# AutoNaut Status - December 2018

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This document contains an overview of the current works on the AutoNaut platform.

## Level 1

Level 1 implementation is stable and tested with the last sea trials in October 2018.

### Iridium Gateway 1

Since the last sea trials, Iridium Satellite communication has been implemented and tested with hardware-in-the-loop experiments. The functionalities implemented are:

- **mailbox check**: periodic device (RockBlock+ with Iridium 9602) activation and mailbox check for received messages (1 time per day) - immediate or time-driven application of eventual commands sent by operator;
- **housekeeping message**: periodic device activation and message construction (timestamp of the state: power settings, operating units/sensors, telemetry data, ...) (1 time per day - 12h shifted from mailbox check) - the message can be modified, but will normally a format of this kind: iridium/computerID, UTC_time, lat, long, power_settings;
- **anomalies recording**: a set of *prioritized* anomalies is defined: power-related anomalies and communication anomalies - priorities are time thresholds that when exceeded trigger construction of a message and immediate dispatch to the operator;
- if one anomaly is experienced and notified to the operator, he/she can reply with a new set of commands - for example, he/she can switch off ("1" bit in the power settings binary string), switch on ("0" bit in the power settings binary string) or reboot ("2" bit in the power settings binary string) a sensor/computer.

### Speed-based autopilot gain scheduling

PI gain selection is now based on the AutoNaut SOG. To be tested with next sea trial.
More stable and precise control action can be achieved computing the rudder angle with a PID controller. Employing a PID requires estimation of the COG derivative, measurement not available with current set of sensors. A fixed-gain state observer (or KF) with wave filtering will be implemented and tested hopefully with the next trials. This does not have high priority.

## Level 2

### Waypoint Navigation

Good improvements have been done since last sea trials. GPS-based has been implemented and tested in simulation. PID controllers need tuning and sea trials test. Navigation is only based COG information coming from GPS. Desired COG based on target coordinates and current ones. The error is computed as difference between desired and current COG. A first-order model with integrator is employed to describe the dynamics between rudder angle and ship heading. Simulation parameters need adjustment for more realistic simulations.

### 3G/4G Modem

Portable modem has been selected and purchased. Specifications at this link:
https://i.mt.lv/cdn/rb_files/ltap_mini_lte-180823100648.pdf. The modem is equipped with internal GPS (with IP67 antenna) and LTE card. Two SIMs can be integrated in the modem, which is equipped with two slots for related antennas. The modem will be placed inside the hull (not sure inside the watertight boxes), whereas antennas will be placed outside.The modem will provide the BeagleBone with internet connection in fjords and along the coasts of Norway, through Ethernet connection. This will allow the operator to control, monitor and command the AutoNaut through Neptus.

### Iridium Gateway 2

A second unit will be purchased soon, same model as the first one (RockBlock+ with Iridium 9602). This will be integrated in Dune and Neptus to allows plans dispatching and ship monitoring in absence of 3G/4G network coverage. Periodic and priority-based message dispatching to the operator will be implemented also in this case. LSTS implementation already supports different features, adaptation will be needed.

### Airmar Weather Station

The weather station is going to be interfaced to Level 2 instead of Level 3 computer. This because data from the sensor will be used for navigation. First integration of the sensor is planned. This will involve electrical interfacing and data transmission to the BeagleBone board and driver development in Dune for sensor data acquisition.

## Level 3

Level 3 system is at embryonic stage. The computer is chosen and available, as well as a preliminary design of the hardware interface for the scientific payload. The scientific payload includes several sensors: Seabird EcoTriplet, Seabird 49 FastCAT CTD, Aanderaa Oxygen Optode 4835, Nortek Signature 500 ADCP. Additionaly, Water Sampler and Fish Tracker need to be selected and integrated.
Level 3 computer development is planned to start once Level 2 functionalities are stable and tested with sea trials. However, selection of the last two sensors has already started. Sensors integration and data acquisition/processing in Level 3 may also be proposed as term project or master thesis.
Level 3 computer will run ubuntu 16.04 or GLUED as OS. Dune is chosen as core software for sensor triggering and data management. This choice is due to already tested capabilities of Dune to deal with most of the scientific sensors available. Ethernet connection makes Level 2-Level 3 communication possible. No internet connection is actually needed to Level 3 from Dune instance running on Level 2, Level 3 one can be managed (sending plans for data collection). Normally, the operator will be able to send plans to L2, including also plans to be dispatched to L3.
L3 will be switch of for most of the time (i.e. during normal point-to-point navigation). Once the zone of interest is reached (an area of preselected radius around the target coordinates), L3 is powered and the plan is sent from L2. The plan will specify which sensor to trigger and a temporal window for each of them. Detailed design of this phase still need to be done. Once data collection is over, data are packed and compressed. The data package will be both stored in L3 non-volatile memory as well as sent to L2 via Ethernet for backup storage and possible forwarding via Iridium.
Detailed design of a complete data collection routine will come.

### Current and future payload

For a complete list of sensors, with specifications and descriptions, visit
http://129.241.10.115/doku.php. The current navigation and communication payload (Level 1, Level 2) is:

- Echomax Active-XS Dual Band Radar Transponder (Level 1s);

- Airmar 120WX Weather Station (Level 2, both scientific and for navigation);
- Raymarine AIS350 Class C Receiver with dedicated GPS (Level 2);
- Garmin GPS16x HVS (Level 1);
- Owl VHF (Level 1);
- Rockblock+ Iridium (Level 1);
- Garmin GPS 18x-5Hz LVC (Level 2);
- Rockblock+ Iridium (Level 2);
- Horn (Level 1);
- RB912R-2nD-LTm&R11e-LTE Modem (Level 2).

The current scientific payload (Level 3):

- WetLabs EcoPuck Triplet;
- Seabird SBE 49 FastCAT CTD;
- Aanderaa Oxygen Optode 4835;
- Nortek Signature 500 ADCP;
- Fish Tracker (model tbd);
- Water Sampler (model tbd).

## Water Sampler

Ongoing literature survey. Choice to be taken after talk with biologists and statement of the constraints to be respected in order to provide useful water samples.

## Fish Tracker

Collaboration started with Prof. Jo Arve Alfredsen to include a fish tracker in the scientific payload. A device has already been purchased and dedicated to the AutoNaut, therefore it is included in the list of sensors to be integrated on Level 3 computer. The device will communicate to the board through RS485. The purpose of its integration is to actively track fishes in order to better understand their behaviors in the fjords, in their outlets and in the open sea.

### Radiometer

To be discussed.
Reference: www.vliz.be/imisdocs/publications/310400.pdf,
www.vliz.be/imisdocs/publications/309684.pdf

## Next steps

### Early January

Early January is dedicated to drilling 6-7 holes on the AutoNaut hull. Holes will host watertight connectors that will connect navigation sensors, antennas and 3G/4G modem from outside to inside the hardware compartments. Some sensors (like both GPSs) will be fixed on the mast on dedicated 3D-printed components. An additional hole will be drilled in order to host an external charging port for the batteries. It is desired to reduce bulky cables inside the compartments. Also, fixing structures are meant to be crafted, in order to stabilize the hardware boxes and the few components inside the hull. Mechanical design and works are prioritized.
Immediate next steps involve testing L2 functionalities: waypoint navigation and collision avoidance algorithm with AIS data information. The first test will also test the new PID autopilot with state observer on Level 1. Tests will be carried out through WiFi Rocket communication. If the integration of the modem is completed by the time the first sea trial is carried out, experiments will be performed via 3G/4G communication. This has secondary priority with respect to stabilizing navigation capabilities. Third step, will be conducting a complete mission with satellite (Iridium) only communication. Stability and reliability is needed to face long-term missions.
Months of January and February are dedicated to development and sea trials. My idea is to carry out 3 sea trials and start and conclude testing of L2. Once the above is tested and demonstrated to be stable, L3 development will start.

Some of my free time is dedicated to the AutoNaut wiki http://129.241.10.115/doku.php, where what has been done and what I'm doing is mostly documented.

# Sensors and computers installation

In this installation the sensors are mounted as follows:

- the Seabird CTD is mounted on the centre line forward of the hull joint, but far enough aft to reduce the chance of aeration to a minimum;
- the Nortek ADCP is mounted on the centre line just aft of the hull joint;
- the Wetlabs puck and Aanderaa Optode sensors are mounted on the bottom of the fin, aft of the ADCP.

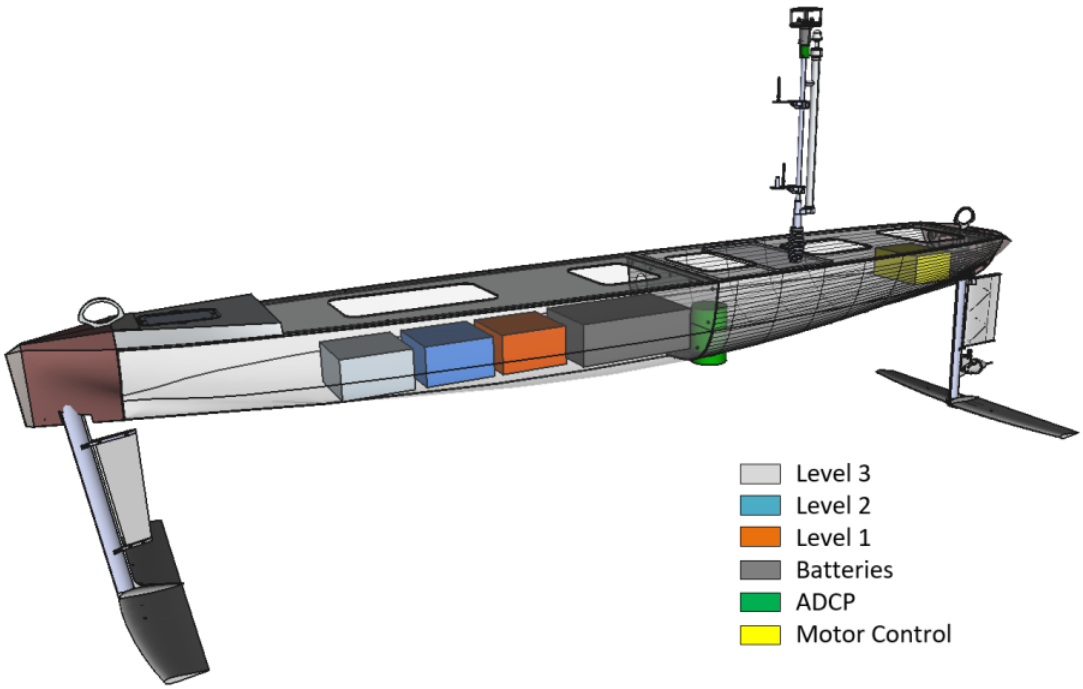


Figure 6.7: Placement of units in the hull.

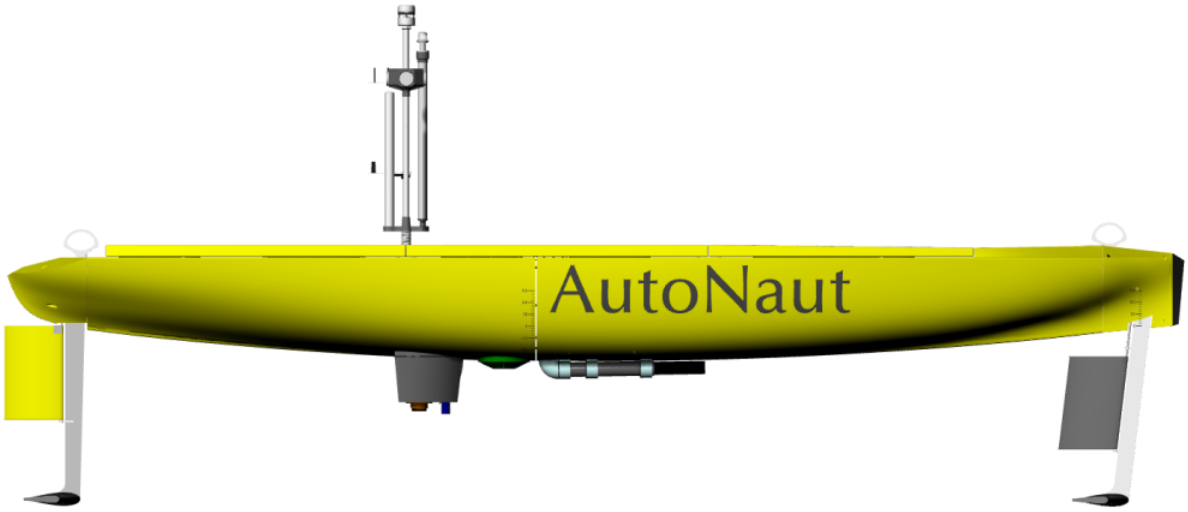


*Fig 1: profile view*

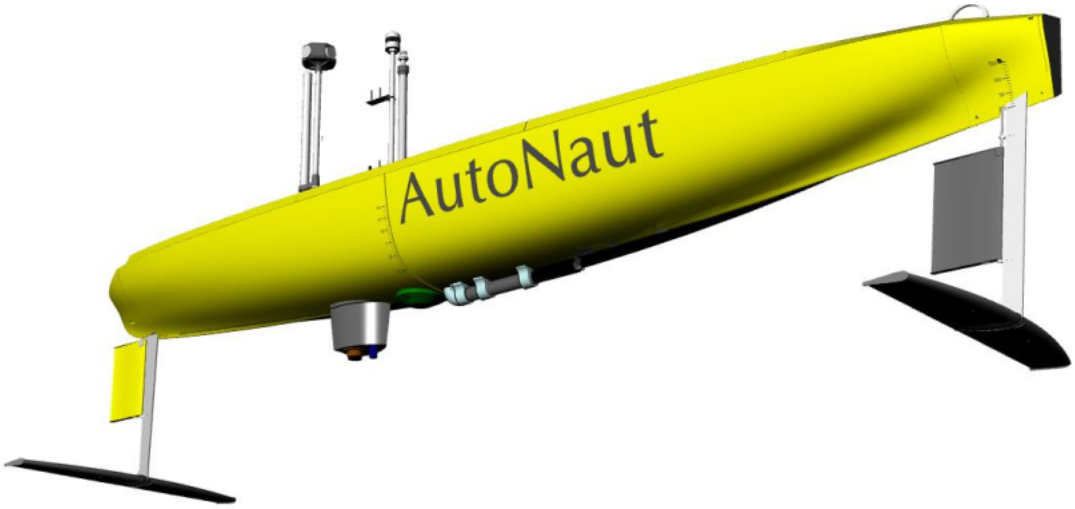


*Fig 2: starboard bow underside view*