



# MUREX ROBOTICS

>> MATE UNDERWATER ROBOTICS AT PHILLIPS EXETER  
>> EXETER, NEW HAMPSHIRE, USA

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## JOB SITE SAFETY ANALYSIS

*The MUREX Safety Manager is expected to oversee enforce all JSA control methods and safety protocols. Failure to comply with safety standards may result in temporary suspension, removal from the deployment team, and most severely, a requirement to leave the company at the CEO's and Safety Manager's jurisdiction.*

### **Required Personal Protective Equipment (PPE)**

- All team members must wear closed-toe, non-tip shoes when working with the MUREX ROV. The drive team and pool deck members are also expected to wear safety goggles and tie up any hair longer than the shoulder.

### **Required Training**

- All MUREX Team Members undergo intensive safety protocol training and drills in the first week of recruitment and a week before any official deployment. Crew deck members (drive team, pool deck) are furthermore expected to memorize and adhere to all JSA control methods and specifically the MUREX ROV Deployment Checklist.

## JSA Table


Tasks	Hazards	Controls	Responsible Person(s)
Personal Protective Equipment (RPPE) Compliance Check	Injury, falling, snaring	Safety Manager checks that all members comply with the PPE (closed toe, non-tip shoes, safety goggles, hair tied up)	Safety Manager
Entering and Exiting with ROV	Damage, Injury	Equipment is properly packed into a toolbox and cart. Two members carefully manoeuvre the cart to ensure the ROV and equipment does not fall off. One member manoeuvres the topside as a suitcase.	All Team Members
Pool Deck Clearance	Injury, falling, snaring	Pool deck is checked and cleared for any objects and debris.	Safety Manager, Pool Deck Members
ROV Deployment (see Fig 1)	Electrocution, Leakage, Damage and Loss of Equipment, Malfunctioning ROV, Injury	The Safety Manager is expected to coordinate pre-deployment checks. The checks ensure that the ROV is a safe condition to operate and be deployed. All crew deck members must follow the deployment checklist as listed in Fig 1.	Safety Manager, Pool Deck Members
Pool Deck Operation	Injury, Drowning	Pool deck members must maintain three points of contact with the ground when retrieving or deploying objects.	Safety Manager, Pool Deck members
Topside Operation	Electrocution, Injury, System Failure	Drive Team checks topside wiring, continuity, and setup. Tether manager keeps the tether away from the control station. A Schottky diode prevents reverse polarity input and reverse currents induced by Back EMF of inductive loads.	Safety Manager, Drive Team, Tether Manager



## JSA Table (cont.)

Tasks	Hazards	Controls	Responsible Person(s)
Tether Management	Injury (tripping), ROV Disconnect due to EMI resulting in failure of mrXPLC, Entanglement with ROV and other debris	<p>The selected tether is flexible and modified with flotations to maintain neutral buoyancy. A trained tether manager ensures the tether is out of the way to prevent tripping, and uncoiled to minimize EMI affecting mrXPLC.</p> <p>Guard rails are added around the ROV to prevent the tether from being ensnared or tangled around the thrusters.</p> <p>A second tether manager communicates with the main tether manager, and operates the SMART cable wire and the carabiner recovery line to prevent inter-tether entanglement.</p>	Safety Manager, Tether Manager
System Failure	Permanent Damage, Loss of Equipment	If leakage or abnormal power conditions are observed, Drive Team immediately cuts off power using an emergency kill switch integrated in the topside. LEDs easily indicate electronics status to Pool Deck members.	Safety Manager, Drive Team, Pool Deck members
ROV Retrieval	Injury, Falling, Drowning	Two pool deck members lift the ROV from each side and maintain three points of contact with the ground.	Safety Manager, Pool Deck members
Post-Deployment	Post-Deployment Damage	Enclosures are checked for leakage. Seals are removed. Calcium buildup on enclosures and cameras are cleaned with isopropyl alcohol.	Safety Manager

# Fig 1. MUREX ROV Deployment Safety Checklist


**MUREX ROBOTICS**  
 DO IT RIGHT.

Inspector Name: \_\_\_\_\_  
 Date: \_\_\_\_\_  
 Competition Round: \_\_\_\_\_

**MATE Deployment Safety Checklist**

<i>Pre-Power-On Checklist</i>				
#	Role	Item	Signal Phrase	Status
1	Safety Manager	Chassis supports at least 600N	<i>Chassis Cleared</i>	
2	Safety Manager	Thruster cannot move more than ±2mm in any direction	<i>Thrusters Cleared</i>	
3	Safety Manager	All propellers, servos, and motors spin freely	<i>Motion Cleared</i>	
4	Safety Manager	All manipulation devices are unobstructed and are attached securely	<i>Claws Cleared</i>	
5	Safety Manager	Tether is prepared with flotations and supports full weight of robot	<i>Tether Cleared</i>	
6	Safety Manager	All potential ingress points lubricated and sealed	<i>Ingress Cleared</i>	
7	Safety Manager	All vacuum plugs and seals free of debris	<i>Seals Cleared</i>	
8	Safety Manager	All wiring in the robot, topside, and float are secured and unexposed. Tether is not continuous/ shorted	<i>Wiring Cleared</i>	
9	Demo Team	Topside computers have over 50% charge and the software is ready to launch	<i>Programming Cleared</i>	
10	Demo Team	Topside powered, controller connected, demo team ready for power on	<i>Topside Cleared</i>	
<b>Pre-Deployment Checklist</b> (Demo Team: <b>On Standby</b>   Safety Manager: <b>Ready For Power On</b> )				
1	Demo Team	Final visual inspection of topside wiring and setup.	<i>Power On In 3..2..1</i>	
2	Safety Manager	The motors produce power up and arming sequence ( 3 beeps in increasing pitch then 1 high pitch beep)	<i>Motor Arming Cleared</i>	
3	Demo Team	Topside computer connects to "MUREX TOPSIDE"	<i>Connection Cleared</i>	

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The MUREX ROV Deployment Checklist is a stringent set of pre-deployment checks and guidelines enforced by the Safety Manager and executed by crew deck members. The checklist ensures that the ROV is ready for deployment and will not sustain any damages or malfunctions, which could result in permanent loss of equipment/components and injury to crew deck members.

**Fig 1. MUREX ROV Deployment Safety Checklist (cont.)**

4	Demo Team	Amcrest Camera, Reolink Camera, and MUREX Carrier Board all show up on the OpenWRT Portal (192.168.8.1)	<i>System Cleared</i>	
5	Demo Team	Running <u>mrx -init</u> on topside to <u>initialize</u> all systems	<i>Software Initialized</i>	
6	Safety Manager	Visually inspect thrusters to ensure all are spinning	<i>Thrusters Good</i>	
7	Demo Team	All cameras are unobstructed and have low latency	<i>Cameras Good</i>	
8	All	Safety Manager picks <u>up robot</u> and rotates along all axes.	<i>&lt;Roll/ Pitch/ Yaw&gt; &lt;Testing/ Good&gt;</i>	
<b>Deployment Procedure</b>				
1	Demo Team	Final inspection of all software systems and topside.	<i>All Systems Good</i>	
2	Safety Manager	Final inspection of ROV and tether.	<i>Ready for Deployment</i>	<input type="checkbox"/>
3	Safety Manager	Safety Manager <u>lowers robot</u> into the pool.	<i>ROV Deployed</i>	

**Deployment Notes:**


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