- Manufacturing of individual parts of the copter units / fasteners/ lifting elements
- Change the assembly of the copter using the manufactured parts, bring this to the operational level, set up;
- Trial (test) flight.
- Discern two messages (a picture with random letters and numbers)
    - *On the wall (vertical)*
    - *On the floor (horizontal)*

4.4.8 Expected module performance result:

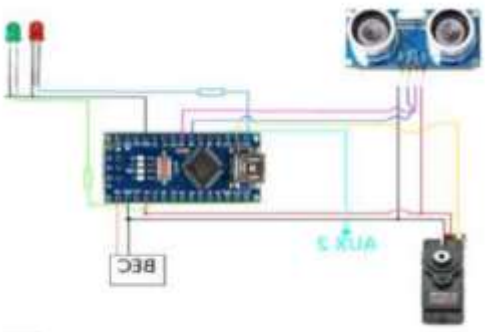
- Control of the manufacturing accuracy has been performed.
- Surfaces of the manufactured units have been finished.
- The circuit has been assembled; the unit is all set up and functions properly.
- The device is installed in the manufactured unit housing.
- The unit is mounted on the quadcopter.
- The unit is paired with the electrical equipment of the quadcopter.
- The assembled unit's performance has been demonstrated to the experts.
- The unit has been tested in the real flight mode.
- The 3D model of the unit submitted by the competitor corresponds to the manufactured unit. If not, the modeling points are not awarded.
- All deliverables, diagrams and drawings have been prepared; the checklists have been signed and handed over to the expert responsible at the end of the module.

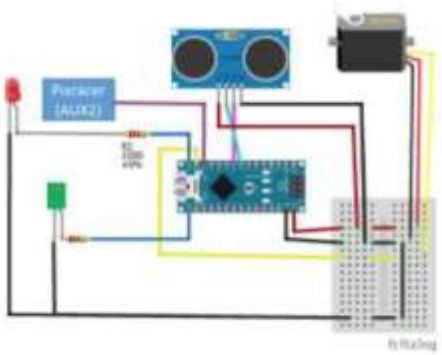
4.4.9 Technical assignment. *Example*

Unit	TECHNICAL ASSIGNMENT *FPV camera housing*
General description	**Manufacture** a device for installing FPV cameras which enables the adjustment of the camera rotation angle using a servodrive
Elements used:	FPV camera, VTX (video transmitter), servodrive
Specification	The servodrive controls the camera rotation angle (0 to 90 degrees)
	Capability of emergency replacement of the camera (maximum 30 sec)
	Capability to adjust the focus
	Capability to change VTX channels
	Components (video transmitter, camera, servodrive) shall have proper holders (seats)
	Point of attachment for the developed element: bottom/top frame
	Mounting type: bolt/screw connection
Characteristics to be assessed	Versatility, ease of installation, optimal material consumption, etc., originality of the idea, scalability

4.4.10 Project example. Method:

Manufacture the copter unit which allows one to determine the distance to the object in two planes with demonstration of light indication. Example of the method:





4.5 *Module F* Autonomous flight programming

4.5.1 Completion time: 4 hours.

4.5.2 Assessment: measurement, judgment aspects.

4.5.3 Test Project:

No.	Task	Time:	Assessment
Submodule F-1			
1	Installation of the autonomous flight gear onto the UAV. Installation of the camera and the Raspberry Pi, additional equipment	60 min	measurement
2	Equipment configuration (demonstrate to the experts and get a signature)		
	Break (not included in test project time)	15 min	
Submodule F-2			
3	Programming and debugging at the site: transition to Position, autonomous take-off and landing, route passage with addition of on-board indication, completion of the mission in offline mode	170 min	measurement
4	Scoring attempt	10 min	measurement, judgement
	Total module performance time	**4 hrs**	

4.5.4 Equipment of the Test Project performance:

- Training quadcopter kit for the UAV Operation skill, *COEX Klever 4 WorldSkills Russia*
- Laptop, additional sensors compatible with Raspberry Pi
- Navigation system using Aruco tags
- Toolbox, electric magnet, LED strip
- **Software**
  QgroundControl, Python, FileZilla (sftp client), Putty (ssh client).

4.5.5 Module performance conditions:

- The competitor shall be able to switch the copter over to manual control mode in unforeseen situations. This is checked during the test take-off in autonomous mode.
- All installation parameters and a fully set-up operating system image with installed libraries are handed over to the competitors before the module. The original image file is copied to the competitors' laptops. The competitor is entitled to overwrite the image independently.
- No penalty points are awarded. The timer does not stop.
- Reference measurement instruments (rulers) are available on site. The competitors' tools shall be checked against the reference ones on day C-1

4.6.6 Timing of autonomous flights

Flights	Time:		Performance conditions	Flying zone
Registration of parameters and measurements	***5 min***	*limited*	*One or more competitors on the field*	*Aruco Map area*
Trial testing			The number of attempts is unlimited	Any free flight zone
Test take-off	***5 min***	*limited*	"Switching" the copter over to manual control mode by the expert	Any free flight zone
Test flight	***5 min***	*limited*	Counting from entry into the flight zone	Any free flight zone
Program debugging	***7 min***	*limited*	copter "switch-over"	*Aruco Map area*
Preparation for the scoring attempt	***2 min***	*limited*	copter "switch-over"	*Aruco Map area*
Scoring flight	***10 min***	*limited*	Scoring attempt: 1 copter "switch-over"	*Aruco Map area*
	competitor shall make sure that 3 experts are present			
The sequence in which the competitors enter the field is controlled by the experts.				

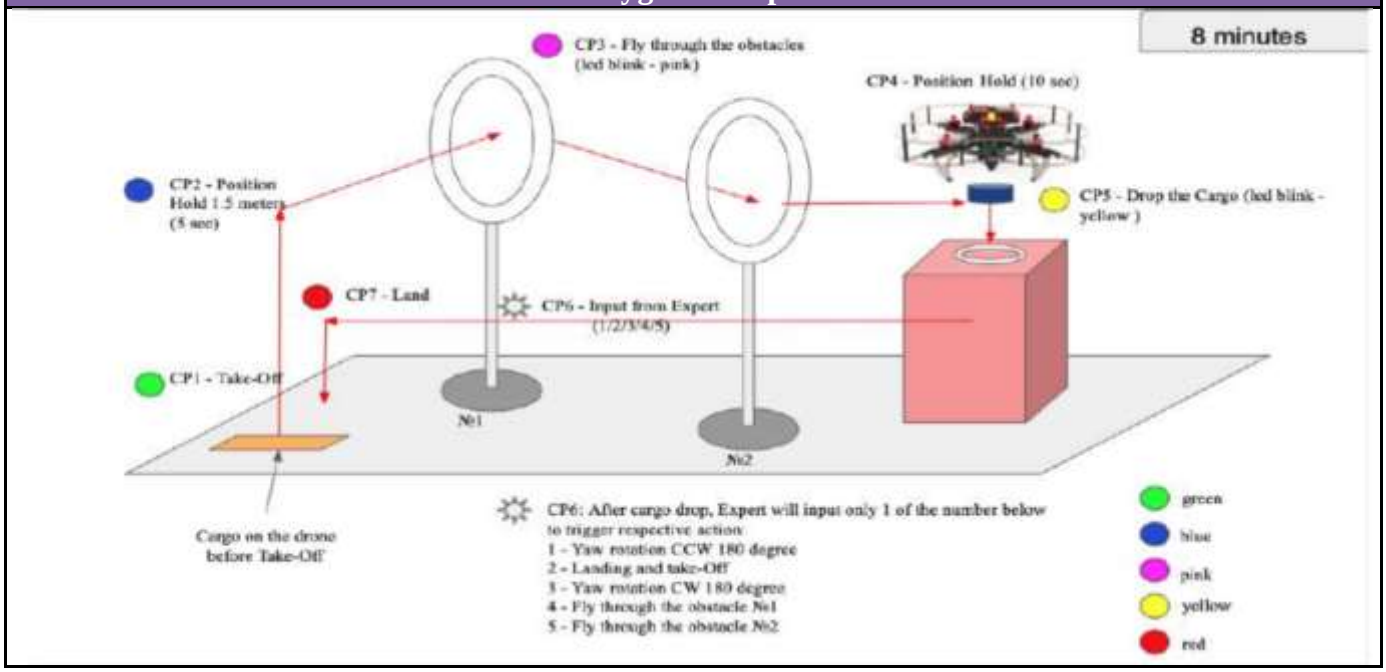
4.6.7 Terms of use of Internet resources

Permitted actions	Forbidden actions	Penalties
Software use: • Putty • Notepad ++ • WinSCP / other SFTP client • Arduino IDE • Etcher • Text editor Any Python programming language shell/development environment	Login to messengers, cloud storage, mail, forums, and social networks. (If a competitor accidentally clicks on a link, it should be closed within 15 seconds)	Points scored by the competitor for this module are nullified if the competitor visits the restricted Internet resources in the module.
Use of built-in documentation	Use one's own media storage. It is forbidden to bring any records to the workstation	Penalty according to the Technical Description
Access to the following Internet resources: - Gitbook, reference books the of Python programming language commands, reference materials on Arduino, ROS, pinout of the boards and sensors used, color codes.	Installation of prepared programs and finished codes on the competitor's laptop and their use in the competition.	Points scored by the competitor for flight programming are nullified.

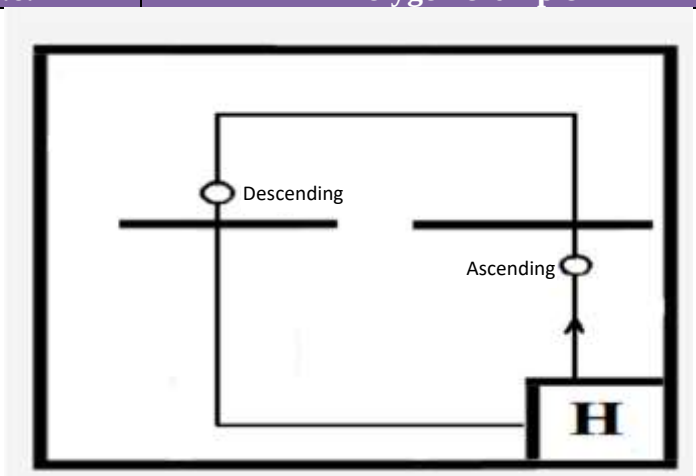
4.6.8 Expected module performance result:

- All of the required equipment is installed on the UAV.
- Operability of the equipment has been demonstrated to the experts. All signatures in the checklists have been obtained within the allotted time.
- The program for autonomous execution of the task by the copter and the flight along the given trajectory has been compiled.
- Autonomous flight along the given trajectory has been performed, with the established mission being accomplished.
- The copter and flash drive with the program code have been handed over to the experts.

4.6.9 Example of a polygon with the mission description: Perform an autonomous flight on the route with the known obstacles, fly around them.

Polygon example


4.6.10 Performing flight tasks in autonomous mode: Fly through the maze in autonomous mode and find the exit using the sensors

4.6.11	Polygon example	Elements of the route
		*Floor ArUco markers used as a navigation system. QR codes / colored floor tags*
		Barriers in the form of screens/barrier elements/walls representing the maze
		Cargo hidden in one of the cells of the maze

	4.6.12 Test Project	Activity	Expert signatures		
Submodule F-1 (70 min)			*Exp1*	*Exp2*	*Exp3*
1	**Installation of the equipment for autonomous UAV flight and** obstacle detection	Install Raspberry Pi 3			
		Install RPi camera			
		Install LED strip			
		Install the electromagnetic gripper			
		Connect power to Raspberry Pi			
		Connect camera to Raspberry Pi			
		Connect LED strips (power supply and signal)			
		Demonstration of the flight mode switching (Stabilize - Position) on SwD			
		Demonstration of emergency shutdown of the motors (Kill Switch) on SwA			
2	**Equipment configuration**	Demonstration of camera operation			
		Camera focus adjustment			
		Demonstrate the LED strip control through the program *- at the competitor's discretion*			
		Demonstrate the connection of RPi and the flight controller			
		Demonstration of availability of software connection between Rpi and the flight controller through the terminal (connected: correct) mavros / state or get telemetry			
		Demonstration of operation of the electromagnetic gripper through the program (terminal) — at the discretion of the competitor (cargo grabbing, delay of 5 seconds, reset)			

- The competitor demonstrates the performance of each Test Project to the experts.
- Experts register the completion of the task and sign the checklist.

Submodule F-1 shall be completed within the designated time and the signed checklist shall be submitted. After the agreed time, no points for said tasks are awarded.

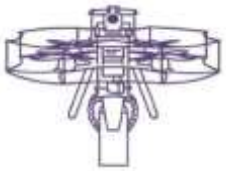
Submodule F-2 (170 mins)					
1	**Test flight in the Position fly mode**	Trial: Hovering over Aruco tag (15 sec)			
		Trial: Safe landing in manual mode			
2	**Writing a program for autonomous flight.** **All actions performed autonomously** **(only on the main field)**	Take-off + LED (green) + cargo lifting			
		Hovering (at least 1.5 m for 5 seconds) + LED (blue/light blue)			
		Flying through obstacle 1 + LED (flashing pink)			
		Flying through obstacle 2 + LED (flashing pink)			
		Hovering (over the drop zone for 10 seconds) + LED (flashing yellow) + dropping the cargo into the cargo receiver			
		Expert typing 1, 2, 3, 4, 5 using the keyboard			
		Correct response of the drone to the command given by the expert			
		Autonomous landing in the landing zone + LED (red)			
3	**Scoring attempt**	According to the Test Project			
4	**Task completion time**	< 6 minutes = **2 points** between 6 min 1 sec and 8 min = **2 points**			
	The competitor shall complete the Test Project (8 min). No second attempt is given.				

Submodule F-2 (Task 1) shall be completed within the assigned time, not counting the time taken on the scoring attempt.

Submodule F-2 (Task 2) shall be performed during the scoring attempt.

- The competitor is allowed to correct the program codes before resuming the flight in case of a failed attempt within the assigned time.
- It is forbidden to make changes in the program codes during the autonomous flight (unless otherwise specified in the task).
- The number of restarts is not limited during the attempt.
- The score will be awarded based on the best restart of all those performed within the assigned time.
- 30 minutes before completion of submodules F1 and F2, the experts walk around the workstations to record the demonstrations specified in the checklist.
- The competitor demonstrates the performance of each Test Project to the experts.
- Experts register the completion of the task and sign the report.
- Tasks are accepted as they are completed by the competitors during the main competition time (not including the bonuses).

Module H Operation with payload



4.7.1 Completion time: 2 hours.

4.7.2 Assessment: measurement, judgment aspects.

4.7.3 Test Project:

No.	Task	Time:	Assessment
1	Modification of the copter design (installing the payload (gripper) on the copter and equipping the payload system with light indications). Equipment configuration	100 min	measurement
2	Pre-flight preparation. Testing of the payload system / gripping device	10 min	measurement
3	Completing flight mission with payload system / gripping device	10 min	measurement
	Total module performance time	**2 hrs**	

4.7.4 Equipment used:	
	Training quadcopter kit for the UAV Operation skill, COEX Klever 4 WorldSkills Russia
	Competitor's toolbox according to the Technical Description of the skill
	Tool kit
	Software: QgroundControl, Arduino IDE

4.7.5 Mystery challenge: Route, obstacles and nature of the cargo.

4.7.6. Module performance conditions:

- Installation and operability of the gripper / payload system, including the light indication, shall be demonstrated to the experts prior to the scoring attempts. Thereafter, no points for installation and configuration will be awarded.
- The flight mission may include:
  - Take-off.
  - Gripping an object.
  - Moving the object within the flight zone.
  - Spraying liquids at the specified points.
  - Flying with cargo through obstacles (1 lap, 10 loads, 10 obstacles) within the specified time (4 min). Pre-flight preparation time before the attempt is 2 minutes (flights along the route, passing elements and grabbing cargo are allowed). Time taken to eliminate any breakdowns which occur or are discovered during performance of the scoring attempt is counted as part of the competitor's competition time (the timer is not stopped). A penalty is charged for touching the floor, grid, or route elements.
  - Landing at the specified place with / without cargo.
- Testing time in the flight zone is 2 minutes. The sequence is controlled by experts. The number of training attempts is no more than 2.

4.7.7 Cargo transfer tasks

- 5 minutes before the end of the module, the experts inspect the demonstrated equipment of the competitors and sign the checklist.
- It is forbidden to make contact with the floor, grid and route elements during the cargo delivery. Contact with the cargo receiver is allowed.
- The checking time before the flight to perform the scoring attempt is 2 minutes. It is allowed to take off and move within the landing area.
- Deliver the cargo to the unloading zone while flying through the obstacles.
- During the scoring attempt
    - The competitor may enter the flight zone to repair the copter
    - The competitor may not touch the balls with his or her hands

If the ball falls to the ground during the flight, the competitor may grab the ball with the gripper and unload it directly into the box without passing through the obstacle.
No points are awarded for passing through an element (obstacle).

4.7.8 Flight timing

Experts control the priority and access to the flight zone.
Any actions may be performed only with the permission and under the control of an expert.

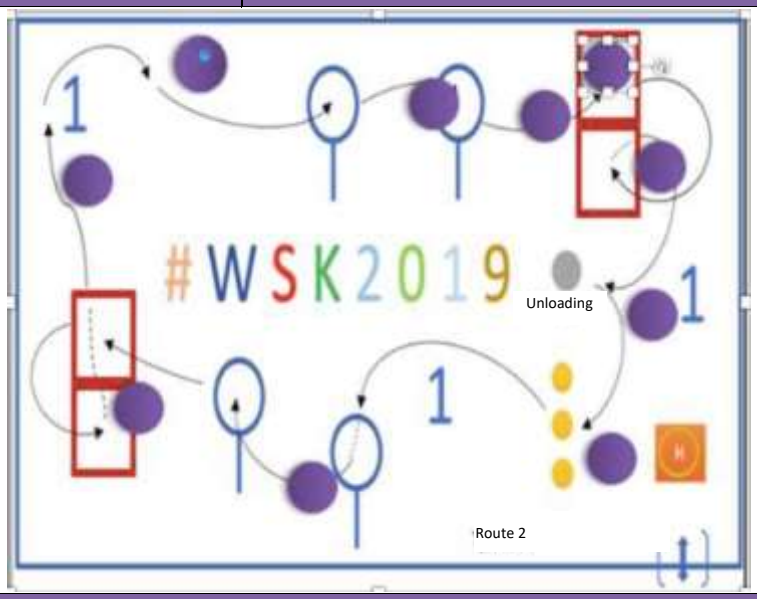
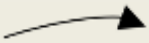
- Test flights may be performed for the duration of the Test Project performance time (1 hour 10 minutes). The number of attempts is not limited within the total competition time of the module and the sequence.
- The test flight time is 2 minutes from the moment of entering the flight zone. In the absence of a queue, it is allowed to repeat the test flight (up to 2 minutes).
- Pre-flight preparation time before the test flight is 2 minutes (flights are allowed only within the take-off and landing zone). Flying through obstacles is prohibited. In case of flying through an obstacle, the competitor is deprived of the right to further testing before the scoring attempt.
- The time of the scoring flight is 3 minutes.
- The time is not stopped for elimination of any breakdowns which occur or are discovered during performance of the scoring attempt.
- The competitor is allowed to enter the flight zone during the scoring flights to repair / turn over / put the copter on the ground in accordance with the safety regulations. The timer does not stop.
- At the end of the assigned time (60 minutes), the scoring flights will be carried out in a random order according to the degree of preparedness of the Competitors.

4.7.9 Expected module performance result:

- All of the required equipment is installed on the UAV.
- Operation of the payload / grabbing system is clearly indicated by the light indication.
- The tasks for transferring / moving the objects on the polygon have been performed (UAV grabbed 10 cargoes, flew with them through the specified obstacles and delivered them to the unloading area within the shortest time).

4.7.10 Example of a polygon with the mission description:

It is required to grab 10 cargoes, fly with each cargo through the obstacles assigned thereto, and deliver all cargoes to the unloading area.

4.7.11 Module G	Exercise No. 1	Unloading accuracy, speed, amount of cargo	
			Cargo delivery location, two areas
			Cargo pick-up point
			Double level gate
			Window, second floor
			Cargo transfer trajectory

Task description	Requirements for the result
The route has 10 points with cargo and 3 unloading locations	Following the route
Grip the cargo at the specified points	The cargo is held in place during the transfer
Transfer the cargo to the unloading area, by flying through the obstacles assigned to the cargoes	No contact is made with the floor, grid, and route elements
Flight mission completion time	Maximum time to perform the task is **4 min**

Counting penalties for the module.

- If the competitor is not able to complete the task on his/her own, the installation and adjustment shall be performed by the compatriot expert or the technical expert on his/her behalf.
- In this case, the competitor will be charged with a penalty to the amount of 25% of the points he/she gained for this module.
- Points for the equipment installation and adjustment will also not be awarded.

ANNEXES TO TP 19-20

Annex 1 **Toolbox**

	Mandatory TOOLBOX	**TO BE BROUGHT ALONG BY COMPETITORS**
	Description	***Link***
1	A screwdriver with a bit set for precise work, FIT 56188	https://www.220-volt.ru/catalog-123104/ or equivalent
2	Mini side cutters (oblique pliers), 115 mm	http://www.fitinstrument.ru/catalog/handtool/4000000/4800000/51000/catalog-view-51025.html
3	Mini pliers, 125 mm	http://www.fitinstrument.ru/catalog/handtool/4000000/4800000/51000/catalog-view-51255.html
4	Fine pliers, 160 mm (Hobbi)	https://mastermarket.info/home/12431-ploskogubcy-fine-160-mm-hobbi.html or equivalent
5	Stripping and wire crimping pliers, 225 mm, Hans 1932-09	http://steelmotors.ru/1932-09 or equivalent
6	REXANT straight fine pointed tweezers, 120 mm. 1202938	http://anlan.ru/catalog/14267 or equivalent
7	Anti-static tweezers	https://air-hobby.ru/katalog/product/1752-pintset-antistaticheskiy.html or equivalent
8	Metal beam caliper, type 1, precision class 2, 125 mm, step of 0.1 mm [3445-125]	http://www.computermarket.ru/main/catalog/catid/1357130.aspx or equivalent
9	Propeller key, 8 mm	https://air-hobby.ru/katalog/product/1864-klyuch-dlya-propellerov.html or equivalent
10	Set of needle files, 160 x 4 mm, 10 pcs, rubber handles MATRIX	http://matrixtm.ru/product/7247/ or equivalent
11	Reinforced knife 25 mm, 5 blades in the set	http://ryazan.vseinstrumenti.ru/ruchnoy-instrument/dlyashtukaturno-otdelochnyh-rabot/stroitelny nozhi/kantselyarskie/inforce/usilennyj-25mm-5-lezvij-vkomplekte-gw-06-02-06/ or equivalent

	Inforce GW 06-02-06	
12	Scalpel knife, 5 spare blades (scalpel)	https://www.chipdip.ru/product1/8420517257 or equivalent
13	Mini end cutting pliers	https://www.ulmart.ru/goods/3554775#tab-reviews or equivalent
14	Mini needle-nose (long-nose) pliers	https://www.sds-group.ru/items_9311.htm or equivalent
15	3–5x mounting magnifying glass	https://www.chipdip.ru/product/ct-7038a or equivalent
16	AA batteries (4 pcs)	http://www.vseinstrumenti.ru/electrika_i_svet/el_teh_prod/batarejki/kosmos/kosmos_element_p or equivalent
17	Measuring tape	https://leroymerlin.ru/product/ruletka-systec-3 or equivalent
18	Soldering equipment	http://chipresistor.ru/product/payalnik-s-regulirovkoy-temperatury-yihua-907/ or equivalent
19	Safety coat	https://global-sp.ru/products/khalat_rabochiy_muzhskoy_be or equivalent
20	Transparent safety goggles	http://www.vseinstrumenti.ru/spetsodez or equivalent
21	Multimeter	http://www.vseinstrumenti.ru/instrument/izmeritelnyj/multimetry/mastech/tsifrovoj_multimetr_ equivalent
22	FPV camera	https://air-hobby.ru/katalog/product/2512-kamera-kingkong-199c.html or equivalent
23	Lens for FPV camera	https://air-hobby.ru/katalog/product/2257-linza-runcam-dlya-micro-kamer-fov-145-degree-13q-2
24	5.8 GHz FPV transmitter	https://air-hobby.ru/katalog/product/914-peredatchik-fpv-58-ghz-ts832-40ch-race-band.html or e
25	FPV video receiver	https://air-hobby.ru/katalog/product/2587-fpv-shlem-c-dvr-ls800d-40ch.html or equivalent
26	Training quadcopter kit for the UAV Operation skill, COEX Klever 4 WorldSkills Russia	https://copterexpress.ru/
26	Repair set for the entire COEX Klever 4 quadcopter range	https://copterexpress.ru/
27	Software for 2D and 3D design (on	SolidWorks/ Inventor/ Компас/ AutoCad/ CorelDraw/ Fusion, or equivalent

	the USB stick)	

- Items 22, 23,24,25 are permissible.
- Competitors who do not have this equipment will be provided with standard equipment according to the general IL.
- The competitor shall check the equipment / tools issued to him or her and sign the report.

Annex D3

List of multi-rotor UAV elements

No.	Description	Type	No.	Description	Type
HOUSING ELEMENTS					
1	Central frame		4	Protection of propellers No. (1–4)	
2	Additional lower/upper frame		5	Beam protection No. (1-4)	
3	Beam No. (1 to 4)		6	Leg No. (1 to 4)	
FIXATION (MOUNTING) PARTS					
1	Post, 40 mm		4	Stiffness plate	
2	Post, 6 mm		5	Attachment for battery	
3	Screw M3		6	LED strip attachment	
ELECTRONICS					
1	Flight controller (Pixracer)		4	Post, 20 mm	
2	Single-board computer (Raspberry PI)		5	Flat cable for connection of radio receiver set	
3	Micro-controller (Arduino Nano)		6	Power supply cable	

Annex D3

List of multi-rotor UAV elements

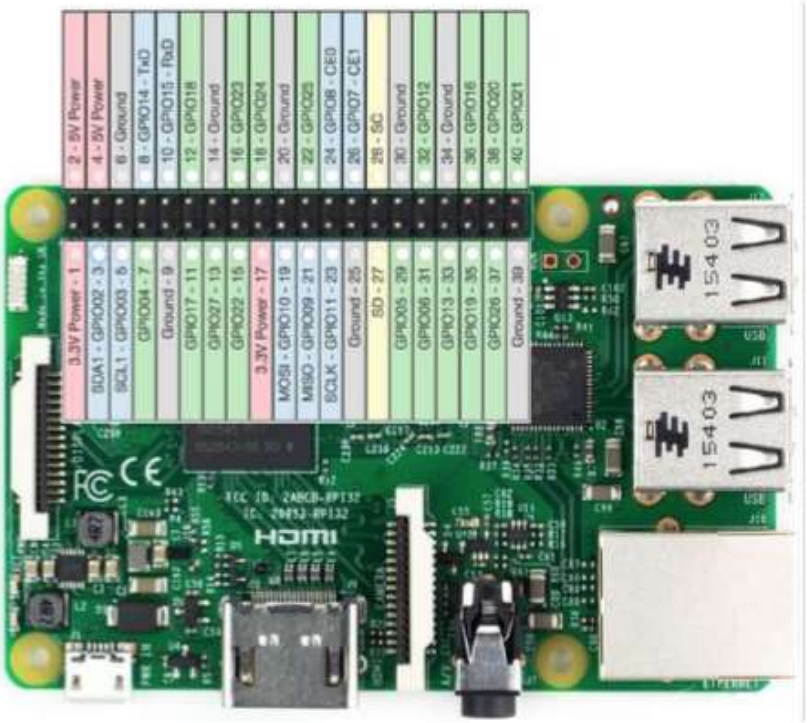
No.	Description	Type	No.	Description	Type
OTHER ELEMENTS					
1	RPi camera		4	LED strip	
2	Flat cable for RPi camera		5	Connecting wires	
3	Micro USB to USB cable				
POWER UNIT					
1	Battery		3	Power terminal, XT60 socket	
2	Power distribution board (PDB)		4	Power terminal, XT60 pin	
PROP-ENGINE SYSTEM AND RADIO EQUIPMENT					
1	Propeller No. (1–4)		4	Radio panel	
2	Motor with nut No. (1–4)		5	Radio receiver	
3	Speed controller (ESC) No. (1–4)		6	Jumper (Bind connector)	

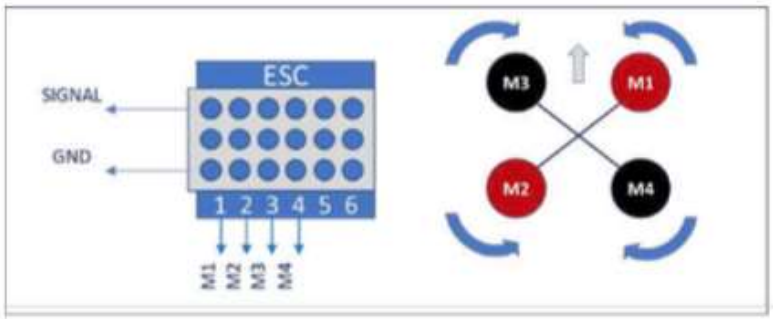
Annex
for the Copter Unit Manufacturing module
Check list

Check list **Competitor _____**	**Expert signature**		
	EXP1	**EXP2**	**EXP3**
Competitor chose the assembly based on his or her own print job			
The camera is installed on the mounting holder (seat) on the developed unit			
The servodrive is installed on the mounting holder (seat) on the developed unit			
VTX is installed on the mounting holder (seat) on the developed unit			
Demonstration of fully-fledged flight performance of the unit at the workstation			
The servodrive moves the camera (programmable control) from 0 to 90 degrees			
Hot swapping of the camera by the competitor (no more than 30 seconds)			
Demonstration of changing the focus of the camera manually (assembly and mounting of the unit on the drone)			
Demonstration of changing VTX channels manually (assembly and mounting of the unit on the drone)			
Scoring attempt: Horizontal message is recognized			
Scoring attempt: Vertical message is recognized			

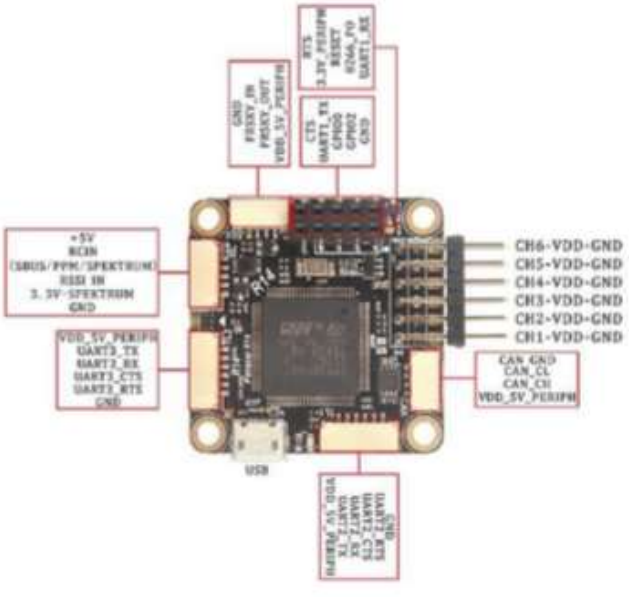
The task is verified and signed by 3 experts.
The competitor hands in the sheet to the expert in charge.
The task is considered unfinished without 3 signatures.

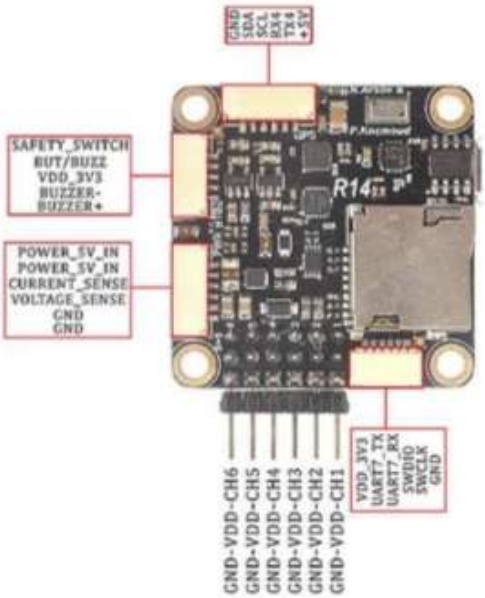
Annex. Diagrams.

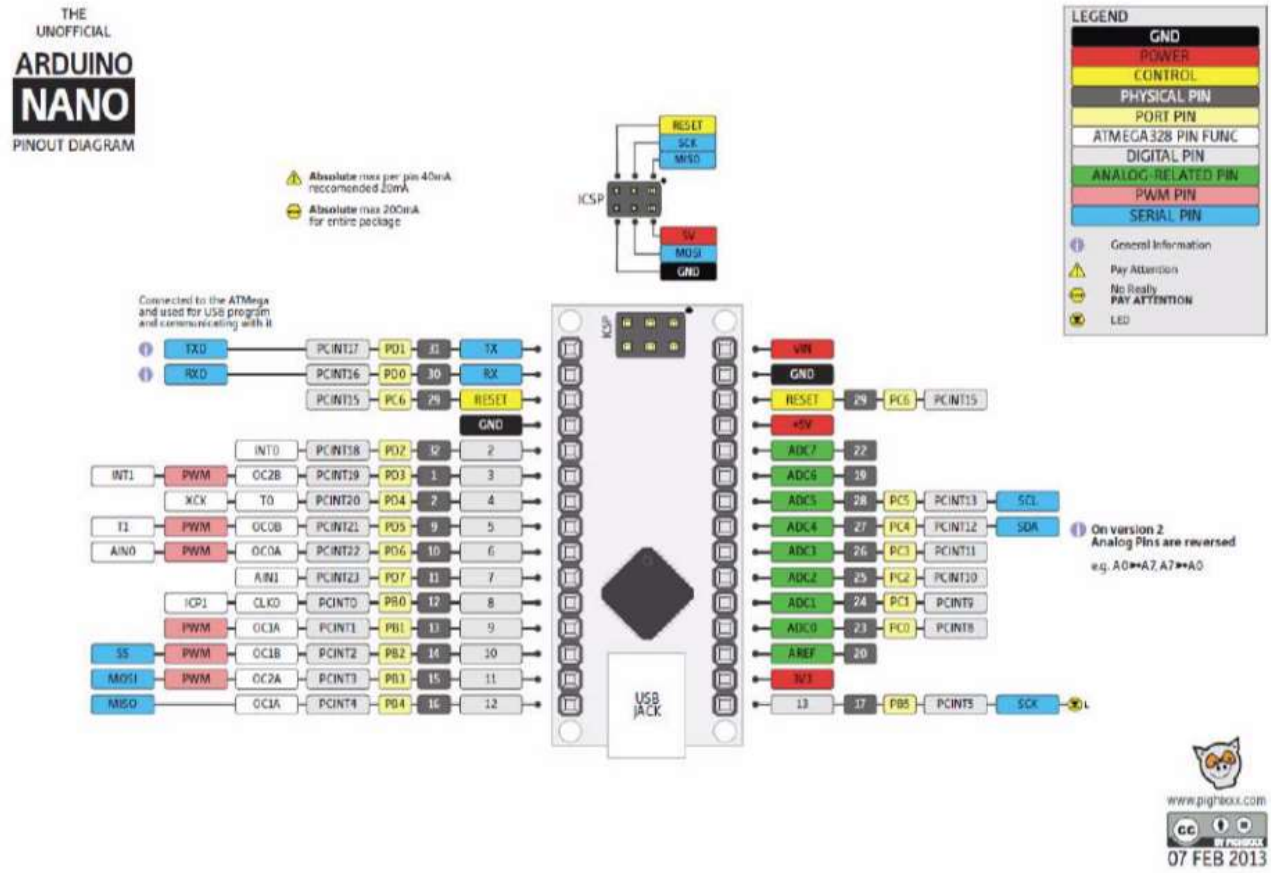




PIXRACER






THE UNOFFICIAL
ARDUINO NANO
PINOUT DIAGRAM
LEGEND
GND
POWER
CONTROL
PHYSICAL PIN
PORT PIN
ATMEGA328 PIN FUNC
DIGITAL PIN
ANALOG-RELATED PIN
PWM PIN
SERIAL PIN
General Information
Pay Attention
No Really
PAY ATTENTION
LED
ICSP
RESET
SCK
MISO
5V
MOSI
GND
USB JACK
On version 2 Analog Pins are reversed
e.g. A0↔A7, A7↔A0
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