robosoft
Advanced Robotics Solutions

Maintenance manual
robuROC6

09/03/2010

Version: E		
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Document versions and distribution

Versions

Version	Date	Action	Pages changed
A		Completed document	
B		Complete re-editing	All
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Distribution list

Name	Company	Date
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1 Introduction

1.1 Document objectives

This manual is intended to supply information necessary for the maintenance of the robot to keep it in good working order.
However, as routine maintenance of the robot involves different areas of expertise, e.g., mechanics, electronics, and informatics, we recommend consulting qualified personnel.

1.2 Glossary

[C]	
cb555	Robosoft controller card based on the Motorola MPC555 microcontroller.
Up-pitch	Upward angle of the front pod with respect to the middle pod.
[H]	
Dead-man	Button that must be maintained pushed during robot movement in manual mode. Releasing the button will immediately stop all movement. This is an anti-panic device.
[R]	
Roll	Longitudinal (roll) angle between one pod and the others.
[T]	
Pitch	Up-and-down (pitch) angle between one pod and the others.
[P]	
Supervisor PC	PC that sends frame sequences to the cb555.
Down-pitch	Downward angle of the front pod with respect to the middle pod.
Pod	Unit consisting of an axle and associated electronics (the robuROC6 consists of three pods).

2 About the robuROC6

The robuROC6 is a mobile robot designed for research and exploration applications in an outdoor environment. It is an articulated platform with six independent power wheels organized into three pods with pitches and roll linkages between them. The kinematics allows the platform to adjust to different types of terrain and to climb over obstacles larger than its wheel radius.

2.1 Technical specifications of the robuROC6

Parameter	Value	Remarks
Use	Indoors and outdoors	
Type of terrain	City, uneven ground	
Obstacles	25 cm step type	
Slope	45° unloaded	
Geometry	• 6 independent wheels • 2 passive articulations (roll) and 2 active hydraulic articulations (pitch)	Better obstacle climbing
Stairs	Yes	
Weight	Approximately 160kg unloaded	
Load capacity	100 kg	Evenly distributed on each pod
Maximum speed	13,68 km/h with fully-charge batteries	Not dependent on load over flat terrain; dependent on available battery voltage
Dimensions (l x w x h)	Overall dimensions in mm: • 6 wheel configuration: 1660 x 800 x 530 mm • 4 wheel configuration: 1610 x 800 x 910 mm • Ground clearance: 110 mm	
Autonomy	3 to 5h	Depending on type of use
Energy source	Li-ion batteries	
Water resistance	IP65	Protected against water streams from any direction (NF EN 60529)
Humidity	100 % condensation-free	
Temperature	• In use: 0°C + 50°C • Storage: - 10°C + 50°C	Possibility of starting at - 10°C with pre-heating
On-board computer	2 cb555	
Programming	SynDEx + C++ under RTAI Linux	
Sensors	• Odometry • Joystick • Inclinometers • Ultrasound • Video • Tactile bumpers • Microphone • Loudspeakers • Temperature	
User interface	• User panel • Remote emergency stop • Task module interface	
Supervisor interface	RS232 link	
Task module interface	According to specifications	Specifications book Ref 1.0 ind A
Color	Green (RAL 7034)	

2.2 Overview

The robuROC6 has been optimized for stability and for obstacle-climbing. It is perfectly suitable for use on uneven ground.

Figure 1 : General view of the robuROC6

2.3 Operating conditions

2.3.1 Security rules

⚠ Read this manual before using the platform.

⚠ For maximum security, we recommend following the instructions in this manual.

⚠ The vehicle operator must at all times have visibility of platform maneuvers.

⚠ Keep a safe distance from moving platform.

⚠ Always keep the remote control within easy reach in case of problem.

⚠ In case of problem, immediately stop the robot using either of the emergency off buttons: on the robot or on the remote control.

2.3.2 Operating rules

⚠ There are three elements for stopping the vehicle in case of problem:

1. The remote control unit. The batteries of the remote control should always be charged. Power can be restored to the robot using the remote control.
2. An emergency off button on the robot.
3. A general battery power-off switch.

⚠ To start the vehicle, **all three stopping elements must be activated** (see the quick-start chapter of the user manual).

⚠ To turn the vehicle off, deactivate all three elements in the following order:

1. Push the remote control off button.
2. Push the emergency off button.
3. Turn the general power-off switch to the OFF position (turn counter-clockwise to the vertical position).

⚠ Check that plugs are in place on any unused connectors.

⚠ Carry out regular maintenance and control of the material according to intensity of use (see chapter 2.5).

⚠ **DO NOT WAIT UNTIL BATTERIES ARE COMPLETELY DRAINED BEFORE RECHARGING.**

⚠ Use only the charger supplied with the robuROC6.

⚠ To limit wheel odometry errors, **check tire pressure weekly.**

⚠ **Obstacle- and sidewalk-climbing should be carried out at slow speed.**

2.4 Nomenclature

Figure 2 : General view

Figure 3 : Rear view

Number	Name

1.	Front pod
2.	Middle pod
3.	Rear pod
4.	Wheel
5.	Hydraulic piston
6.	Emergency stop antenna
7.	Loudspeaker
8.	Front infrared light
9.	Front ultrasound
10.	Front video camera
11.	Task module connectors
12.	Tow ring
13.	Joystick
14.	Rear video camera
15.	Rear infrared light
16.	Rear ultrasound
17.	User panel
18.	Tactile bumper
19.	Ventilation slots
20.	Microphone

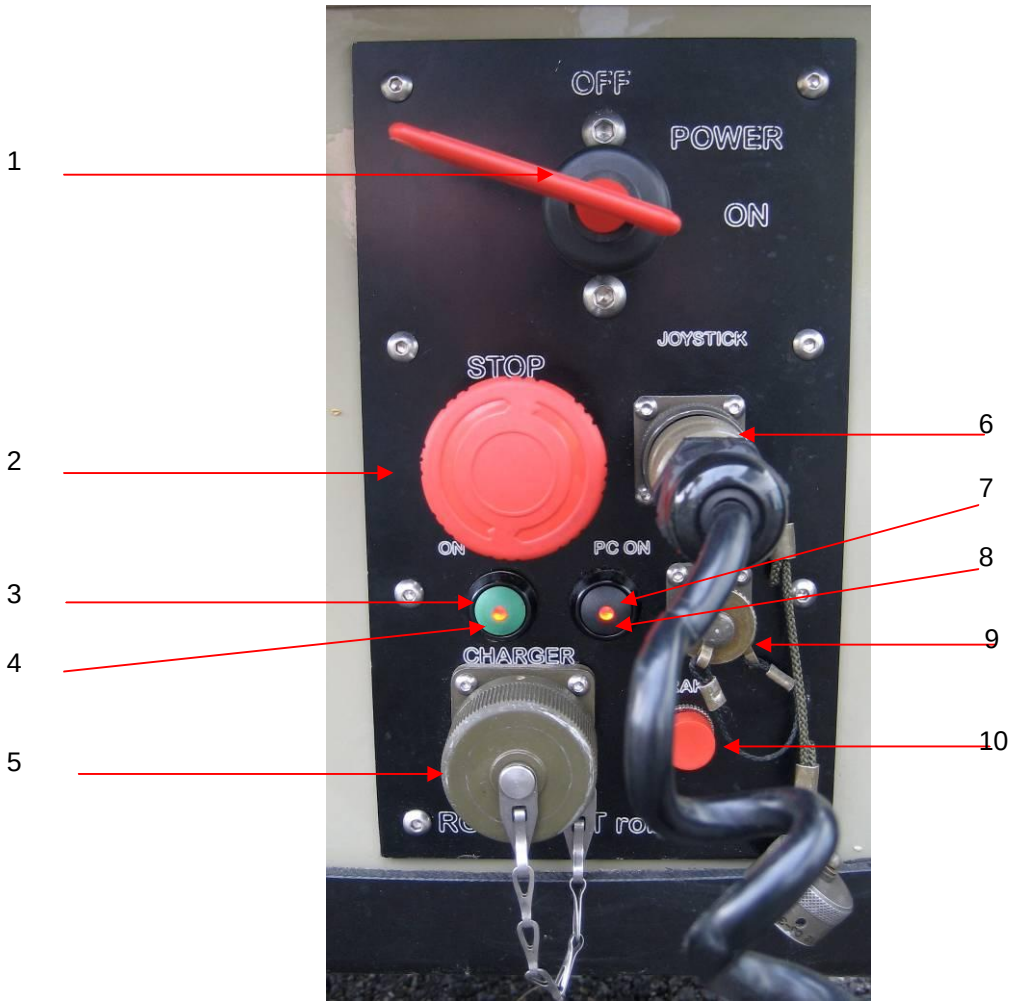


Figure 4 : User panel

Number	Name
1	General power on-off switch

2	Emergency off button
3	Power reactivation button
4	Power activation light
5	Battery charger connector and protective cap
6	Joystick connector and protective cap
7	Supervisor PC and task modules on/off button
8	Supervisor PC and task modules light
9	Optional
10	Brake switch

2.5 Maintenance

This chapter covers the following types of maintenance operations:

- Preventive : Vehicle maintenance.
- Corrective : Repairs to vehicle damage.

After maintenance operations have been carried out, ensure that all operating conditions are satisfied (see chapter 2.3).

2.5.1 Preventive operations and schedule

Preventive maintenance operations are as follows:

Number	Operation	Schedule			
		As necessary	After each use	Weekly	Monthly
Platform and mechanical elements					
1.	Clean robot	X			
2.	Clean infrared lights	X			
3.	Clean video camera window	X			
4.	Clean fan filters				X
5.	Check rotation axes for foreign matter		X		
Batteries					
6.	Recharge batteries		X		
7.	Recharge remote control		X		
Wheels					
8.	Check tire pressure			X	
9.	Check tire wear				X
10.	Check tightness of lug-bolts			X	
11.	Check rim condition			X	
Security tests					
12.	Check working of security elements		X		
Hydraulic system					
13.	Check oil levels			X	
14.	Synchronize hydraulic system	X			

2.5.2 Corrective operations

In the following table:

- **C** indicates operations which may be carried out by client,
- **I** indicates operations which may be carried out by integrator,
- **R** indicates operations undertaken by Robosoft, or by integrator under special authorization from Robosoft.

After carrying out one of the following operations, it is recommended to carry out all the preventive operations above to ensure that the robuROC6 is in working condition.

In case of doubt, do not hesitate to contact Robosoft.

Number	Operation	Authorisation
1.	Open pod	**I R**
2.	Change wheel	**C I R**
3.	Change tire	**C I R**
4.	Change security bumper	**I R**
5.	Change motor	**R**
6.	Disconnect power	**I R**
7.	Change battery	**R**
8.	Change internal component	**R**
9.	Change PC	**C I R**
10.	Change video camera window	**I R**
11.	Purge hydraulic system	**R**

If a corrective maintenance operation is not included in the above list, contact Robosoft for instructions and authorization.

3 Operation details

3.1 Legend

	Time taken for operation	
	min	In minutes.
	h	In hours.
	~~	Variable.
	Level of difficulty	
		Easy, no particular care.
		Middle, proceed carefully.
		Difficult, needs special care.
	Number of people necessary:	
		1 person.
		2 persons.
	Specific tools for this operation	

3.2 Preventive operations

3.2.1 Operation P1: Clean robot

 30min		
 Water hose, soft cloth		

 Shut robot down before cleaning. Turn general power on-off switch to vertical position to ensure that robot power is off.

1. Put protective cap on all connectors.
2. Remove any large foreign material likely to damage robot, paying particular care not to damage hydraulic system.
3. Hose down robot.
4. Dry with soft cloth.

 Do not use a scraper or any corrosive substance which might scratch or damage surfaces.

3.2.2 Operation P2: Clean infrared lights

10min		
Sponge, water without corrosive cleaning products, soft cloth		

Shut robot down before cleaning. Turn general power on-off switch to vertical position to ensure that robot power is off.

1. Put protective cap on general power connector.
2. Clean front and back lights with damp sponge and water with non-corrosive cleaning product, eg, window-cleaner.
3. Rinse with clean water and sponge.
4. Dry with soft cloth..

Do not use a scraper or any corrosive substance which might scratch or damage surfaces.

3.2.3 Operation P3: Clean video camera window

10min		
Sponge, water without corrosive cleaning products, soft cloth		

Shut robot down before cleaning. Turn general power on-off switch to vertical position to ensure that robot power is off.

1. Put protective cap on general power connector.
2. Clean front and back video camera windows with damp sponge and water with non-corrosive cleaning product, eg, window-cleaner.
3. Rinse with clean water and sponge.
4. Dry with soft cloth.

Do not use a scraper or any corrosive substance which might scratch or damage surfaces.

3.2.4 Operation P4: Clean fan filters

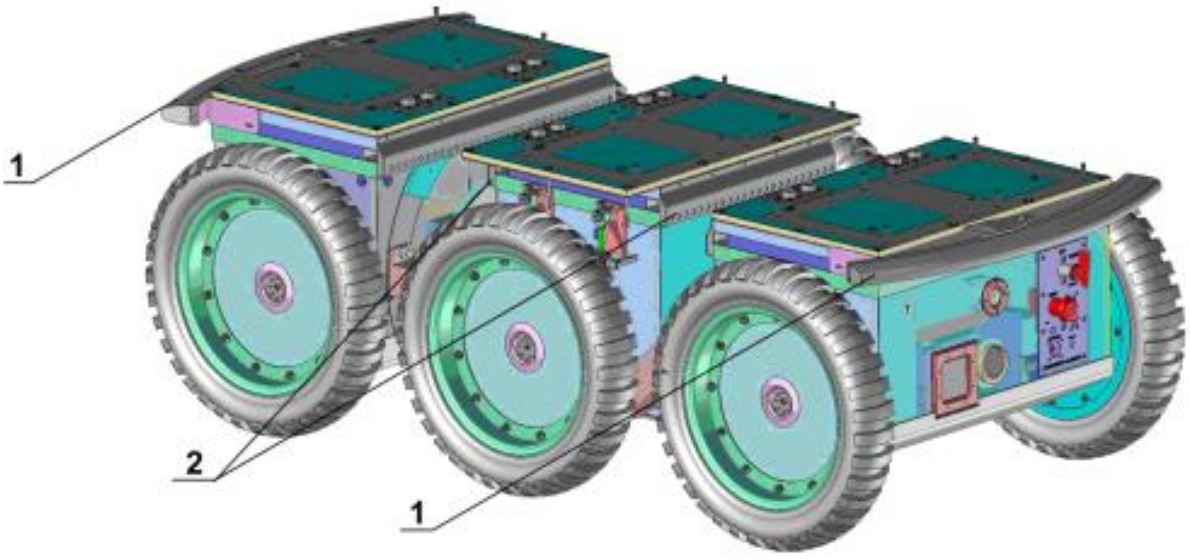
20min		
Hex key		

Shut robot down before cleaning. Turn general power on-off switch to vertical position to ensure that robot power is off.

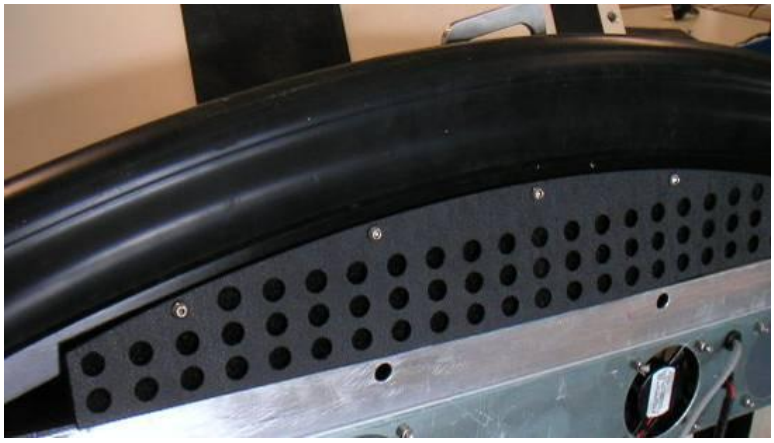
Fan air intakes are covered with foam fiters which must be cleaned regularly to ensure proper cooling of the robot.

These filters are located:

1. Under front and rear bumpers.
2. On both sides of the middle pod.



1. On the front and rear pods:
    - Unscrew the holding screws.
    - Rinse the foam filters using plenty of water.
    - Air dry.
    - Rescrew into place.

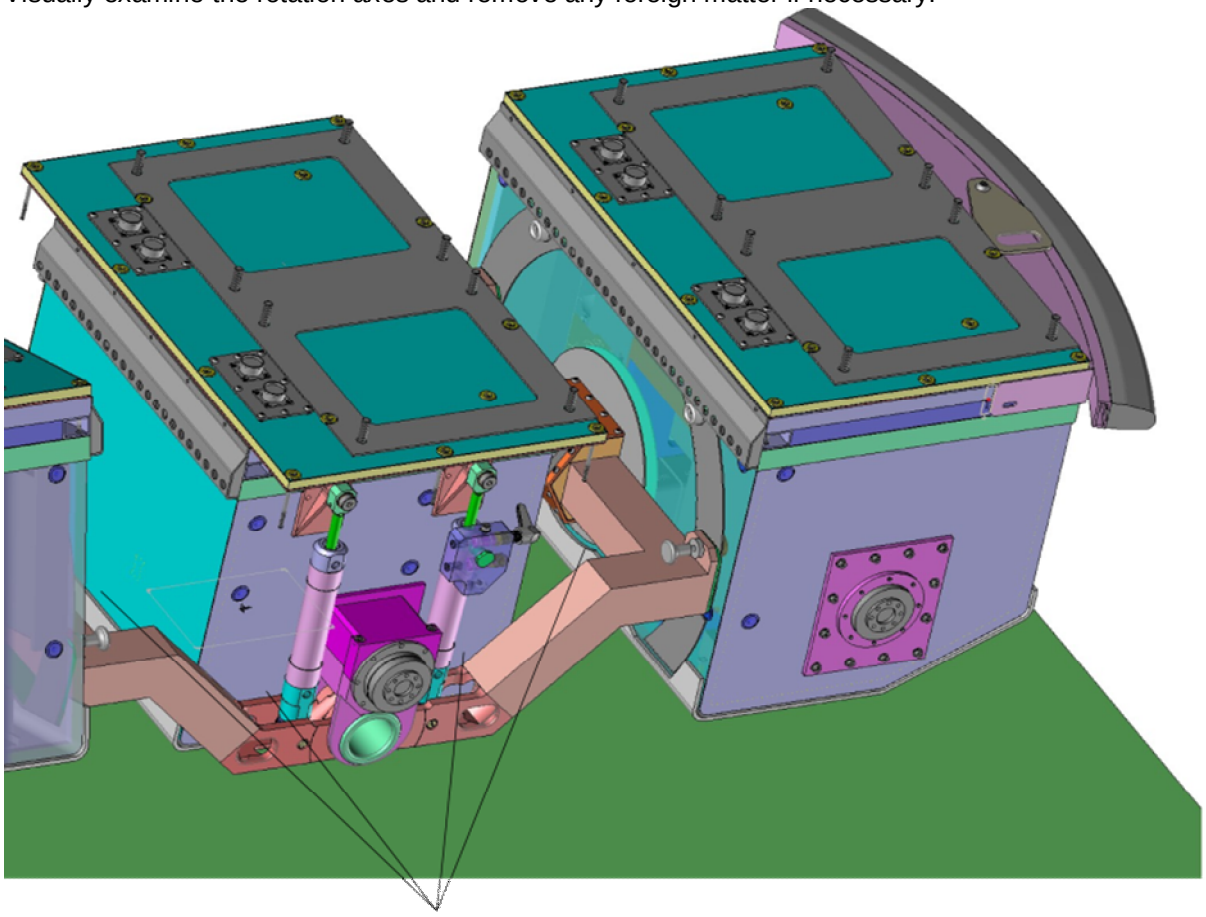


2. On the middle pod:
    - Unscrew the holding screws.
    - Rinse the foam filters using plenty of water.
    - Air dry.
    - Re screw into place.

3.2.5 Operation P5: Check rotation axes for foreign matter

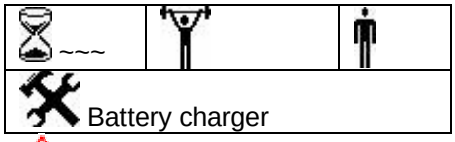
10min		

Visually examine the rotation axes and remove any foreign matter if necessary.



Check for foreign matter in these zones

3.2.6 Operation P6: Recharge batteries

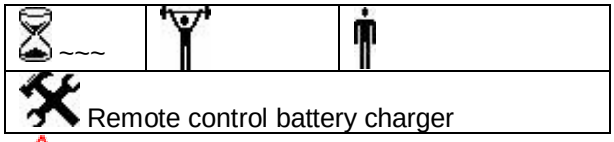


Do not wait until batteries are completely drained before recharging.

1. Turn general power on-off switch to vertical position to ensure that robot power is off.
2. Plug charger into platform (see Figure 4).
3. Turn general power on-off switch so that robot power is on.
4. Plug charger into power source. The green light on the charger should turn on.
5. After charging, unplug charger from the platform and from the power source.

For maintenance, storage, and shipping operations, see the SAFT manual included as an appendix to this document

3.2.7 Operation P7: Recharge remote control



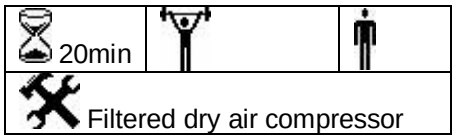
Do not wait until batteries are completely drained before recharging.

Do not use the remote control while it is charging.

1. Push the emergency off button on the remote control.
2. Plug charger into power source.
3. Place the remote control on its charger.
4. While charging, the red light on the remote control is continuously on; the green light indicates the level of charging:
   - Blinking green light: fast charging.
   - Fixed green light: slow or maintenance charging (charge >= 60%).

During use of the remote control, a low level of charge (charge <10%) is indicted by a rapidly flashing red light. This warns the operator that the remote control will soon stop working (in under 15min).

3.2.8 Operation P8: Check tire pressure



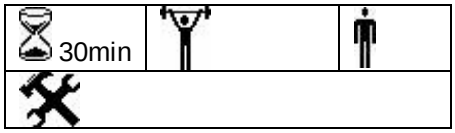
1. Check tire pressure when cold. Normal pressure is **0,5 to 1 bar for the front and rear wheels, 1 to 2 bar for the middle wheels** (to be adjusted for load conditions and type of obstacle-climbing).
2. If the tires are warm, do not deflate if the measured pressure is higher than normal.
3. Inflate if the pressure is lower than normal. **Never inflate to more than 2 bar**.
4. If frequent inflation is necessary, have the wheel checked by a specialist. (See operation C3 for changing or fixing an inner-tube.)

3.2.9 Operation P9: Check tire wear

1. Check the tire-wear indicators between the tire treads.

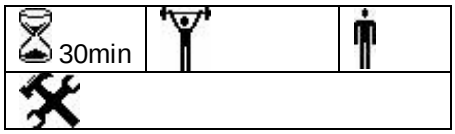
A quick visual check may determine the cause of tire wear.

3.2.10 Operation P10: Check tightness of lug-bolts



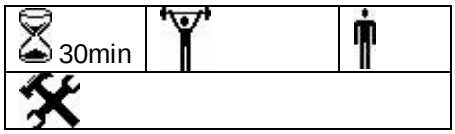
Grab a wheel and try to move it ï it should not move. If there is any play, the lug-bolts are loose. Tighten the lug-bolts, see operation C2.

3.2.11 Operation P11: Check rim condition



The wheel rims are made of fiberglass. Check that there are no nicks or cracks which may have been caused by excessive shock. If the rim is damaged, go to operation C2 for how to change a wheel.

3.2.12 Operation P13: Control working of security elements

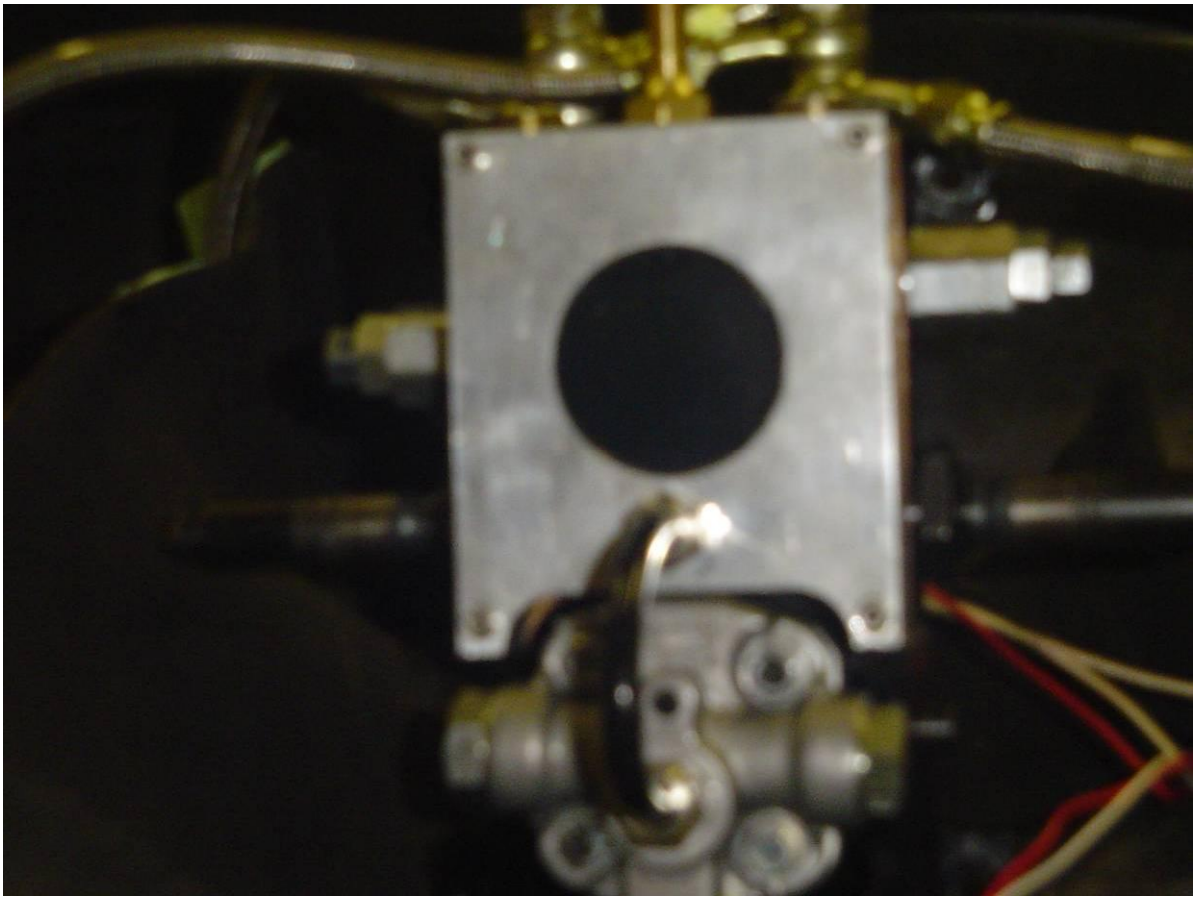


1. Start the robot.
2. Use the joystick to control the robot.
3. Test the security elements (they must all be tested one-by-one):
    a. Front tactile bumper.
    b. Rear tactile bumper.
    c. Emergency off button on the robot.
    d. Emergency off button on the remote control.
4. The vehicle should stop.
5. Reactivate the vehicle.
6. Repeat to test the remaining security elements.

3.2.13 Operation P14: Control hydraulic system oil levels

10min		
Hex key, funnel, SAE 15-30 grade hydraulic oil		

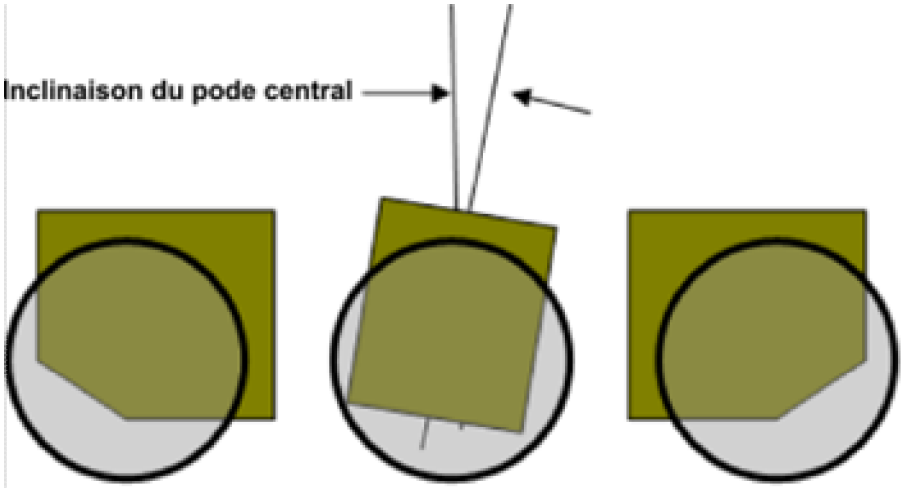
1. The hydraulic system forms a closed circuit, however a slight drop in the oil level may be noticed. This is normal. As needed, top up the circuit with SAE 15-30 grade hydraulic oil.
2. Open the plug (1).
3. Top up the circuit with oil.
4. Close the plug (the plug is not air-tight).



3.2.14 Operation P17: Synchronize hydraulic system

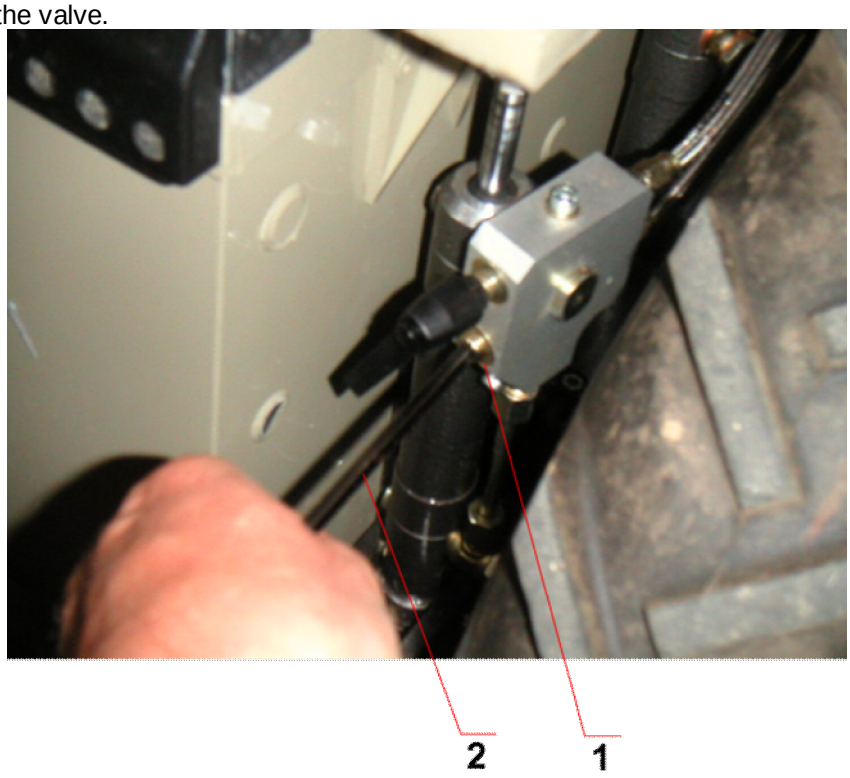
10min		
Hex key (6mm)		

Hydraulic pistons control the pitch of the middle pod with respect to the other pods (the angle should be the same fore and aft).
Through internal leakage, it is possible that this synchronization may drift, with the following consequences:



To realign this angle:

1. Open the synchronization valves (1) with the 6mm hex key (2).
2. Manually level the pod.
3. Close the valve.



3.3 Corrective operations

3.3.1 Operation C1: Open pod

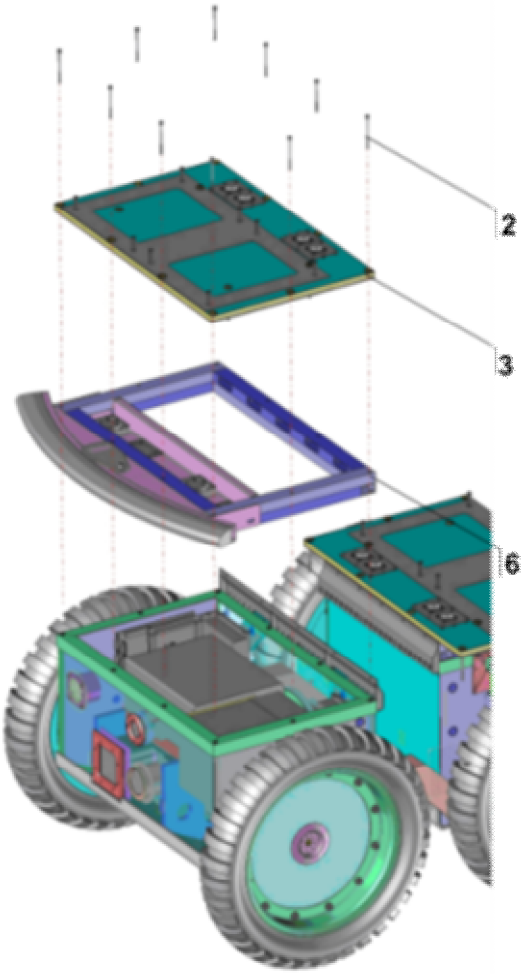
30min		
Hex key		

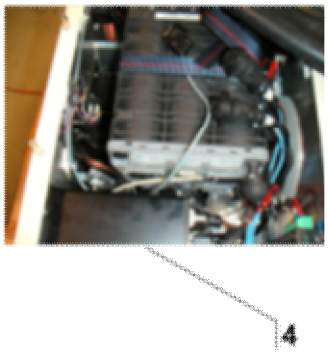
3.3.1.1 Opening:

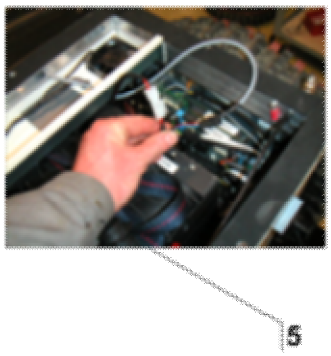
1. Cut power with the general power on-off switch.
2. Undo the holding screws.
3. Remove covering plate.
4. Disconnect the task module connectors.
5. Disconnect the bumper and fans.
6. Remove the bumper and fan holder.

3.3.1.2 Closing:

1. Reverse the above steps.
2. Lightly lubricate the holding screws to avoid lock-up.
3. Tighten the M4 screws to a maximum torque of 2 Nm.





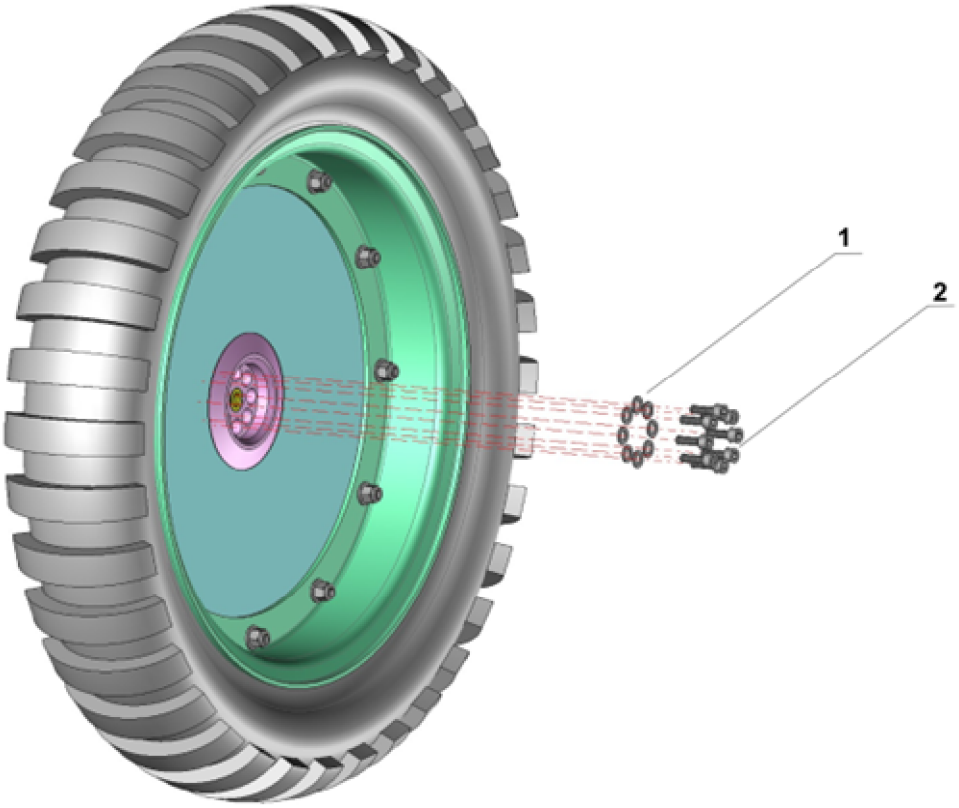


3.3.2 Operation C2: Change wheel

5min		
Hex key		

The wheel is attached by 7 lug-bolts (2) and lock-washers (1).

1. Raise the pod and place it on blocks.
2. Undo the log-bolts.
3. Put the new wheel into place.
4. Tighten the lug-bolts (don't forget the lock-washers).
5. Place the robuROC6 back on the ground.

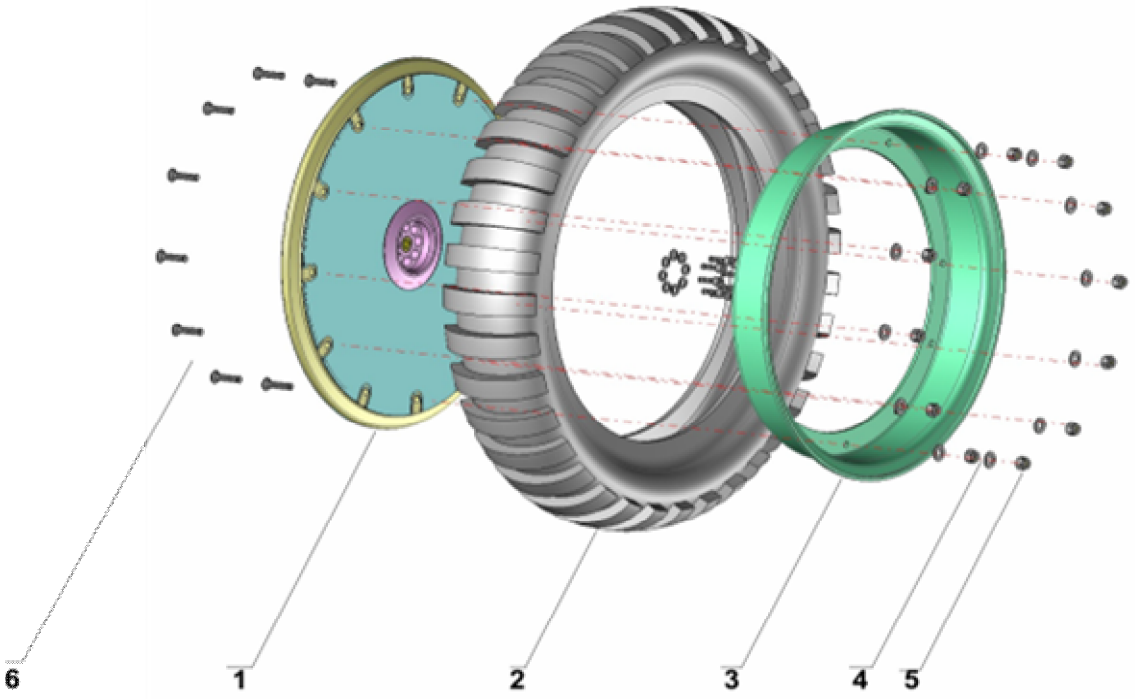


3.3.3 Operation C3: Change tire

5min		
Hex key		

⚠ Do not use a tire iron, you will damage the fiberglass rim.

1. Follow the steps of operation C2 for removing a wheel.
2. Deflate the inner tube (not shown).
3. Undo the 12 nuts (4-5-6).
4. Remove the fiberglass rim (3).
5. Remove the tire (2) and inner tube.
6. Replace the defective tire or inner tube.
7. Mount the tire by reversing the above steps.
8. Inflate the tire to 2 bar for positioning on the rim.
9. Deflate the tire depending on the axle on which the wheel is mounted (see operation P8).
10. Mount the wheel according to operation C3.



3.3.4 Operation C4: Change security bumper

30min		
Cutting pliers, soapy water		

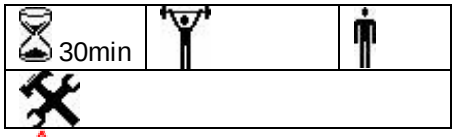
1. Carry out procedure C1.
2. Carry out procedure C6.
3. Cut the two branch wires at the connector.
4. Remove the rubber part of the bumper by pulling it out of its groove.
5. Mount the new bumper by slipping it into the groove (the soapy water will help).
6. Reposition the cable and the connector.
7. Close the covering plate as for C1.

3.3.5 Operation C5: Change motor

30min		

- The robot must go back to workshop.
- Contact Robosoft.

3.3.6 Operation C6: Disconnect power



This operation must precede any work inside the robot.

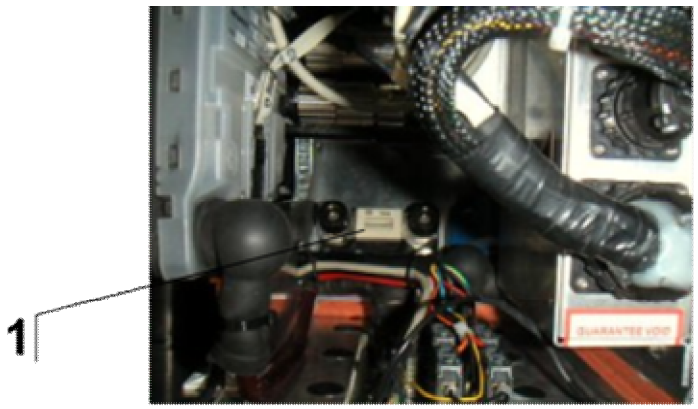
Opening the pods as in procedure C1 must precede this operation. Steps must be carried out strictly in the given order.

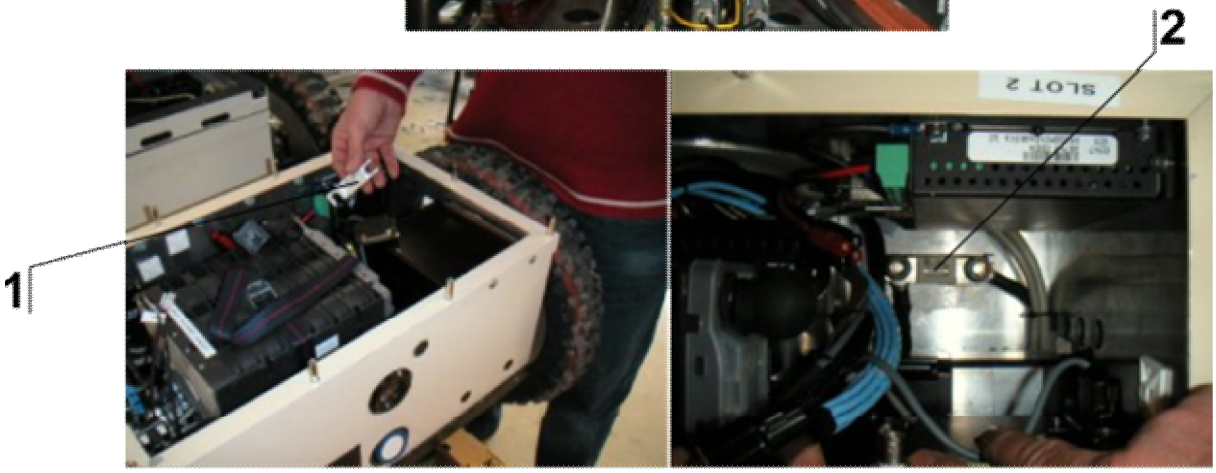
3.3.6.1 Disconnecting power:

1. Remove the ï fuse (1) in the front pod.
2. Remove the + fuse (2) in the rear pod.

3.3.6.2 Reconnecting power ï reverse the above steps:

1. Manually tighten the + fuse (2) in the rear pod.
2. Put the ï fuse (1) back in the front pod.





3.3.7 Operation C7: Change battery

30min		
Wrench (13mm)		

⚠ This operation may be carried out by integrator only after written agreement from Robosoft.

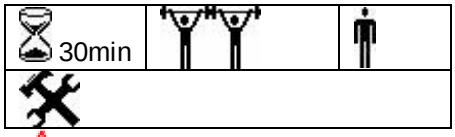
⚠ Steps must be carried out strictly in the given order.

1. Cut the power and carry out operation C1 on all three pods.
2. Disconnect the electronics bus on all three batteries (undo the steel clip and disconnect the black connector).
3. You MUST carry out operation C6 (disconnecting power).
4. Remove battery holding straps.
5. Disconnect the power cables on all three batteries with the wrench (it may be necessary to slightly lift the batteries to have access to bottom terminals).
6. Follow the above steps in reverse to replace battery.

⚠ Never connect the battery terminals while removing nor while storing. A short-circuit will cause a very strong discharge which may severely damage the battery or make it explode.

⚠ For any battery maintenance, storage, or shipping operations see the SAFT manual included as an appendix to this document.

3.3.8 Operation C8: Change internal component

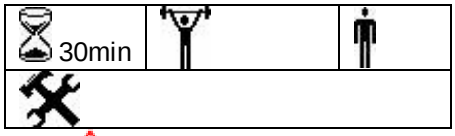


⚠ This operation may be carried out by integrator only after written agreement from Robosoft.

⚠ Steps must be carried out strictly in the given order.

1. Cut the power and carry out operation C1 on all three pods.
2. Disconnect the electronics bus on all three batteries (undo the steel clip and disconnect the black connector).
3. You MUST carry out operation C6 (disconnecting power).
4. It may be necessary to remove one of the batteries (as in operation C7) in order to gain access to component.
5. Remove the component according to the specific instructions supplied by Robosoft.
6. Follow the above steps in reverse to replace component.

3.3.9 Operation C9: Change PC



⚠ This operation may be carried out by integrator only after written agreement from Robosoft.

This operation must be carried out the same as for operation C8.

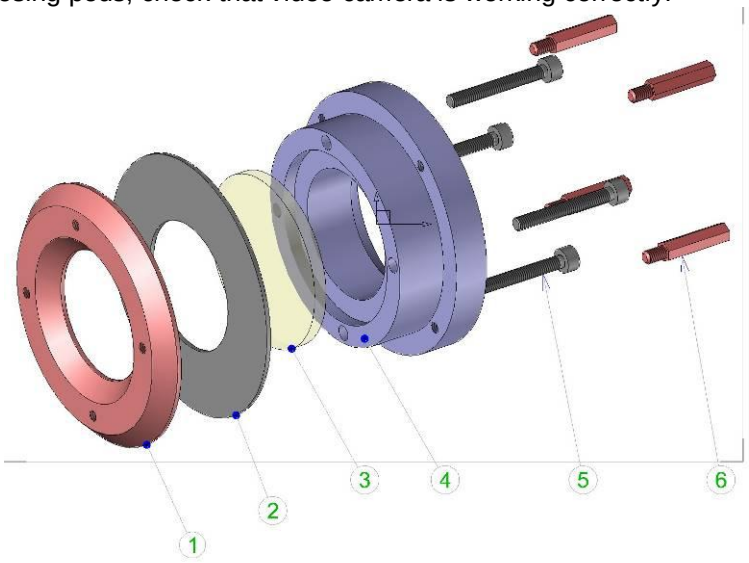
3.3.10 Operation C10: Change video camera window

30min		
Hex key, wrench		

This operation may be carried out by integrator only after written agreement from Robosoft.

All three pods must be opened, and one of the batteries must be removed to gain access to the video camera compartment.

1. Cut the power and carry out operation C1 on all three pods.
2. Disconnect the electronics bus on all three batteries (undo the steel clip and disconnect the black connector).
3. You MUST carry out operation C6 (disconnecting power).
4. Remove battery holding straps.
5. Disconnect the power cables on all three batteries with the wrench.
6. It may be necessary to slightly raise the batteries to have access to bottom terminals.
7. Unscrew the camera attached to the struts (6) taking care not to change the lens adjustment.
8. Unscrew the four screws (5).
9. Remove the front cover (1) and o-ring (2).
10. Check the o-ring and replace if necessary.
11. Replace window (3).
12. Follow the above steps in reverse to re-install video camera, ensuring that the o-ring is properly in place.
13. Before closing pods, check that video camera is working correctly.



3.3.11 Operation C11: Purge hydraulic system

120min		
Hex keys, screwdriver, SAE15-30 grade hydraulic oil, compressed air tank, plastic tray, compressed air regulated at maximum 0.3 bar, power supply at 24V 3A, paper towels, alcohol, thread lock		

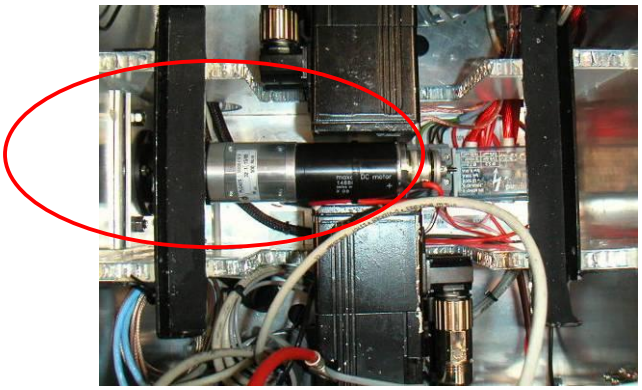
The robuROC6 is equipped with a system to synchronize the pitch joints. Any air bubbles in the system will lead to play in the joint resulting in oscillation of the middle pod.

⚠ This operation may be carried out by integrator only after written agreement from Robosoft.

⚠ It will be necessary to completely take down the hydraulic system.

3.3.11.1 Disconnecting the hydraulic system

1. Lift the middle pod as far as possible with the hydraulic system.
2. Open the middle pod and remove the battery (see C1, C6, C7).
3. Remove the hydraulic system motor.

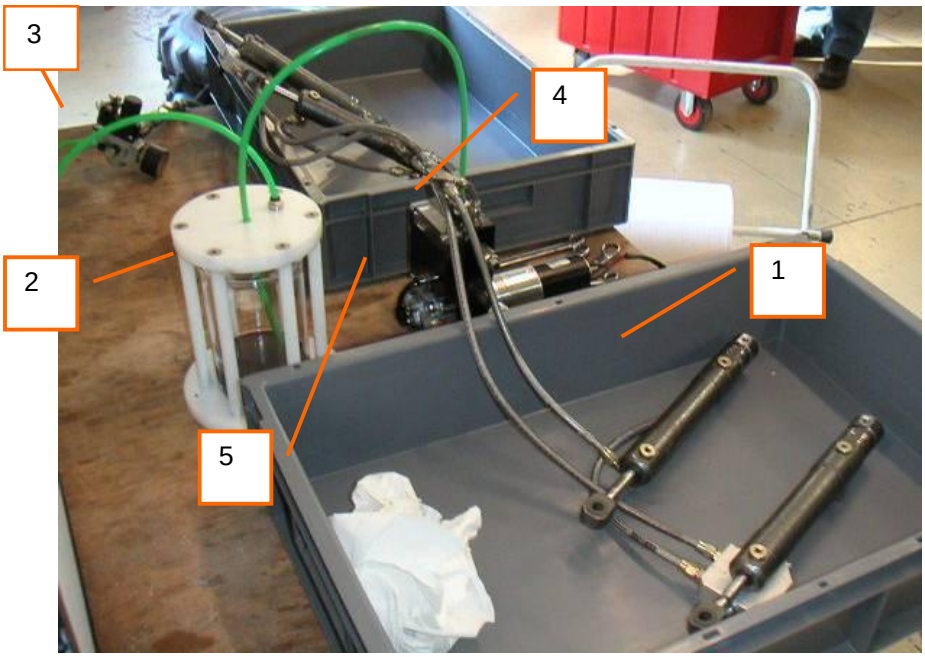


3.3.11.2 Removing pistons

1. Remove the 4 shoulder bolts.
2. Remove the 8 articulated axes using the screwdriver.
3. The middle pod must be raised as far as possible for this operation in order to gain access to the internal axes (raise by hand if necessary).

3.3.11.3 Purging the system

1. Installing material:
   a. The pistons should be placed in plastic trays to contain the purged hydraulic oil (1).
   b. The compressed air tank (2) is used to charge the hydraulic system with oil (see operation P14 for oil grade).
   c. The air pressure regulator ensures constant charge pressure.
   d. Oil is injected via the filler plug (4). The tank should be full to avoid introducing air into the hydraulic circuit (5).



2. Purging pistons:
   a. Hold piston with plug end up.
   b. Unscrew all piston plugs.
   c. Check that oil is flowing normally, without air bubbles.
   d. Tighten plugs while allowing oil to continue flowing; seal is ensured by a rubber gasket and BS screw.

Do this operation for all 8 plugs (upper and lower chambers of each cylinder).

3. Check:
   a. To check the result, it may be necessary to run the hydraulic pump in both directions.
   b. Use a power supply stabilized at 24V and with current limited to a maximum of 3A.
   c. Raise and lower the hydraulic cylinders by manually switching the solenoid valve.

3.3.11.4 Re-assembly

1. Clean the cylinders with the paper towels, optionally doused with alcohol.
2. Reassemble the hydraulic cylinders.
   - Reverse the order of the above disassembly steps.
   - Use normal-strength thread lock, e.g., Loctite 243, to ensure tightness.
3. Re-install battery and pod-covers as in C7, C6, C1.

4 Appendixes

4.1 User manual for batteries SAFT Li-Ion VL41M72V39Ah

4.2 User manual for charger EVE 72v-10A 671ED1051670.