AutoNaut

MAINTENANCE MANUAL

AutoNaut
wave propelled
unmanned surface vessel (USV)

Introduction

AutoNaut® is an unmanned surface vessel (USV) forming part of an Unmanned Maritime System (UMS) comprising: the AutoNaut vessel, remote control workstation (RCW) or base station, support system and personnel. All these parts of the UMS are important to its safe operation.

This manual describes a structured routine for maintaining the AutoNaut vessel (vehicle / platform) so that it functions in a safe and environmentally sound manner with the minimum of downtime. Adherence to the routines described will extend the life and reliability of the vessel and its components.

The sea surface is an extremely hostile environment, if something goes wrong aboard an unmanned vessel there is no possibility of making repairs at sea, therefore every mission should begin with AutoNaut in excellent working order. Because everything needs to be right before each mission, long or short, the knowledge and procedures required before each launch and recovery operation are covered in the Technical Manual. This Maintenance Manual is concerned with routine inspection and maintenance over time.

As with all machines, wear and tear depends on what work they do. The maintenance periods described here assume continuous use with monthly launch and recovery, and that full checks in accordance with the Technical Manual are completed before every launch. This schedule is of course somewhat arbitrary and therefore indicative of the maintenance periods required.

Period Code

Pre	before every launch
Post	after every recovery, to check if repairs are needed or new parts are required before the next mission
Mon	monthly
3 mon	3 months
Annual	annual - full shore test of system
3 yr	3 year – load test certs, replace gaskets and seals
5 yr	5 year - AutoNaut should be returned to the AutoNaut Ltd factory for deep maintenance

IMPORTANT NOTE: The most critical part of maintenance is to ensure every effort is made to wash AutoNaut thoroughly with fresh water on recovery, every time, and to ensure that salty fingers are washed and dried before coupling and decoupling connectors. Great care must be exercised at all times to prevent electronic components being exposed to salt water or a salt laden atmosphere. Any ingress of salt water to the interior should be sponged out with fresh water, and dried.

Sections

A Hull
B Wave propulsion
C Electrical power systems
D Auxiliary propulsion
E Control system
F Communication
G Sensors
H Navigation
I Lifting and launching
J Documents

FUNCTION		EQUIPMENT	SUB-ITEM	PERIOD	MAINTENANCE / INSPECTION	CHECKED
A	Hull	Hull body				
			Exterior signage	Pre	Check owner's exterior ID and contacts are clear, flag state registration if applicable, AutoNaut ID, anti-tamper notices.	
		Exterior	Hull skin	Pre/ post / annual	Check for deep scratches, impact marks and cracking. Check paint coat sound. Remove marine fouling. In some areas antifouling will be required. Recoat as necessary.	
			Bow and stern cones	Pre	Check for impacts and cracking. Check location fixings are secure.	
		Deck	Deck	Pre/ post	Check deck for impact marks and cracking: make good any defects before next mission.	
			Lift hoops	Pre / Post 3 year	The hoops are a welded part of the strut base plate, see below. They are deliberately over-engineered to take snatch and shock loads when launching and recovering in up to sea state 4. Check for cracks and twisting. Lift hoop design has undergone finite element analysis and are certificated to SWL of 500 kg, which is twice the design load of 250kg. The design stipulates both hoops are to be used when lifting. If the vessel is lifted by a single hoop because it is the only way to recover the vessel then	

FUNCTION		EQUIPMENT	SUB-ITEM	PERIOD	MAINTENANCE / INSPECTION	CHECKED
					before reuse a full structural survey of the associated bulkhead and hull area should be completed in consultation with AutoNaut Ltd	
			Hatches	Pre / post 3 year	Visually examine hatch seals. Repair or replace as necessary In particular look for grit and damage to the rubber element and deformation of the hatch cover or coaming. Replace hatch seal rubber element	
			Vents	Pre annual	The Gore vents have no service interval. Any indication of water ingress requires the vent to be replaced with new (available from AutoNaut Ltd). Inspect underside of vents.	
		Mast	Mast	Pre / Post / annual	Examine carbon fibre mast for signs of wear and cracks. Carbon fibre is likely to fail completely if it fails at all. Replace with spare mast if necessary. Remove mast and fittings. Check pole thoroughly before refitting.	
			Mast Base	Pre Mon	Examine mast base and spring, ensure mast fixings are secure in mast base. Examine deck around mast base for signs of cracking, if found inform AutoNaut Ltd for advice.	
		Connectors	PV	Pre / post annual	Visual inspection of deck connectors for corrosion or damage. Full shore test (check voltage output per panel).	
			Antennae	Pre / post annual	Visual inspection of cables and antennas on mast. Full shore test.	
			Airmar	Pre / post / annual	Visual inspection of connectors. Full shore test.	

FUNCTION		EQUIPMENT	SUB-ITEM	PERIOD	MAINTENANCE / INSPECTION	CHECKED
			Nav light	Pre / post / annual	Visual inspection of connectors. Full shore test.	
		Interior	Watertight	post	Firstly vent battery compartment with bilge pump and carefully open battery compartment hatch to vent hydrogen gas before switching any systems. On recovering the vessel carefully dry hatch tops before opening to avoid drips, then inspect each compartment for water. Track down cause of any leakage. Rectify before next mission. Sponge out each compartment with fresh water and dry.	
			Hull skin	Pre / post annual	Visual check interior and exterior of hull for cracks, signs of collision. Thorough internal and external inspection for signs of damage.	
			Bulkheads	Pre / annual	Visual check bulkhead integrity. Visual check integrity of watertight glands. Maintain as interior hull skin.	
			Internals	Pre / post monthly	**IMPORTANT**: thorough visual check of all fixings, screws, bolts, straps etc holding batteries, internal equipment and payload in place. **It is critical they are fully secure and cannot move in storm conditions at sea: remember the AutoNaut can be capsized and will self-right in storm conditions.**	
			Bilge pumps	Pre / post / annual	There are three pumps. Check the pumps run when switched on. These pumps are designed to run dry. This facility is used by pilots to ventilate the compartment where the battery could vent hydrogen. Check the gauze filter in bilge is not obstructed. The inlet and outlet pipes are quite delicate, check their integrity, particularly the outlet hose join to the outlet one-way valve through the deck. Full shore test.	
B	Wave propulsion	Struts	Struts	Pre / post	Check fixing bolts are tight. Visually inspect struts for damage, wear, or bending. Remove marine fouling.	

FUNCTION		EQUIPMENT	SUB-ITEM	PERIOD	MAINTENANCE / INSPECTION	CHECKED
			Ballast blocks	Pre / post	Check fixings are tight Visual check of material for wear or cracking	
			Foil Axles	Pre / post	Visually inspect axle weld to strut	
		Foils	Fore	Pre / post /	Remove marine fouling. Visual inspection of: 1. Foil surface. Remove marine fouling. 2. locating pin and nylock 3. Spring return mechanism. 4. check for wear on axle/foil interface	
			Aft	Pre / post /	Remove marine fouling. Visually inspect foils as above.	
	Steering	Rudder	Blade	Pre / post	Visual inspection of blade and fixings to shaft. Remove marine fouling.	
			Head	Pre / post	Visual inspection of rudder head for wear or looseness. Bolts to be secured with LocTite/thread lock.	
			Servo	Pre / post / monthly	**IMPORTANT: It is critical to successful missions that the servo always works without fault. Therefore although servos should last much longer it is recommended the servo O rings are replaced after 90 days at sea, or at the next opportunity on longer missions.** With the system switched off, the rudder, servo and linkage is checked by moving the rudder blade gently from side to side. The servo gears should turn smoothly. If in any doubt, such as hearing clicks or grinding from the servo gears, replace the servo with a new one.	
			Coupling	Pre / post / monthly	Manually check the servo drive rod is properly secured to the rudder coupling. 'LocTite or similar threadlock has been applied to fixing screws. There should be no play when the arm is moved). Visually inspect the rudder coupling.	
			Rudder connector	Pre / post / monthly	Visually inspect servo connector on transom for corrosion and servo cable insulation for abrasion or cuts. If in doubt replace with a new servo unit.	

FUNCTION		EQUIPMENT	SUB-ITEM	PERIOD	MAINTENANCE / INSPECTION	CHECKED
C	Rudder/ Thruster systems	Electronics box	PDE	Pre / post Annual 3 yr	Visually check exterior for corrosion and salt water damage. Carefully clean seals. If water has got inside please contact AutoNaut Ltd to assess damage and if necessary source a replacement. Open box in 'clean' workshop. Inspect electronics for corrosion or other signs of damage. Reseal. Follow with full shore test. Replace seals on boxes.	
		Electrical connections			Inspect for corrosion and faulty connections. Clean and preserve.	
		Battery	4 x 70Ah lead gel	Pre Post 3 year	Check battery charge and condition. Grease terminals to limit corrosion. Double check battery securing straps Before disconnecting battery ventilate compartment: DANGER of H_2 explosion. Replace with new batteries.	
			PV Panels	Pre Post	Visual inspection. Attention to connector pins, security of bonding to backing panel and scratches to surface. Wash panels with fresh water and carefully remove any salt or other encrustation.	
D	Auxiliary propulsion	Thruster		Pre / Post	Visually check all fixing screws and bolts on Thruster exterior and bolts securing it to stern strut. Check wiring is clean and without abrasions, and waterproof connector is clean and correctly assembled. Turn propeller by hand to ensure freedom of rotation without any untoward stiffness.	
G	Sensors		Airmar	Pre / post annual	On mast. Visually inspect security of fixing, wires and connectors. Full shore test.	

FUNCTION		EQUIPMENT	SUB-ITEM	PERIOD	MAINTENANCE / INSPECTION	CHECKED
			Cameras	Pre / post	Check mountings are securely fixed. Check cabling and routing through deck gland.	
H	Navigation	Nav light	All round white LED	Pre / post Annual	Visual check of cable from Echomax. Full shore test.	
I	Lifting and launching	Trolley		Pre Post	Check wheels are in good order and cradles are securely fastened. Rinse off thoroughly with fresh water. Grease axles.	
		Lift strops		Pre	AutoNaut may be lifted directly with a two point lift at the bow and stern which requires strops (safe working load 1000 kg each) to be attached to the fwd and aft hoops and a crane. The hull can also be lifted by under-hull strops >50mm wide but **care needs to be taken** to avoid damaging the antifoul wrap, foils or any through hull sensors during such an evolution. Strops must be secured fore and aft to prevent them slipping along the hull. **Maintenance:** Lifting strops used should be load tested and marked accordingly. They have limited service lives and must be retested at the intervals marked upon them. At the end of life or if they have been damaged they must be disposed of by destruction so that they cannot be reused inadvertently.	
		Personal Protective Equipment (PPE)			Appropriate personal protective equipment (PPE) should be worn when lifting or moving the AutoNaut, e.g. protective footwear and appropriate gloves. Safety helmets should be considered if the AutoNaut is to be lifted above chest height of the operators.	
J	Documents				Full compliance with international guidance requires all parts of the Unmanned Maritime System (UMS) to play a part in the safe operation of a USV such as AutoNaut. These include not just the vessel as covered in this manual, but the Remote Control Workstation and its operators, support system and personnel. It is recommended maintainers read the Technical Manual which offers advice for the safe operation of the systems.	