PT Geyser functional description

The PT Geyser is a Popup Tag designed for attachment on tuna and shark.
It´s programmed for logging environmental parameters and releasing it self at a certain time and transmitting the measurement results to Argos satellites.

The PT Geyser main feature is the Argos-3 interactive communication capability that ensures effective transmission of data as all packages are acknowledged by the Argos-3 satellite.

The PT Geyser will provide behavioral information and geolocation.
This document specifies the main capacities of the PT Geyser, and describes its basic functionality.

A summary of specifications is provided at the end of the document.

Table of contents

1. The PT Geyser physics

The casing

The casing is made of carbon fiber.

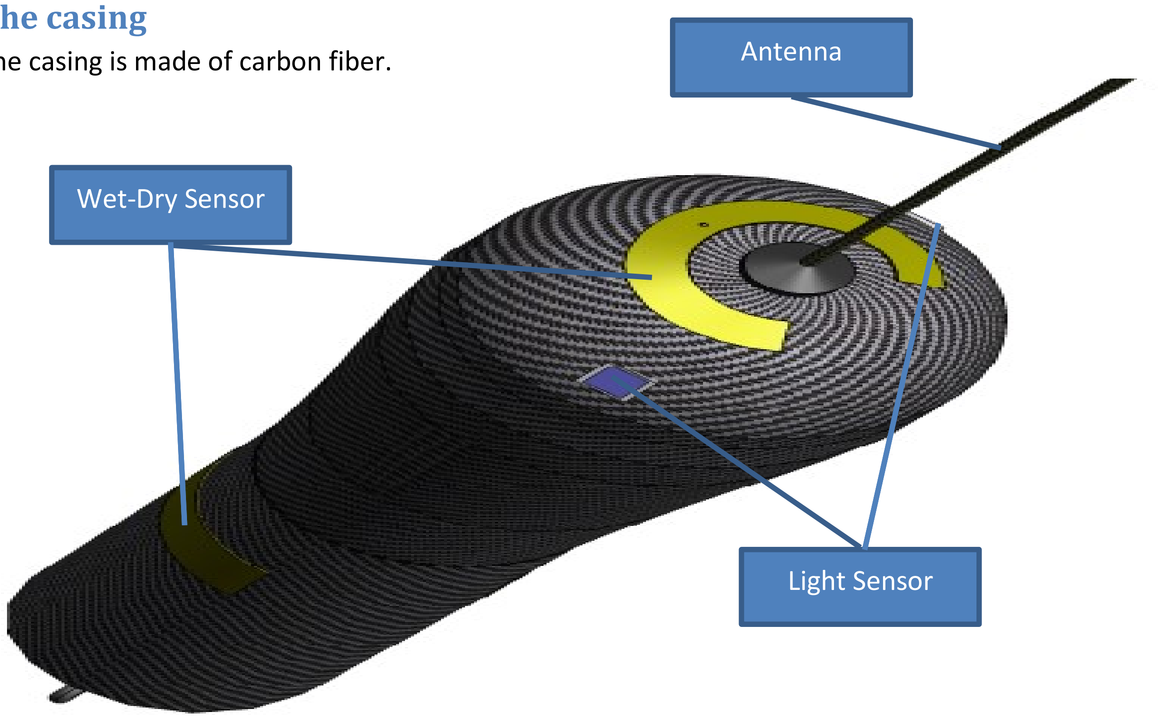


Figure 1 Casing top view

The carbon fiber casing is strong and light weight. The casing is designed to withhold 100Bar pressure, and just enough buoyancy to popup to the surface when released. The battery is placed at the narrow end, ensuring the tag is vertical when floating, and the Y-shape increases stability when transmitting.
In figure 1 one can see the light sensor, actually there are two one on each side, the antenna is on the top and the wet-dry sensor is the two metallic plates.

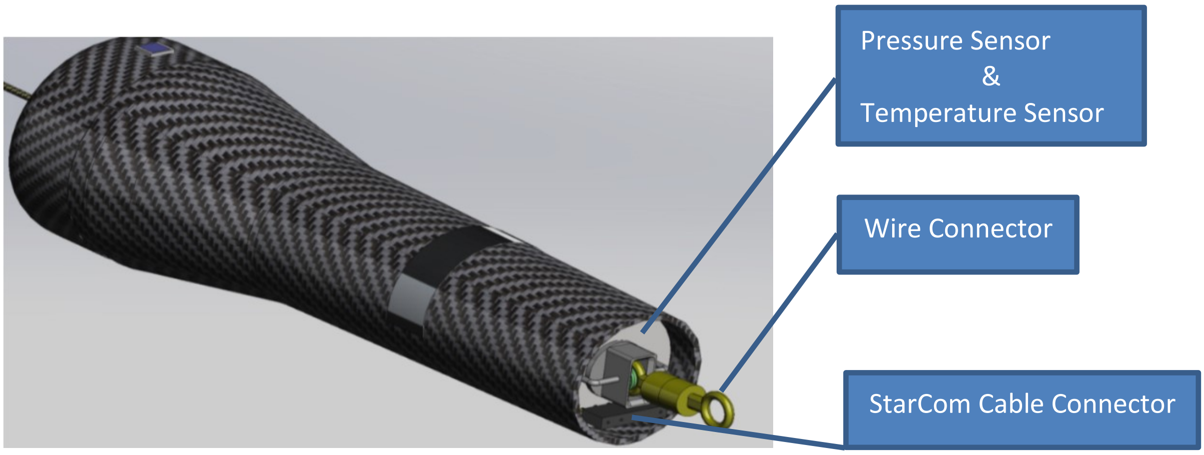


Figure 2 Casing bottom view

The wire connector can be seen in the casing bottom. The pressure sensor as well as the temperature sensor is positioned there.

PC connection to PT-Geyser

PT-Geyser has two communication options:

- **USB**
  Direct USB communication via a standard USB D-sub cable.
- **RS232**
  Star Oddi (SO) has made a special "StarCom" cable, that can MCLR (HW reset) PT-Geyser.

Baud speed is 38400. The cable connection is at the bottom of the casing, see figure 2.

The PCB boards

There are two PCB boards in the PT Geyser

- The MCU board
  This is the heart of the logger where the MCU and all the measurement circuits reside.
- The RF-board
  The RF board is placed on top of the MCU print. It contains the Artic, the Argos communication chip, designed by AnSem.

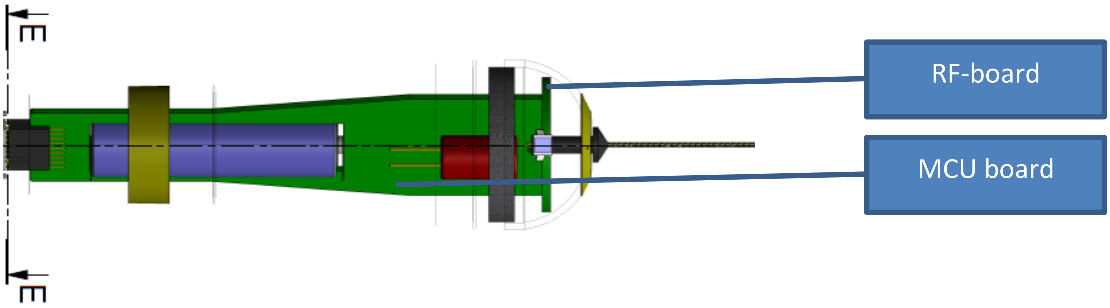


Figure 3 PCU boards

The MCU communicates with Artic chip via a SPI bus. Baud 1Mb.
Other connections to the Artic board are PS and interrupt lines INT1 and INT2.
In this application the Reset line is not used but tied to the 3.3V.

2. Measurement parameters

There are two types of measured parameters, the primary and the secondary.

Primary measurement parameters

The main measurement parameters are environmental parameters:

- T: Temperature: -2°C to 45°C
- P/D: Pressure/Depth: 0m-1000m
- L: Light: 50muLux to 120000Lux

The primary parameters are the ones that provide behavioral information and geolocation.
All these parameters are measured at the same time.

Secondary measurement parameters

The secondary parameters are:

- Ti: Temperature inside the casing -2°C to 45°C
- C: Wet / Dry sensor 0 to 4095 (raw value)
- Tilt: 3 axes X, Y, Z +-90°
- R: Release measure 0 to 4095 (raw value)

Ti:

The Ti is used for correcting changes in measurement circuitry with temperature. It´s measured at the same time as the primary parameters and used when converting primary measurements to unit values. The correction, of the circuitry offset due to variation in the casing temperature, is carried out on the raw data before the actual unit conversion.
The Ti sensor is on the MCU PCB.

C: Wet-dry sensor

The Wet-Dry sensor is used for "Surface Test", it´s basically a conductivity sensor.
Its value is measured as an analogue signal and the Wet-dry determination is via a limit value.

X, Y, Z: Tilt sensors

The tilt sensors are basically accelerometers. When the acceleration is within the earth's gravitation field the values can be converted correctly to tilt.
The sensors are perpendicular to each other, forming a 3D vector space. Each vector has a +-90° range. The X and Y vectors are in the MCU print board plane and the Z is perpendicular the print board.
The Tilt sensors are used for transmission availability detection.
The tilt sensors are on the MCU PC.B

R: Release function

The Popup function of the tag is carried out by applying a voltage to the fastening wire.
This will bring about a deterioration current in the wire. After about 3 to 8 hours, depending on ocean salinity and temperature, the wire will break. This event is monitored by measuring the voltage over the wire as an analogue signal.
The break determination is via a limit value.

3. Production, calibration and testing

Star-Oddi has been producing recorders since 1993, and over the years proven production procedures have been established. These production procedures are applied to all Star-Oddi recorders and PT Geyser is no exception.

One of the procedures is that all recorders are individually calibrated. This is done to ensure reliable calibration. The profile for each sensor is found by analyzing its measured raw values against an accurate reference meter.

The main steps in the production process are:

- **Primary assembly**
  PCB component mounting.
  External sensors and antenna connection.
  PCB´s connections.

- **Testing**
  All components, sensors and functions in the recorder are tested.
  The PT Geyser´s receive their SO-ID as well as the Argos-ID and CLS authentication.

- **Final assembly**
  All comes together in/on the casing, PCB, sensors and battery.
  The casing is closed.

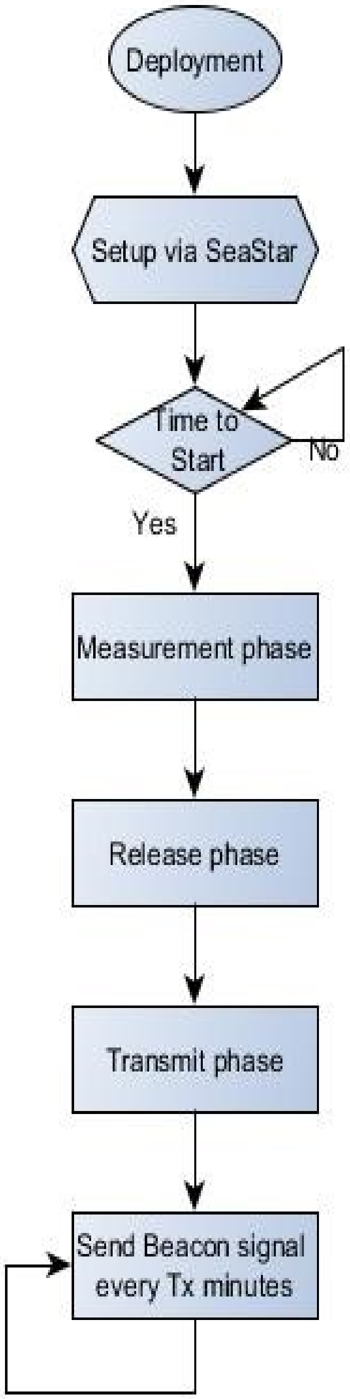
- **Calibration**
  Each sensor is calibrated individually against accurate reference meters. The whole calibration process is monitored and controlled by PC-programs.

- **Post testing**
  The recorders are tested against specific temperature, pressure, light and angle sources.
  The final test is an Argos communication test.

4. Basic operation

In figure 4 the basic operation flow is pictured. When operational there are four main phases the PT Geyser goes through. Delay before starting, measurement phase, release phase and transmit phase.

The user set's PT Geyser up in a new measurement sequence



Main setup parameters are:

- Start time
- Release time
- Mode: Tuna or shark

In the SHARC project certain parameters are fixed.

- Measurement frequency: Every 20 seconds
- Statistical time slot: 6 hours
- Statistical histogram, number of bins: 8

Please refer to the PT Geyser manual for more detailed information.

PT Geyser is sleeping but checks the RTC every minute.
At a predefined time the PT Geyser starts measuring.

PT Geyser measures, converts to unit values, calculates statistical and light transmission packages and stores the whole thing in the Flash data memory.

At a predefined time the PT Geyser goes into release mode.
It will run a current to the wire to corrode it.
PT Geyser monitors if the wire is broken and if it has surfaced

When released and surfaced the PT Geyser goes into transmit mode. It will transmit to Argos3 as much information as possible, starting with the light packages, then the statistic packages and finally the bulk data packages.

Having sent all the packages and received acknowledgement on all, PT Geyser sends out a Beacon signal every Tx minutes until the battery runs out.

Figure 4 Basic operation flow diagram

5. SeaStar user application program.

SeaStar is a Star-Oddi developed multitier application program.
The PT Geyser is incorporated as a module into SeaStar where the user can:

- Define a measurement sequence.
- Start the logger in a predefined offline measurement sequence
- Stop logger in offline measurement and retrieve measurement data
- Convert raw data to unit values.
- View data in various graphical and text formats.

The main difference between PT Geyser and other loggers that Star-Oddi produces, besides the popup and transmission functionality, are the statistical functions data stored in memory. SeaStar will be able to work with these statistical and light data and enhance those via conversion of raw data. Also there will be support for PT Geyser in PatternFinder®, Star-Oddi's expert system software

The user is guided through the communication process via the "Connection wizard".

Figure 5 Connection wizard

When connected the "Recorder wizard" takes over.
More detailed information on the SeaStar software can be found in the PT Geyser user handbook.

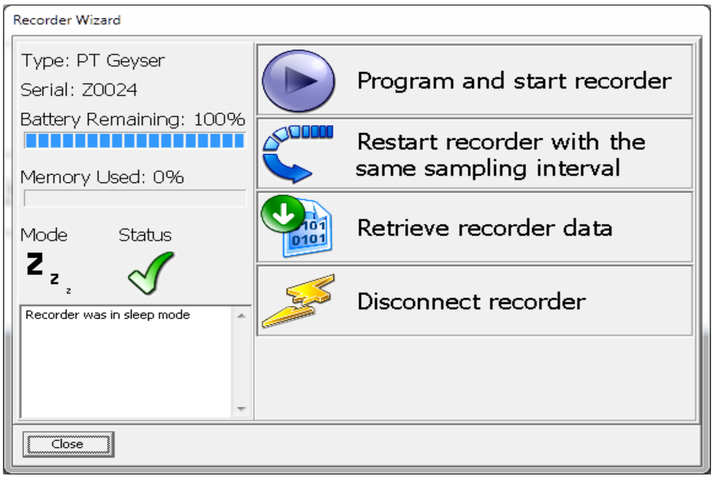


Figure 6 Recorder wizard.

6. Setup via SeaStar

Prior to deployment the user must define the measurement sequence and transfer the settings to PT Geyser. Having started SeaStar the user is guided, via a wizard, connecting to PT Geyser and to the setup form.

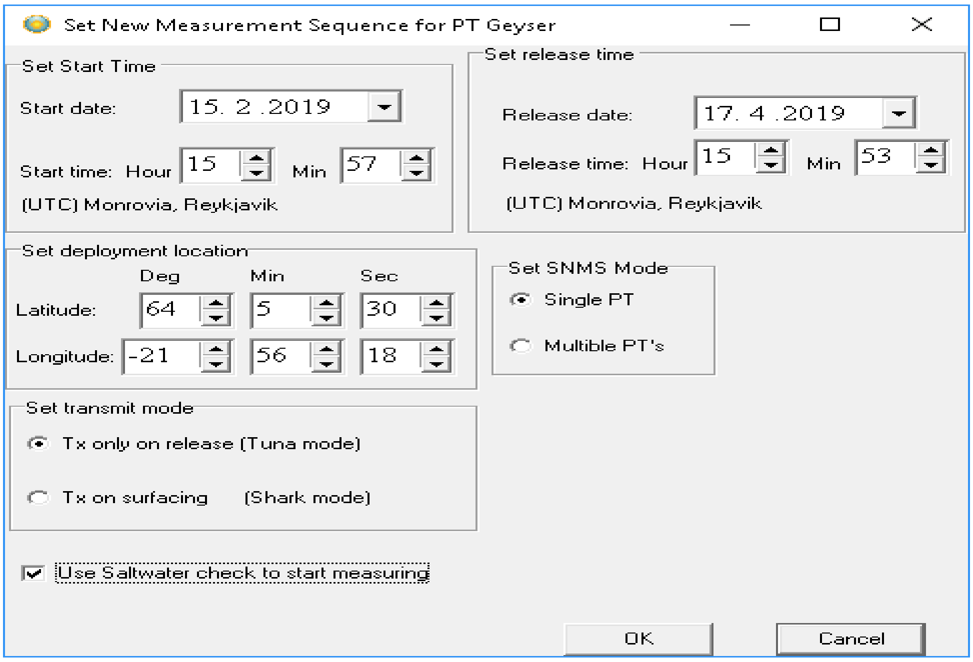


Figure 7 New measurement sequence in SeaStar

As can be seen in figure 7, the setup procedure is a straight forward one, and there are only a few items to define:

- Measurement start time
- Release time
- Deployment location
- Transmit mode

The rest is fixed like:

- Measurement sampling time: 20sec
- Timeslot: 6 hours
- Bulk storage interval: 2min
- Max elevation angle in pass limit = 5°

Having hit the OK button, SeaStar:

- Converts local time to UTC
- Calculates the memory used at release time and number of packages to transfer.
- Energy usage is calculated in the various phases.

This information is presented to the user so he can review his settings and alternatively make changes before starting the PT Geyser in the new measurement sequence.

When starting PT Geyser, SeaStar transfers the setup definitions to PT Geyser as well as:

- **Latest Artic program.**
  AnSem supply's the latest version and at Star-Oddi it´s integrated with SeaStar.
  The program is transferred to PT Geyser and stored in its Flash memory. Comparison test involves retrieving the program again from PT-Geyser and matching it to the one sent to the logger.
- **Orbital Parameters**
  Star-Oddi retrieves all the relevant information from the Argos website, and integrates with SeaStar.

UTC

As the Light Processing and Pass Prediction functions use UTC (Coordinated Universal Time), the most practical thing is to set the RTC (Real Time Clock) in PT Geyser up in UTC.
The UTC conversion is based on the PC time and the regional settings in the PC.
DST (Daylight Saving Time) is displayed and the user can make changes if necessary.
Measurement start time, release time and initiation time are all converted to UTC.
This means all measurements have reference in UTC and all timestamps in the transmit packages are UTC.

When data is retrieved via SeaStar all timestamps are UTC. The user can choose to convert UTC to another time zone:

- Local time, via PC regional settings
- Time zone defined by the user, for example deployment location time.

7. Measurement phase

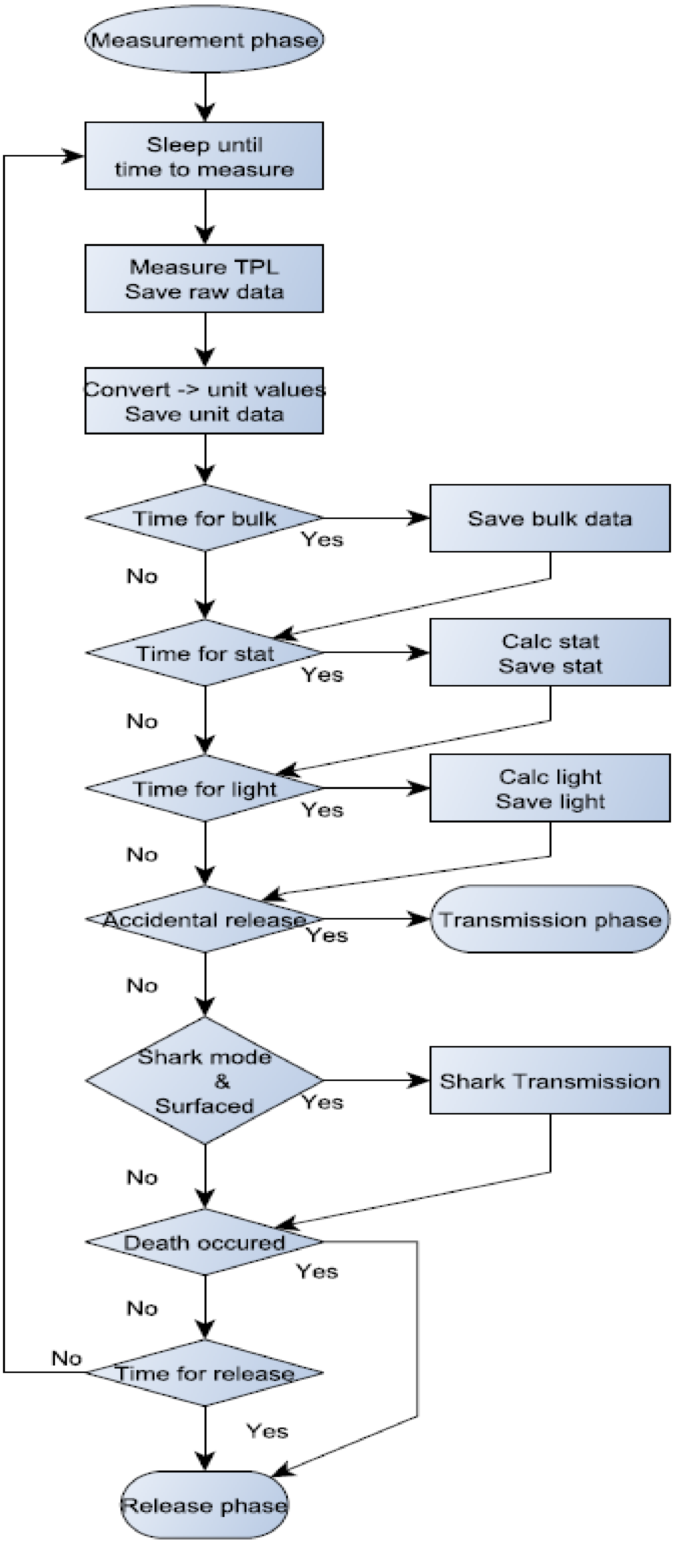


Figure 8 Measurement phase flow diagram

In the SHARC project measurements are taken every 20 second

Temperature (T), Pressure(P) and Light(L) as well as casing temperature (Ti) are measured and save in Flash Raw data memory section.

T, P and L are converted to unit values and saved in Flash Convert data section

Bulk data is saved as Tx packages in Bulk data section. "(2 minutes sampling of the units/compressed values of T and D)

In SHARC project statistics is calculated and saved in Stat data section, every 6 hours.

Light packages are calculated once every 24 hours, and saved in Light memory section

If tag is on surface for X hours an accidental release is defined to have occurred

If in shark mode and on surface, LocR is transmitted,

If the tag is at bottom (= constant depth) for Y hours the animal is “declared dead” and tag goes into release phase.

If it´s release time then the tag goes into the release phase otherwise it will continue in measuring.
NB: SeaStar makes sure release time occurs before memory is full.

8. Data collection and processing

Data collection

The SHARC project defines:

- Measurement parameters
    - T Temperature
    - P Pressure
    - L Light
- Sampling frequency = every 20 seconds
- Statistical time slot = 6 hours
- Statistical number of bins = 8
- Bulk data saved every 2 minutes

Raw data

The PT Geyser measures every 20 seconds T, P, L and Ti (for circuitry temperature correction) and stores the raw data Tb, Pb, Lb and Tib „as is" in the Ext-Flash-Raw-data-section.

Converted data

The raw data T, P and L are converted into to unit values via calibration transfer functions, usually 5° polynomials. Then the unit value that are expressed as floating point values, are compressed to unsigned integer values. The compressed values are then saved to Ext-Flash-Convert-data-section.

Temperature:

Unit value: T(°C)= Polynomial-5°conversion of Tb
Compressed value: T_I(9bits)= INT(T*10+30) = value between 0 and 511.
Resolution = 0.1°C
Converting temperature back to unit values in SeaStar or at CLS website:
T(°C)= T_I/10-3

Depth

Unit value: P(Bar)= Polynomial-5°conversion of Pb
Depth value: D(m) = P*dk. (dk= 9.32= 10.19/1.026)
Compressed value: D_I(11bits)= INT(D+10) = value between 0 and 2048
Resolution = 1m
Converting depth back to unit values in SeaStar or at CLS website:
D(m)= D_I-10

Light

Unit value: L($\log_{10}$(Lux))=L10= Linear conversion of Lb
Compressed value: L_I(8bits)= INT(100+20*L10) = value between 0 and 255
Resolution =L10range/L_Irange
Converting light back to unit values in SeaStar or at CLS website:
L($\log_{10}$(Lux))= L10= (L_I-100)/20
L(Lux) = 10^{L10}

The Statistical Processing

Behavioral analysis is the main objective off measuring temperature (T) and depth (D).
In order to send as much information as possible, the TD data is statistically processed and compacted for transmission.

There are two statistical processing units, each yielding a transmission package.

Time-slot processing

Each day is divided into timeslots, in the SHARC project each time-slot is 6 hours.
The MCU processes the TD data in the following way:

Repeat:

1. Read a number of samples at a time from the last 6 hours
2. Loops through them all to find
   - D_min, D_max, D_av
   - T_min, T_max, T_av
3. Finds three calculated intermediate-depths Dref for M3
4. Loop again through the samples to get Inter-Depths, the actual depth measurements closest to Dref.
5. Loop through all Inter-Depths to get the intermediate depths closest to global calculated intermediate depths.

Repeat

1. Read a number of samples at a time from the last 6 hours
2. Loop through them all to find
   - Tmin, Tmax for final Inter-Depths

Complete a statistics package (M3)

Histogram processing

What is defined as a Bin information package (M4) is basically a histogram with 8 bins.
Only 7 bins are represented in the M4 package, but as each bin holds a percentage value the 8th bin can be calculated.
The MCU processes the TD data in the following way:

1. While in Time-slot processing in item 2:
   Counters for the predefined bins are added up.
2. After every other Time-slot processing:
   Complete a bin package (M4)

The Light Processing

Tracking the movements of the research animal is important to the researcher. A geo-location is also necessary for predicting satellite passes. In order to accommodate these demands geolocation is calculation in PT Geyser every 24 hours. The process is named Light Processing as the key parameter in the calculation is the light.

The Light Processing is in two stages:
Initialization:
After 24 hours from start measuring PT Geyser will make the initialization light processing, that will result in a new start time (T_{light}) for the next light processing, and a first estimate geo-location.

Normal calculation:
Every 24 hours light processing is executed starting at the T_{light} time produced by the previous calculation.

The function takes in the following parameters:

- Log base 10 of the light intensity (W/m^2).
- External temperature in (°C)
- Depth in (m).
- Time-stamps in seconds UTC.
- Last estimated geo-location

The function outputs among other things:

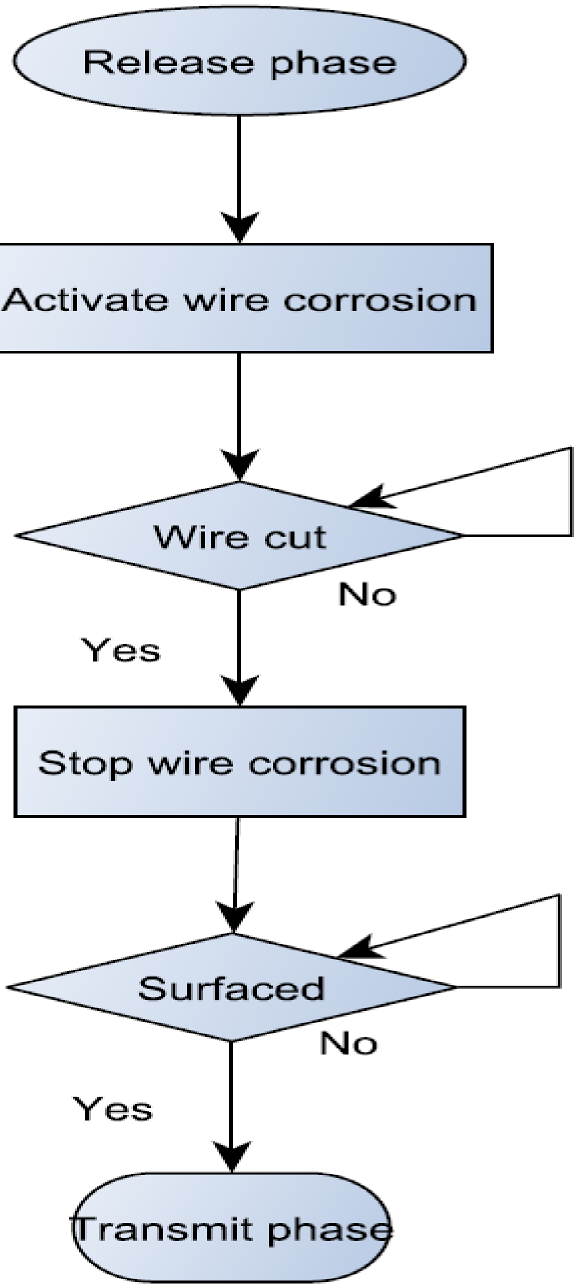
- A new Tb time to be used the next time
- Geo-location estimation
- Sunrise and sunset times
- Water absorption coefficient
- Cloudiness

The result from the light processing is used to create two transmit packages, one for sunset and another for sunrise. These packages contain each:

- 20 Depth & Cloud corrected light samples
- A near surface temperature measurement
- Minimum and maximum depths

When these are received by the Argos system, CLS can use these light packages to calculate an accurate geo-location for each deployment day.

9. Release phase



Voltage is applied to the fastening wire, thereby running deteriorating current in the wire.

The corrosion in the wire is monitored by measuring the voltage over the wire as an analogue signal. It takes about 3 to 8 hours for the wire to break.

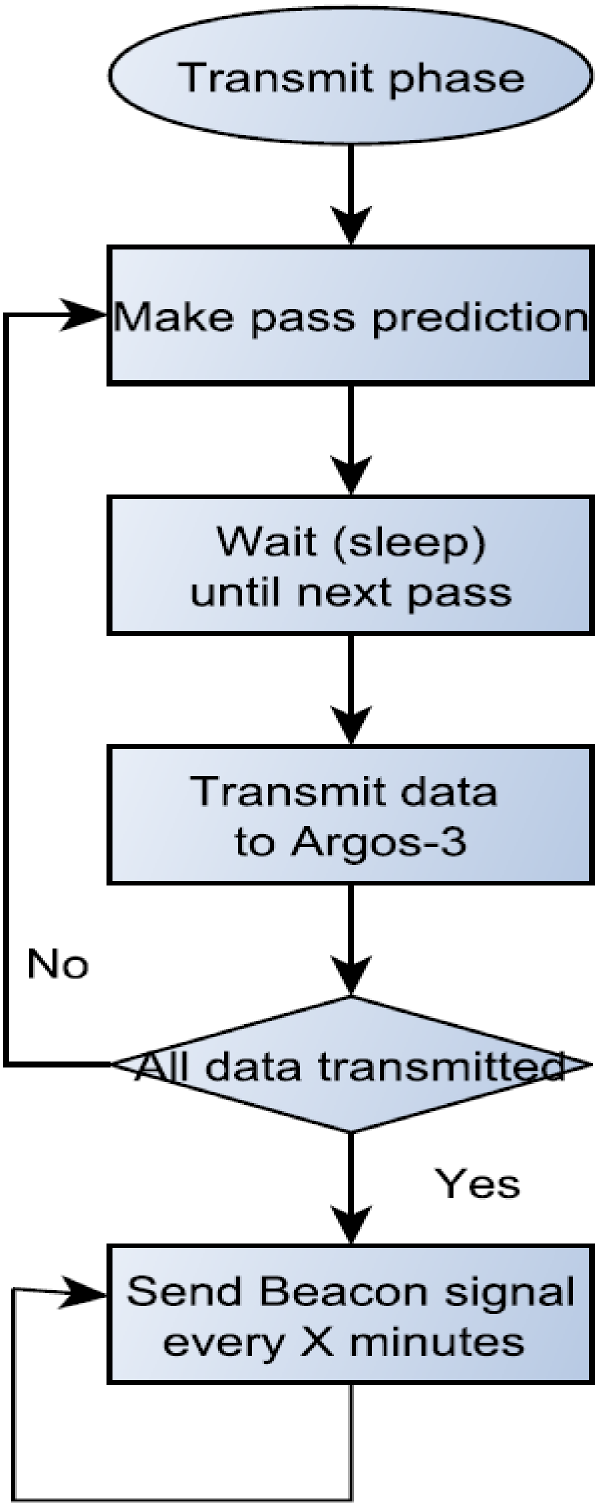
The corrosion function is energy consuming so it must be stopped right after the wire breaks.

Reaching the surface takes some time depending of the depth the logger was on at release time. Depth and wet-dry sensors are checked on regular intervals.

When surfaced it time to transmit data.

Figure 9 Release phase flow diagram

10. Transmit phase



Pass prediction is made for Argos-3 MA and SR satellites. Predtion is repeated until a pass with max elevation > 25° is found

PT geyser saves energy while sleeping

Data packages are transmitted, starting with Light, then Statistics and finally Bulk data. Same package is transmitted repeatedly until an acknowledgment is received from the Argos-3 satellite.

PT Geyser continues transmitting until all data has been.

When all data has been transmitted then PT Geyser goes into a loop and transmits a beacon signal every X minutes until the battery runs out.

Figure 10 Transmit phase flow diagram

Pass Prediction

The pass prediction function in PT Geyser works with two Argos-3 satellites, MA and SR, namely the ones that have interactive capabilities.

The function takes in:

- Start prediction date and time: At what time to start search
- Location: Latitude and Longitude
- Orbital parameters: Definition of the satellites movements and variations.
- Min elevation: Only use satellite passes over a certain minimum elevation angle.

It calculates the next pass for Ma and the next pass for SR.

The pass is defined by:

- Start pass time:
- End pass time (and thus duration can be calculated)
- Maximum elevation angle

At start up PT Geyser receives the latest orbital parameters from SeaStar that have been "harvested" at the Argos website.
Furthermore SeaStar supplies PT Geyser with the time when the orbital parameters have to be renewed. This is 6 months maximum.

When starting in the Transmit phase PT Geyser will make a Pass prediction and after that every time it has finished a "Transmit pass", i.e. communicating with Argos-3 or attempting to communicate.
The Pass Prediction will find the pass nearest in time that has max elevation >=25°.
It will accomplish this by:

- Calculate passes with the minimum elevation angle as 25°
- Then find the pass nearest in time. The satellite ID is noted.
- Calculate passes again with the start time from the previous calculation -15min, and with a minimum elevation angle as 5°
- Then the final result is the start time of the satellite who's ID was found in the first calculation.

It takes approximately 2 sec to complete these pass prediction calculations. Rough estimation shows that number of good passes can vary depending on the location.
For example passes over a 72 hour period show:

	Garðabær	Siggiewi (Malta)
Total passes:	61	27
Good passes (>= 25°):	28	16

This indicates 5 daily good passes on average in the Mediterranean area.

In SeaStar the user can change the "Max elevation" value, default is 25°.

Transmit packages

The "Sensor Management: from acquisition to transmissions V1.5" defines how transmission packages are put together.
All packages contain 29 bytes of data

Bulk data packages (ID = 5)

In the "Sensor Management: from acquisition to transmissions V1.5" these packages are referred to as raw data, but in the PT Geyser documentation we have referred to these data as bulk data, as the raw data are converted to unit data and the bulk data are sampled unit values. (Every 2 minutes)
In this package only Temperature (°C) and Depth (m) are presented. The values are truncated to 9bits for temperature and 11 bits for depth, enabling 10 samples per package = 20 minutes sampling time. This amounts to 72 packages daily.
These packages are saved in the Bulk-section in the Ext-Flash memory.

Statistical packages

In the SHARC project, statistical processing is performed every 6 hours.
The converted temperature, depth and light data covering the last 6 hours i.e. 1080 measurements, are recovered from the convert data section in the Ext-Flash memory. The temperature and depth are then processed and the statistics compressed into transmission packages that are saved in the Stat-section of the Ext-Flash memory. There are two types of stat-packages.

- ***Time-slot packages (ID = 3)***
  There is one package for each timeslot (6 hours), i.e. 4 packages per day.
- ***Bin information packages(ID = 4)***
  In the SHARC project 12 hour bin information can be stored in one package, i.e. 2 packages per day.

Light packages (ID = 1, and 2)

Calculated once daily = 2 packages.
The converted temperature, depth and light data covering the last 24 hours i.e. 4320 measurements, are recovered from the convert data section in the Ext-Flash memory.
These measurements are then used in the Light Processing, resulting in two light packages, one for sunrise and the other for sunset.

11. Data received at Toulouse

The customer can view the transmitted data at CLS Argos website: https://argos-system.cls.fr
All transmissions will have the PT-Geyser CLS-ID, and calculated location.

Page 1 of 2 Show 50 items Diagnostic data Clear filters Data - 1 to 50 of 59

Platf...	Latitude	Longitude	Loc. quality	Loc. date	Pass	Sat.	Frequency	Msg Date	Prg ...	Co...	Alarm	SENSOR #01	SENSO
140659					765	MA	401650098,11	23-Feb-2015 10:18:24	5680	1	N	00	
140659					765	MA	401650098,11	23-Feb-2015 10:19:54	5680	1	N	00	
140659					765	MA	401650098,11	23-Feb-2015 10:22:54	5680	1	N	00	
140659					765	MA	401650098,11	23-Feb-2015 10:31:09	5680	11	N	00	
140659					45	SR	401650095,10	23-Feb-2015 10:36:24	5680	1	N	00	
140659					45	SR	401650095,10	23-Feb-2015 10:37:09	5680	1	N	00	
140659	64° 05' 55"N	21° 57' 05"W	2	23-Feb-2015 10:36:24	540	NP	401650093,04	23-Feb-2015 10:42:24	5680	1	N	00	
140659	64° 05' 55"N	21° 57' 05"W	2	23-Feb-2015 10:36:24	540	NP	401650093,04	23-Feb-2015 10:44:39	5680	10	N	00	
140659	64° 05' 27"N	21° 56' 20"W	3	23-Feb-2015 11:15:02	450	MB	401650102,32	23-Feb-2015 11:18:25	5680	1	N	00	
140659	64° 05' 27"N	21° 56' 20"W	3	23-Feb-2015 11:15:02	450	MB	401650102,32	23-Feb-2015 11:21:25	5680	8	N	00	
140659	64° 05' 27"N	21° 55' 37"W	2	24-Feb-2015 11:39:38	765	MA	401649916,31	24-Feb-2015 11:47:43	5680	1	N	00	
140659	64° 05' 27"N	21° 55' 37"W	2	24-Feb-2015 11:39:38	765	MA	401649916,31	24-Feb-2015 11:50:43	5680	12	N	00	
140659	64° 05' 21"N	21° 56' 23"W	3	24-Feb-2015 12:01:57	675	NP	401649916,81	24-Feb-2015 12:11:43	5680	1	N	00	
140659	64° 05' 21"N	21° 56' 23"W	3	24-Feb-2015 12:01:57	675	NP	401649916,81	24-Feb-2015 12:13:13	5680	10	N	00	
140659	64° 05' 34"N	21° 56' 20"W	3	24-Feb-2015 12:31:58	720	MB	401649917,31	24-Feb-2015 12:43:13	5680	14	N	00	
140659	64° 05' 16"N	21° 56' 37"W	2	24-Feb-2015 13:45:43	630	NP	401649914,26	24-Feb-2015 13:46:29	5680	1	N	04	
140659	64° 05' 16"N	21° 56' 37"W	2	24-Feb-2015 13:45:43	630	NP	401649914,26	24-Feb-2015 13:49:29	5680	1	N	00	
140659	64° 05' 16"N	21° 56' 37"W	2	24-Feb-2015 13:45:43	630	NP	401649914,26	24-Feb-2015 13:53:59	5680	12	N	00	
140659	64° 05' 29"N	21° 56' 35"W	3	24-Feb-2015 14:11:59	720	MB	401649916,65	24-Feb-2015 14:23:14	5680	9	N	00	
140659	64° 05' 35"N	21° 56' 18"W	3	24-Feb-2015 15:00:44	495	MA	401649917,44	24-Feb-2015 15:09:00	5680	11	N	00	

Figure 11 Snapshot from the Argos website

All the data packages have an identification header and a timestamp, as describes in the "Sensor Management: from acquisition to transmissions V1.5"
In figure above, a data package "sensor #01" should hold the package ID.

Furthermore CLS will calculate an accurate location from the light packages. Statistical and bulk data can be viewed graphically (and in tables).

12. Measurement data storage

In order to accommodate the various data formats, the external Flash data memory is partitioned.

				SHARC project (90 days)	
Flash partition	**Size [kB]**	**Bytes/24h**	**24h/partition**	**Packets**	**Size [Byte]**
Artic Program	128				
C + Tilt	768				
Light packets	128	58	2.259	180	5.220
Statistics packets	192	174	1.129	540	15.660
Bulk packets(2min)	1.344	2.088	659	6.480	187.920
Unit data	9.280	15.120	628		
Raw data	20.928	34.560	620		
Total	32.768			7.200	208.800

Table 1. Data storage memory partition

There are 7 partitions, of which there are 3 transmission package-partitions.
The package partitions are made to save time and energy, as the data is laid out ready to be transmitted. Each partition has a storage pointer, indicating how much data has been stored, and the package partition have a transmit pointer, that tell how many packages have been transmitted.

As can be seen in Table 1, in the 24h/partition column, the raw data partition sets the storage space limit, i.e. how many measurements can be saved.
The PT Geyser can save up to 620 days' worth of measurements.

13. Detailed transmission package definition.

M1

Sunrise 29-byte Data Field Message - M1 – 1 message per day

For sunrise, N_S *(20)* records are selected. The first record is at the begin the sunrise (i.e. when $\hat{\alpha} = \alpha_{min}$) and all records are equally spaced in time within the sunrise. The sub sampling period $S_{sunrise,sub}$ must be a multiple of sensor sampling S (the closest) and $S_{min} < S_{sunrise,sub} < S_{max}$.

Field	Units	Nb of bits	remarks
Header identification		3	Set to 1H
Date of first light sample (reference date : January 1st 2014)	Seconds	29	Covers 16 years
Delta samples @ $S_{sunrise,sub}$	Number of 80 sec. steps (value depends on sunrise duration)	4	
Sunrise *Ns* Light samples	$100 + 20 \log_{10}(L)$	8x20	
Temp. Measurement at the minimum observed depth over Sunrise	°C	9	
Minimum observed depth over sunrise	Meter	11	
Maximum observed depth over Sunrise	Meter	11	
SPARE bits	Could be used as a message counter	5	
GRAND TOTAL		232	

M2

Sunset 29-byte Data Field Message - M2 – 1 message per day

Concerning sunset, the same procedure is applied except the last record is at the end of the sunset (i.e. when $\hat{\alpha} = \alpha_{min}$). The sub sampling period is $S_{sunset,sub}$.

Field	Units	Nb of bits	
Header identification		3	Set to 2H
Date of first light sample (reference date : January 1st 2014)	Seconds	29	Covers 16 years
Delta samples @ $S_{sunset,sub}$	Number of 80 sec. steps (value depends on sunrise duration)	4	
Sunset *Ns* Light samples	$100 + 20\log_{10}(L)$	8x20	
Temp. Measurement at the minimum observed depth over Sunset	°C	9	
Minimum observed depth over sunset	Meter	11	
Maximum observed depth over Sunset	Meter	11	
SPARE bits	Could be used as a message counter	5	
GRAND TOTAL		232	

M3

Six-hour time slot M3 Messages – 4 messages per day:

Field	Units	Nb of bits	
Header identification		3	Set to 3H
Date of first sample (reference date : January 1st 2014)	Seconds	29	
Average bloc data		96	122
Profile data		87 (3*29bits)	209
Time slot duration		2	0= 3h/**<u>1= 6h</u>**/2= 12h/3=24h
SPARE bits		15	232
GRAND TOTAL		<u>232</u>	

M4

Two time slots: M4 Message

For the SHARC project: 2 M4 messages per day since we fixed the time slot to 6 hours

Field	Units	Nb of bits	
Header identification		3	Set to 4H
Date of first sample (reference date : January 1st 2014)	Seconds	29	
Time slot 1: 7-bin information		98	
Time slot 2: 7-bin information		98	
Time slot indicator		2	0= 3h/**<u>1= 6h</u>**/2= 12h/3=24h
SPARE bits		2	232
GRAND TOTAL		**<u>232</u>**	

M5

20-minute M5 Message (3x24 = 72 messages per day):

Field	Units	Nb of bits	
Header identification		3	Set to 6H
Date of first sample (reference date : January 1st 2014)	Seconds	29	
10 sets of Temperature	°C	10*9	
10 samples of Depth	Meter	10*11	
GRAND TOTAL		**232**	