3G Environmental Sample Processor (ESP)
Long Range AUV

DRAFT Requirements and Interface Specification DRAFT

Version 1.0

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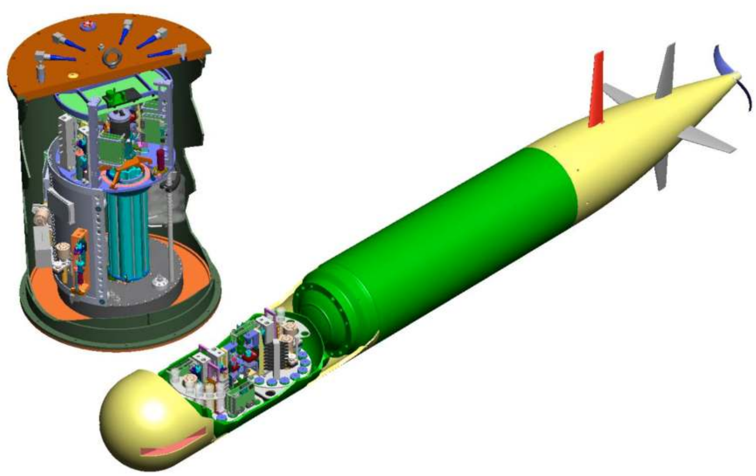

Executive summary

This document is the central repository for specifications, requirements, and interface-control information of a fully packaged G3 ESP instrument integrated for deployment on a Long Range AUV.

Since this is the authoritative repository of requirements and interface information, any substantial changes to the document after release Version 1.0 need to be made through a change request and approval process.

Table of revisions

Table 1: Document revisions.

Date	Version	Major changes
Jan 3, 2012	0.1	First draft begun

1. Introduction

1.2. Document content

This document is the central repository for specifications, requirements and interface-control information for the 3G Environmental Sample Processor (ESP) integration with a Long Range AUV. This document will evolve continually up to the preliminary design review (PDR). After that point, the plan is to have an approved version of the document that is only changed by agreement of both LRAUV and ESP.

1.3. Intended use of the 3G ESP/ASU Analytical Module onboard a long range AUV (LRAUV)

MBARI has developed a new class of autonomous underwater vehicle (AUV) known as the long range (LR) AUV. The LRAUV is capable of multi-week missions in the upper 200m of the water column running at speeds up to 1 m sec^{-1}. The vehicle is also equipped with a buoyancy compensator and can trim to neutral density so that the platform can act as a drifter or profile vertically without active forward propulsion (http://www.mbari.org/auv/LRAUV.htm).

The overarching objective of this project is to install the 3G ESP fitted with an analytical module onto the LRAUV for operations in coastal and oligotrophic ocean waters in support of investigations of microbial mediated biogeochemical cycling. Generally, the LRAUV will spend most of its time underwater, will operate 24/7, and it is highly likely that real-time communications with shore side personnel will be very limited. Thus, the instrument payload must accommodate long periods of operation absent any human intervention. A typical use case scenario for the 3G/LRAUV combination is expected to be as follows:

a. The LRAUV will locate a target parcel of water to sample as defined either by pre-determined location/depth/time of day coordinates (i.e., strictly “hard coded”), or by an adaptive sampling process where water characteristics are determined in real-time using onboard sensors (e.g., CTD or optical sensor package) which, in turn, trigger the initiation of a sampling event when appropriate conditions are met. Sampling may also be initiated adaptively via real-time inputs form a larger, extended networked sensor array that informs the LRAUV as to when or where samples should be collected from.

b. Once at an appropriate location, the LRAUV will signal the 3GESP to initiate sample collection. (Sample collection and processing may take up to 3 hours.)

c. After the sample is collected, the core ESP will pass appropriate material to one or more analytical modules for analysis. (Analysis time depends on detection method, may be short a handful of minutes or much longer, 16 hours.)

d. Based on results of those tests, the ESP may deliberate on further action necessary to process remaining sample (e.g. initiate an additional analysis on material already collected, such as a probe array hybridization following selective qPCR), and/or may “inform” the LRAUV platform of its findings so that the platform can modify its search/operations behavior accordingly.

1.4. Overall architecture

The LRAUV, 3G ESP and analytical module(s) will interface according to the block diagram in Fig. 1. All control of the analytical module, power, and data will be via the ESP controller, which will then interface to the platform (AUV or mooring). In this design, the platform contains or acts as the ‘mooring controller’ guiding the communications and power to any/all contextual sensors as well as the ESP/analytical module.

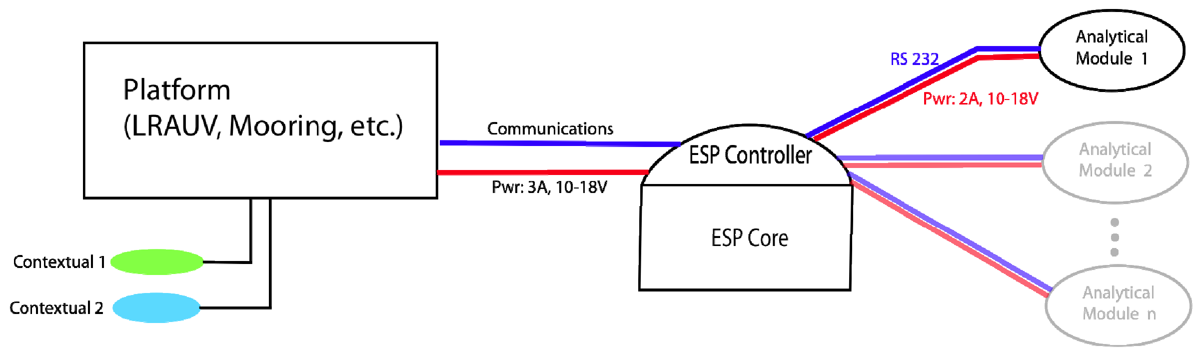

Figure 1. The ESP connects the analytical module to the mooring controller within the platform (e.g., LRAUV or mooring). Multiple Analytical Modules may be attached to the ESP core via the ESP controller, but there is a total of 2A current available for all modules.

2. Requirements specifications for the 3G ESP instrument

2.1 Operating Depth

The 3G shall be operational (able to sample ambient sea water) to a minimum of 200m depth, but closed pressure boundary shall be suitable for excursions up to 300m deep.

2.2 Voltage

The 3G shall operate off the LRAUV main battery bus, and distribute/manage power to its analytic modules. Nominal 10 – 18V, absolute maximum 10 – 24V (during charging)

2.3 Current

Maximum 3A continuous, 5A (in rush) upon contact closure, max 25ms

2.4 Energy

LRAUV and ESP should coordinate to develop an energy per sampling event estimate, (W-Hr/run), dependent on a variety of use-case scenarios and battery options.

2.5 Power Switching

The LRAUV shall have power switching control of the ESP. A procedure shall be developed that prevents the ESP from being shut off during an analysis or other operation unless necessary.

2.6 Data interface standard

Physical protocol: 5 wire RS-232.

A. Naming convention is from ESP perspective

TX	Transmit Data	ESP Drives
RX	Receive Data	AM Drives
HSO	Handshake out	ESP Drives
HIS	Handshake in	AM Drives
SGnd	Signal Ground	

B. Handshake function
   HSO signals AM that ESP is ready to receive
   HSI signal ESP that AM is ready to receive

C. Baud Rate 1200,2400,4800,9600,19200,38400,57600,115200

Handshake signals are required for analytical modules supporting baud rates faster than 9600. Handshake signals are optional (but still recommended) for analytical modules that always communicate at rates of 9600 baud or slower.

Analytical Modules serial data must consist of 8 data bits with no parity.

2.7 Message syntax

2.7.1.2 Syntax …

2.7.2.2 Protocol …

2.8 Commands and Responses

2.9 Communication with shore

This section contains requirements for communication with the 3G while at sea including data specifications as well as command and control.

2.9.1.2 The 3G controller shall be provided a direct connection from shore with data throughput on the order of 200 Bps with .5 second latency.

2.10 Communication with LRAUV

This section contains requirements for communication with the 3G controller and the LRAUV including onshore communication

2.10.1.1 Communication between the 3G and LRAUV are defined as interface X in section TBD of this document. This includes a network link of at least 115200 bps with a protocol that can be run on top of multiple physical layers.

2.10.1.2 The LRAUV shall provide the 3G with any data writers it has requested be read at rate… examples include CTD, Nitrate , and depth measurements.

2.10.1.3 The LRAUV shall provide the highest bandwidth network connection available to the 3G when on shore.

2.11 Vehicle and 3G Safety

This section contains requirements imposed on the LRAUV as well as 3G specific requirements surrounding safety of the LRAUV as a whole.

2.11.1.1 The 3G shall provide physical access for environmental sensors in the 3G hull to be monitored by the LRAUV

2.11.1.2 The LRAUV shall monitor the 3G pressure hull environment in the same way it measures its own pressure hull (e.g. temperature, humidity, water, pressure).

2.11.1.3 The LRAUV shall not request that the 3G sample below depth TBD.

2.12 Pressure housing

The intent is to place the 3G ESP in a 300m rated pressure housing that extends the length of the LRAUV by 24in. This would be a fully separate air space from the LRAUV main housing.

2.13 ESP Instrument Size

The LRAUV can be extended a maximum of 24” to incorporate a 3G ESP payload. MBARI is planning for an 11” diameter instrument to fit inside the current housing geometry. With a hemispherical nose, this forms a bullet shaped volume 23.5” long, encompassing approx 2060 cu-in (33.7L). To ensure a deployable instrument is developed, MBARI will be reserving a volume margin, decreasing as the instrument design progresses. The following table describes the margins and the “design to” volumes of each stage of development. The final 20% margin will be held as reserve to resolve critical issues during instrument validation, and allow space for future capability and improvements.

Design Stage	Reserve Margin	3G "Design To" Volume
Pre-PDR, PDR	40%	1235 cu-in (20.2L)
Pre-CDR, CDR	30%	1440 cu-in (23.6L)
1st Article Build	20%	1650 cu-in (27L)

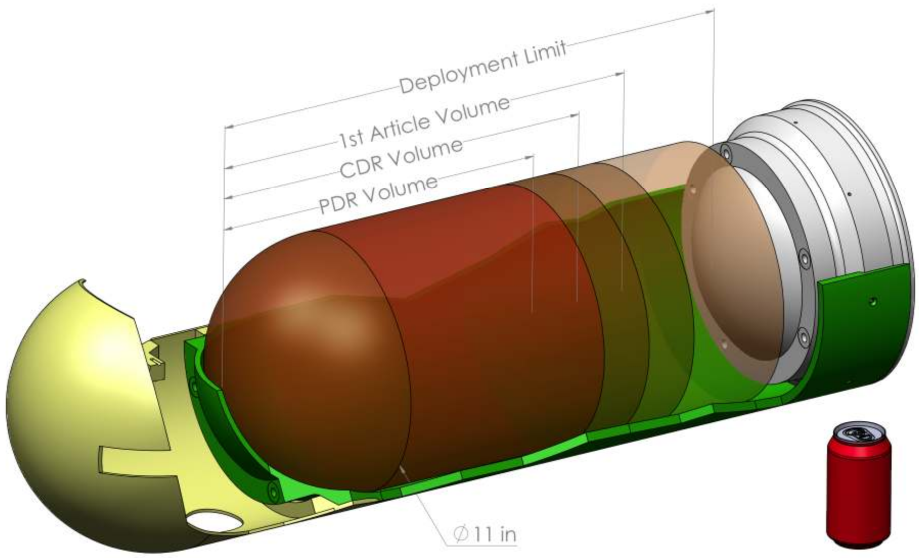

Figure 2. Payload volumes. Goals will gradually eat up reserve as design approaches 1st article build.

2.14 Mass

The 3G ESP instrument total mass shall be managed by designers to be less than or equal to the target allotted. The module size and mass constraints are linked as the instrument shall be deployed on a neutrally buoyant platform. It is expected that the module size will be more limiting than mass, so a general mass budget is provided as a density function of the module's rectilinear box volume as defined above. The module density shall not exceed 0.70 kg/L. Less dense is acceptable, and final deployment mass may be more efficiently adjusted at the platform level rather than the instrument level.

The mass of the 3G ESP will vary during deployment. Mass of the dry housing may change as dry volumes within the ESP are filled with seawater, and some cleaning fluids stored in the ESP may be expelled. The mass of ESP equipment in the seawater flooded nose section may vary slightly. (A reservoir of flushing fluid may be stored at ambient pressure; the flush fluid may be less dense than seawater.) The design of the 3G ESP will need to closely coordinate with the LRAUV to best mitigate the variable mass effects.

At the current stage of design, the ESP mass variability during deployment is not known. The LRAUV platform can adjust to accommodate a mass variance of the 3G ESP payload of XXX grams. The design goal is for the 3G ESP mass variability to be less than this (with appropriate design margins) without the ESP needing to perform mass control during deployment.

2.15 Orientation, Accelerations

The 3G ESP is specified to operate under accelerations up to .5g in any direction at a tilted angle 30º from horizontal. The module shall not be damaged, and normally execute future analyses after exposure to acceleration of 1g in any direction, or orientation in any direction. The module shall function within specifications after multiple exposures to accelerations of 3g in any direction encountered while shipping or in transit for deployment.

2.16 Thermal environment

The 3G ESP shall function in temperatures from 2 to 37 ºC. The 3G ESP shall function within specifications after exposure to temperatures of 0 to 50 ºC encountered while shipping or in transit for deployment.

2.17 Humidity

As there will be liquid reagents that can evaporate into the air space around the ESP, the humidity may be higher than a typical dry electronics housing. At the current design stage we do not have a prediction of the max RH that will develop. Commonly the 2G ESP sees RH up to 50%, and a few time near 80%. The 3G ESP is being designed to function with relative humidity from 0 to 90%.

2.18 Serial numbers

Every unit shall have a unique serial number, and the number should be accessible across RS232.

3. Appendix

4. Glossary

Analytical Module – (AM) The part of the G3 ESP instrument that does the actual detection of microbial products. There are different analytic modules being developed by institutes outside of MBARI, such as ASU and UW. Up to 3 AM's may be used and deployed with the ESP if space, weight and power needs are met by the platform. Also known as the ESP back end.

ESP Core – The sea water processing part of the ESP instrument that filters the raw seawater, creates a refined sample, and presents that sample to one or more analytical modules for detection. Also called ESP front end.