AutoNaut

Management & Operations TRAINING PACKAGE

AUTONAUT – TRAINING OVERVIEW

Management and Operations training

1. AutoNaut – System overview
2. Wave Propulsion
3. At Sea Operations & Safety Management
4. Piloting and Mission Planning
5. Support
6. NTNU specific questions

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AUTONAUT: OVERVIEW

- Wave Propelled
- Unmanned Surface Vessel
- Zero Emissions
- Persistent, offshore data gathering
- Flexible sensor payload
- Global monitoring

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MISSIONS

AutoNaut has deployed for more than 60 missions, including:

- NOC - MASSMO1a MetOcean Scillies, UK. 2014
- NOC – MASSMO1b Marine Life Tracking Plymouth, UK. 2014
- UK Met Office / PML MetOcean Plymouth, UK. 2014
- FCO Surveillance for IUU Plymouth, UK. 2015
- UNMANNED WARRIOR Surveillance for ASW Hebrides, UK. 2016
- Seiche PAM Plymouth & Scotland, UK. 2016
- SWW Water Quality Cornwall, UK. Jan 2017
- BP PAM and ADCP Shetlands, UK. Apr 2017
- NOC – MASSMO4 PAM Orkneys, UK. May 2017
- TING (UoG) ADCP Sweden. Jun 2017
- SRC Fish Monitoring Sweden. Jun 2017
- Offshore O&G Acoustic survey Gulf of Mexico. Dec 2017

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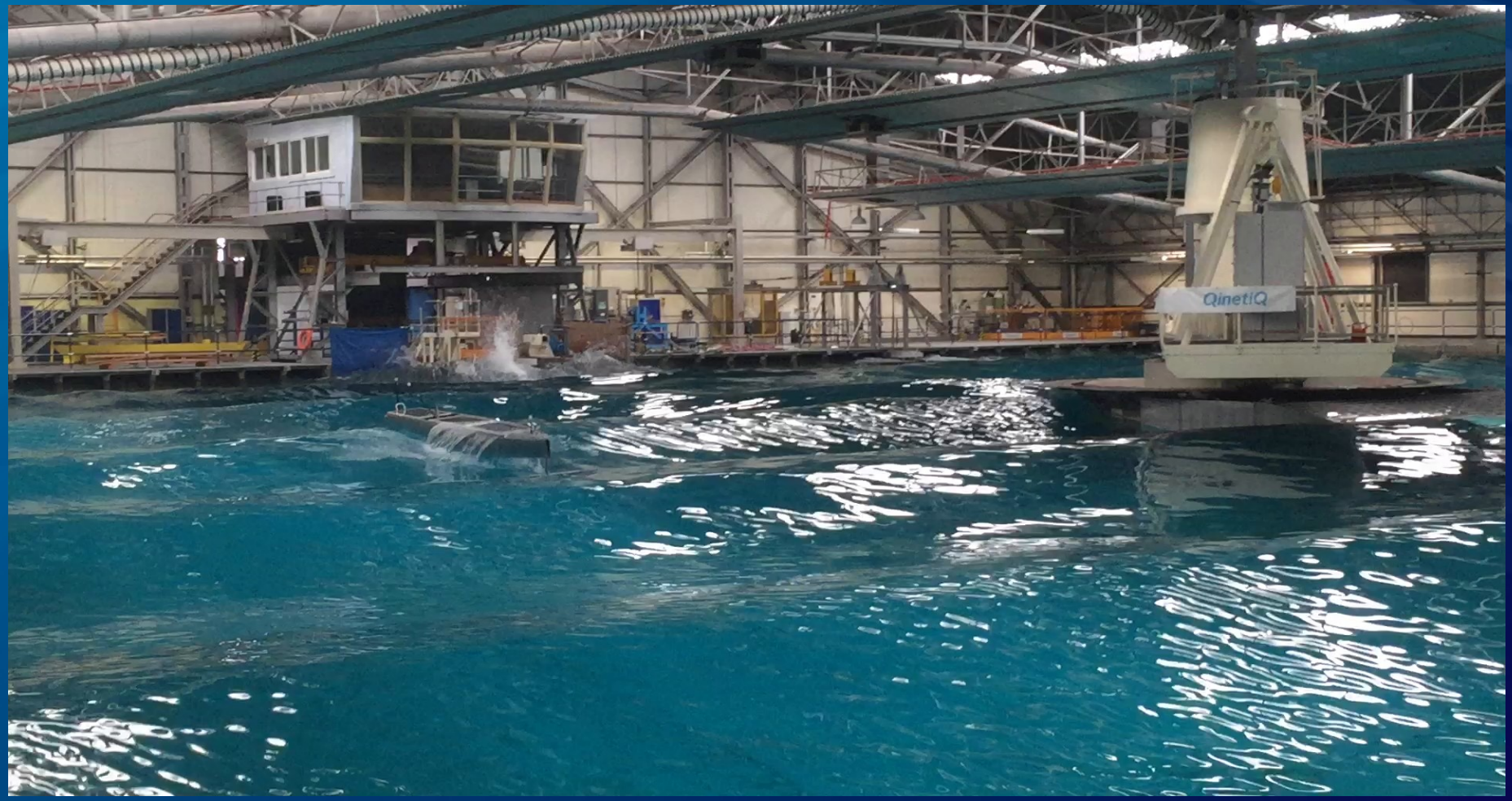
AUTONAUT – WAVE PROPULSION



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AUTONAUT – WAVE PROPULSION

- Pitch and roll of the hull both converted into thrust through the wave foil technology
- Hull designed to maximise available energy for propulsion
- Small wind driven chop is sufficient to generate forward motion
- AutoNaut operates in all directions with respect to the waves including into the wind/waves
- Wind derived waves are what drives AutoNaut
- Long wavelength swells have no affect

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AUTONAUT – WAVE PROPULSION

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AUTONAUT – WAVE PROPULSION

Care of Foils and Rudder

- Foils and rudder need care when operating
- Particular attention when launching/recovering and towing
- Simple rules to follow
    - Never move or tow AutoNaut astern
    - Max forward towing speed 5 knots water speed
    - Be aware of support vessel prop wash and its affect on the foils

When deployed on operations

- AutoNaut will always be underway even in small waves – you cannot ‘stop’ it
- The smaller the waves, the slower AutoNaut will go

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Specific Advice

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AUTONAUT – NTNU SPECIFIC QUESTIONS

Best practices for operations in low-light environments

- Define a working area and stay inside boundaries
- Produce NtM and inform local authorities and vessel operators
- Ensure vessel navigational safety systems are working and powered on – Echomax & nav light, AIS class B transponder
- Common sense power management to ensure mission critical systems have power at all times

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AUTONAUT – NTNU SPECIFIC QUESTIONS

Best practices for control of the USV during multi-month operations

- Test systems and data storage to ensure sufficient storage capacity for duration of planned mission
- Ensure large enough piloting team is trained in the USV operation to match the duration
- Agree and issue a watchbill of pilots to meet the requirement – many options here depending on pilot team size
- Have clear mission plan for pilots to work to during different phases of the mission.
- Maintain regular management oversight of the mission to ensure operating standards are maintained and objectives are being met.

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AUTONAUT – NTNU SPECIFIC QUESTIONS

Identifying misbehaviour of the vehicle – how to distinguish that the vehicles motion is influenced by external factors or internal faults

- Be aware of weather conditions and surface currents - this can impact the performance of the hull through the water.
- Sudden significant change in performance (either speed or steering) for given conditions can be evidence of entanglement with weed/floatsam. Trying to steer around in a circle can clear the obstacle.
- Check speed for given course and weather: any unusual change/difference can be evidence of a problem.
- Check heading/course for weather conditions: if AutoNaut is not holding a good course then that can be evidence of a problem.
- Monitoring system/sub-system current draw can give evidence of a problem: eg a change in the rudder current profile.

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AUTONAUT – NTNU SPECIFIC QUESTIONS

Collision avoidance at sea – good-practices for wave-powered USVs on ship-traffic routes

- Stay away from shipping lanes and routes: only cross lanes perpendicular to traffic directions.
- Avoid Traffic Separation Schemes completely if at all possible.
- Do not approach ship traffic routes in calm conditions when the Autopnaut speed and manoeuverability is low.
- Keep AIS class B and radar EchoMax switched ‘on’.
- Develop an autonomous collision avoidance protocol, eg within the autopilot software, to respond to possible collisions based on the most dangerous AIS ‘target’.

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AUTONAUT – NTNU SPECIFIC QUESTIONS

Vehicle retrieval from the ship using a crane

- When recovering offshore, plan the operation carefully to be as safe as possible
- If possible fully brief and prepare the ship's crew beforehand; eg practice the recovery alongside.
- The bow & stern lifting hoops are suitable for dynamic loading during offshore recovery
- Use long reach poles and snap hooks to capture the hoops, and attach the lifting strops
- Have bow & stern guide lines attached to the lifting strops to prevent the hull from swinging during recovery
- Secure on deck onto cradle/trolley when recovered

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AUTONAUT – NTNU SPECIFIC QUESTIONS

Most important functionalities that should be implemented in the controller for wave-powered USV

- System power management: voltage, current measurement, remote switching of systems and sensors, software current trips, optional auto resets of trips.
- Payload power management by operator using above functionality: develop auto load shedding if needed for low light conditions.
- System status/health monitoring information: battery voltage, PV panel current, system/sub-system current,
- Wind speed and direction data to operator in real time.
- Autopilot with functionality to add, edit and follow waypoint tracks; follow compass heading; manual steering.
- Autonomous AIS based collision avoidance.
- Fixed Obstruction avoidance with operator definable action radius.
- Remote hard reset of controller with auto reboot.

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AUTONAUT – NTNU SPECIFIC QUESTIONS

Modifications to the hull, e.g. adding additional sensors, and watertight connectors

- Hull is glass fibre epoxy resin infused moulding and therefore easy to modify for changes to sensors etc using epoxy resin and glass fibre reinforcing. Deck is glass fibre/closed cell foam sandwich which is stiff and easy to drill holes through for additional connectors.
- Provision exists in deck fittings for a range of different connectors to be added as required.
- AutoNaut technical staff will advise on modifications required to the hull and installation, and recommend connectors, for any proposed modifications.
- EXAMPLE: Simrad WBT-Mini sonar with dual frequency transducer. AutoNaut will deliver new fin for transducer (fits to current fin mountings) and offer advice for the full installation of the hardware into the hull.
- It will be important to ensure that the stability and self righting is not compromised after any additional sensor fit, and AutoNaut design staff will provide advice on this before any installation is carried out.
- A check to ensure that the hull floats upright must be completed after any modifictions to the boat.

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QUESTIONS AND WASHUP

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