ITINERIS

Advances in ocean science from autonomous gliders

# Underwater gliders


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## Autonomous Instruments in Oceanography

Università degli Studi di Napoli Parthenope

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Ministero dell'Università e della Ricerca

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# Contents

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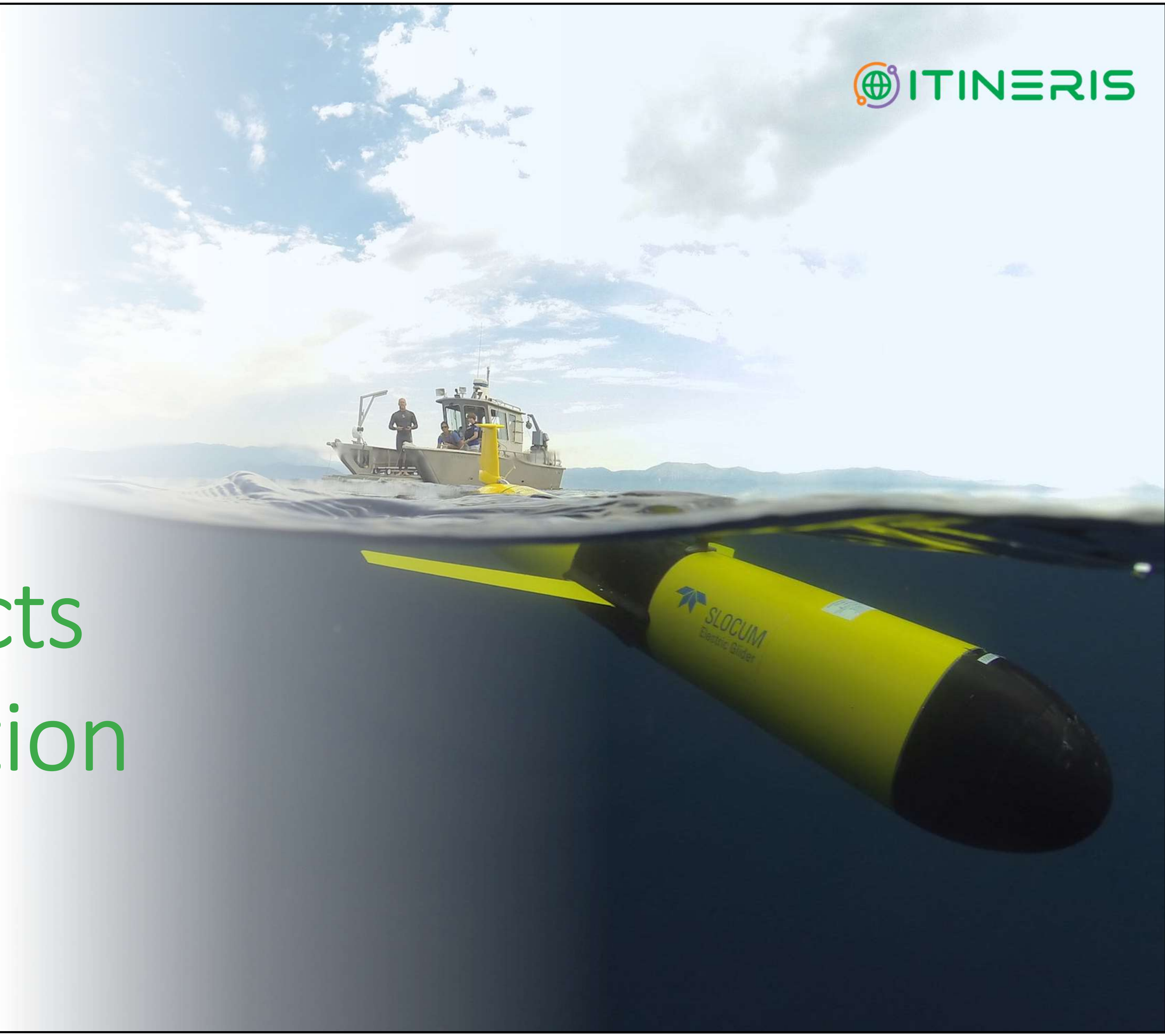


# Technical aspects & instrumentation

# Energy efficiency

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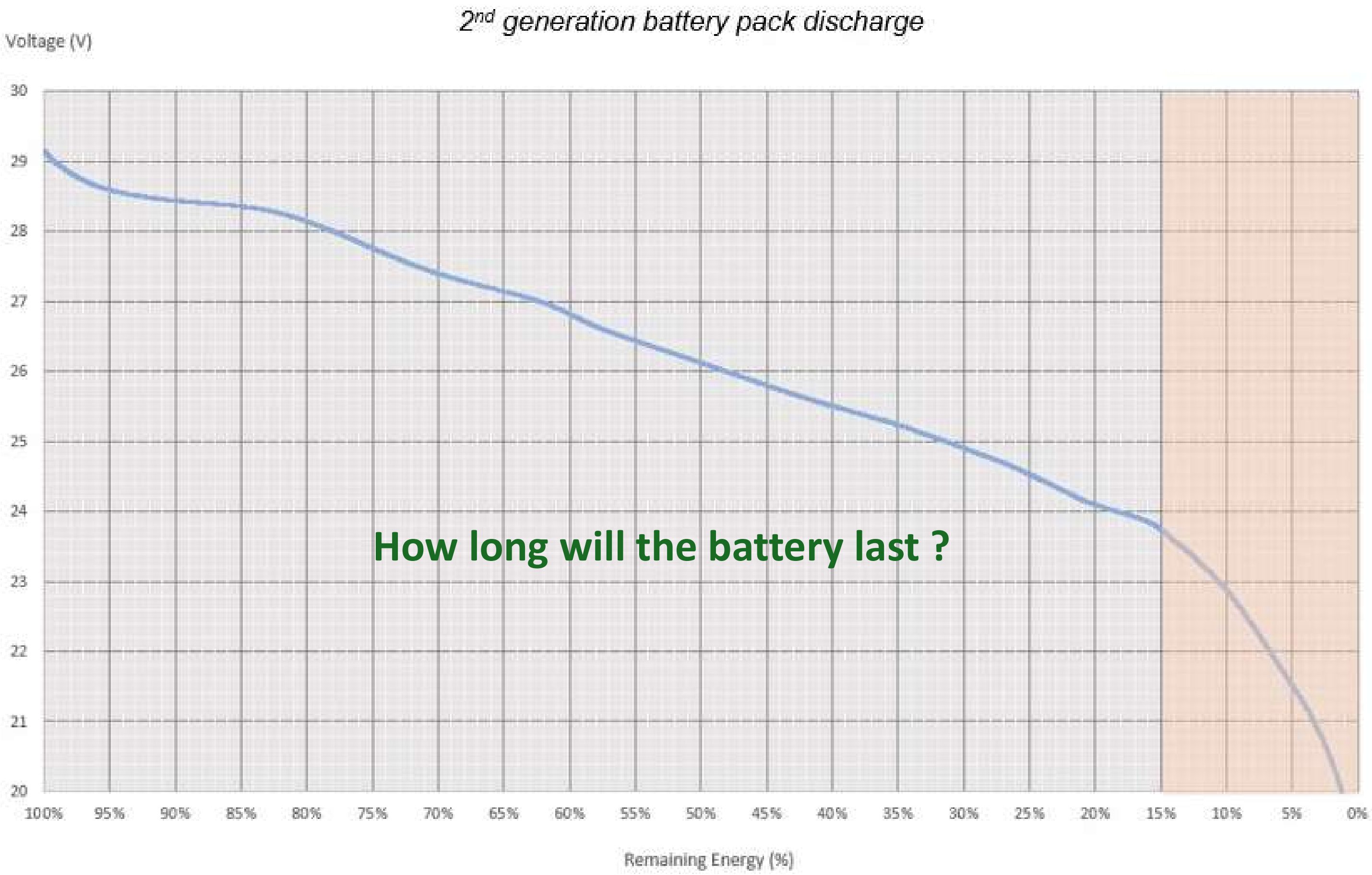
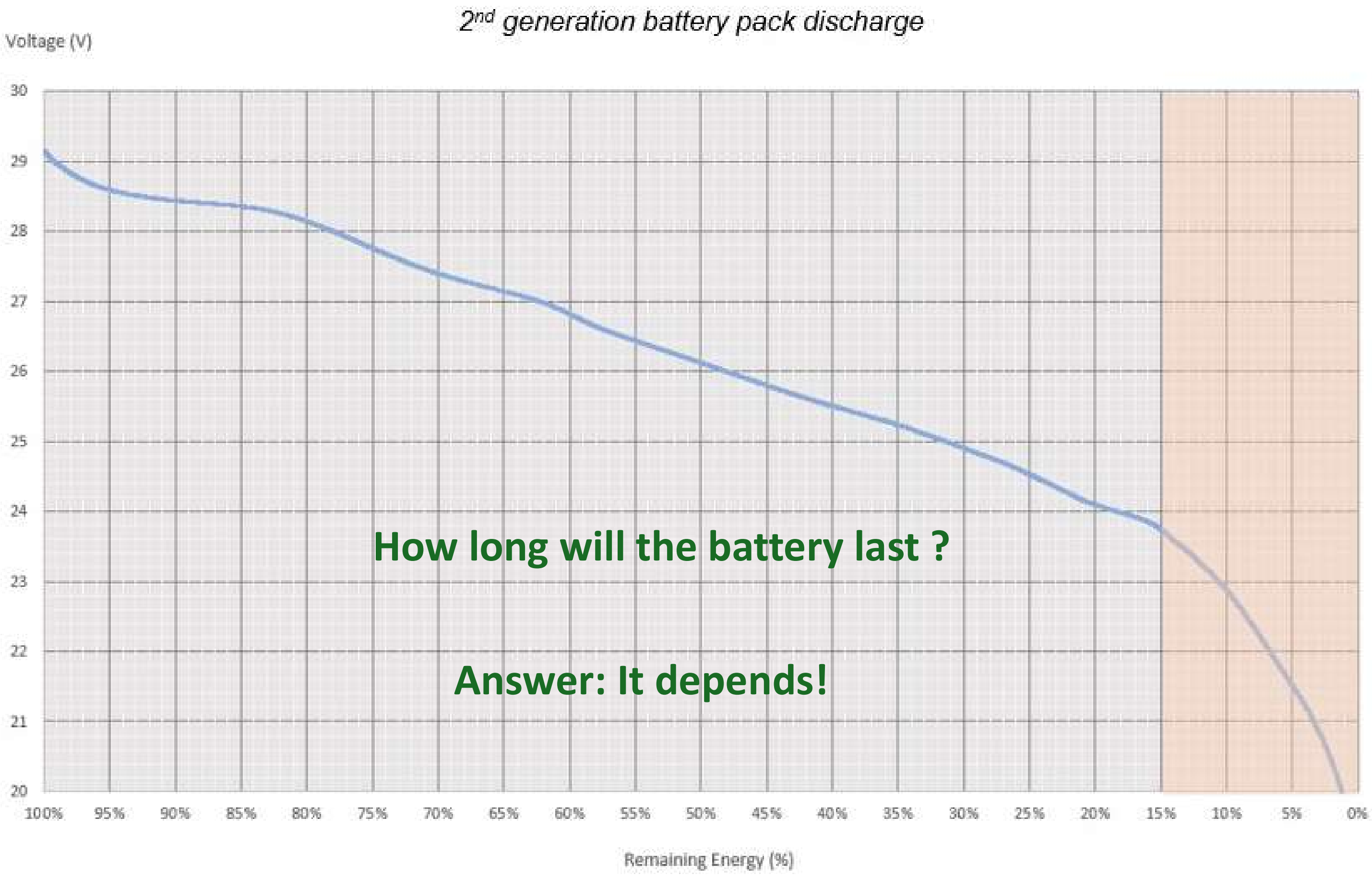


# Energy efficiency




**How long will the battery last ?**

**Answer: It depends!**

# Energy efficiency

**Autonomy depends strongly on 4 factors:**

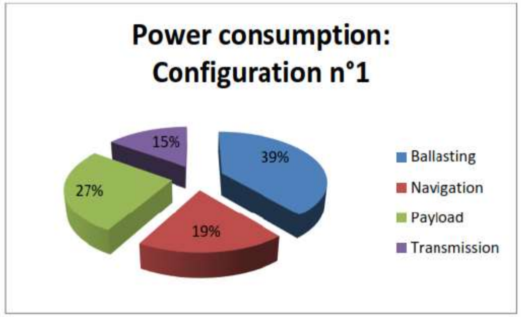
1. The bathymetry: shallow water needs a lot of pumping
2. Payload configuration: sensors and frequency of acquisition
3. Surfacing time: Communication with the satellite at surface
4. Last but not least: your piloting skills!

a) The main energy draw is the buoyancy pump

b) Reducing the glider's speed increases its range:
*fast is inefficient → halving speed increases range by ~4*

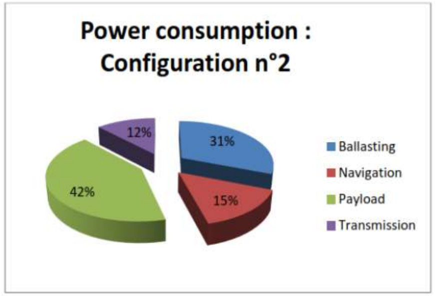
**Configuration 1:**

- 500m depth
- 10ko of data transfered at surface
- Ballast at +/-200ml
- Payload sensors: GPCTD + DO
- Payload CPU turned ON at all time




**Configuration 2:**

- 500m depth
- 10ko of data transfered at surface
- Ballast at +/-200ml
- Payload sensors: GPCTD + DO + WET LABS EcoPuck
- Payload CPU turned ON at all time



## Maximum capacity

A Seaglider with maximized autonomy can run on ~1/3 to 1 Watt

↓

which can lead to **12-15 months** operation covering **~10 000 km**

GPCTD-DO sampling at 10s

vertical: 20-30 cm/s & horizontal: 20-40 km/day

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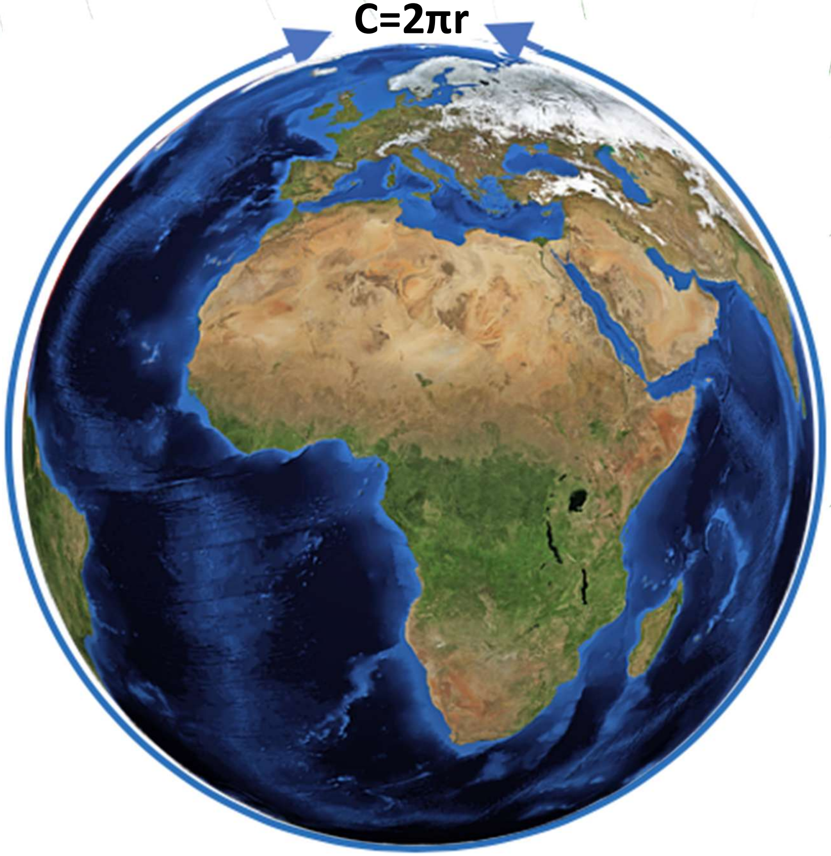
**What is the Earth's circumference ?**



# Maximum capacity

A Seaglider with maximized autonomy can run on ~1/3 to 1 Watt

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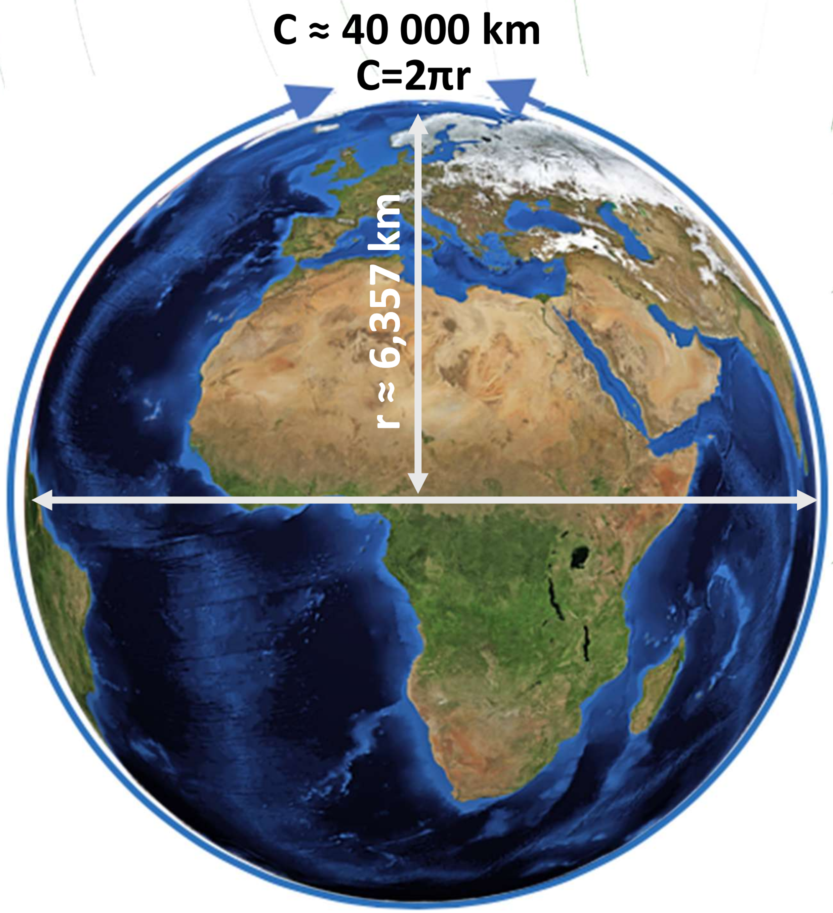
↓

**1/4 of the way around the world!**

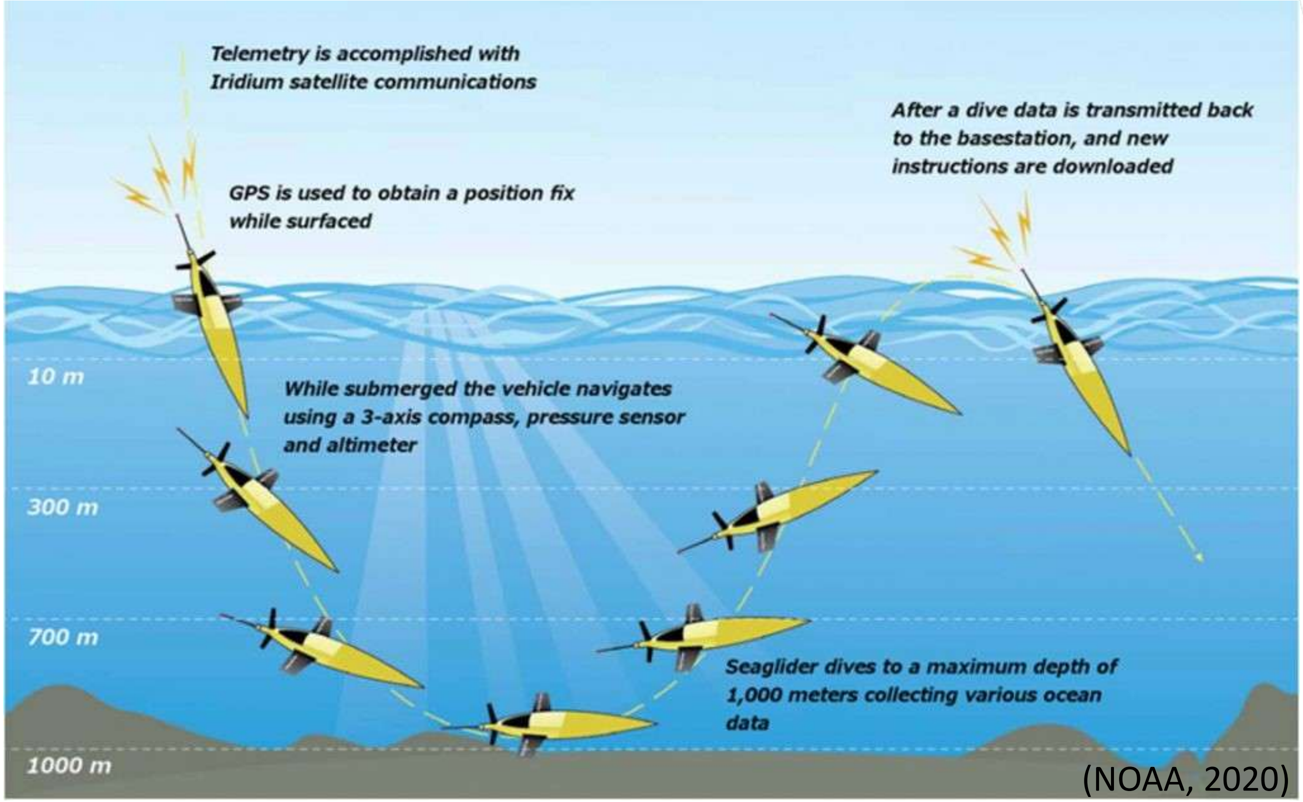
GPCTD-DO sampling at 10s




vertical: 20-30 cm/s & horizontal: 20-40 km/day

# Technical aspects

## Communication & navigation basics



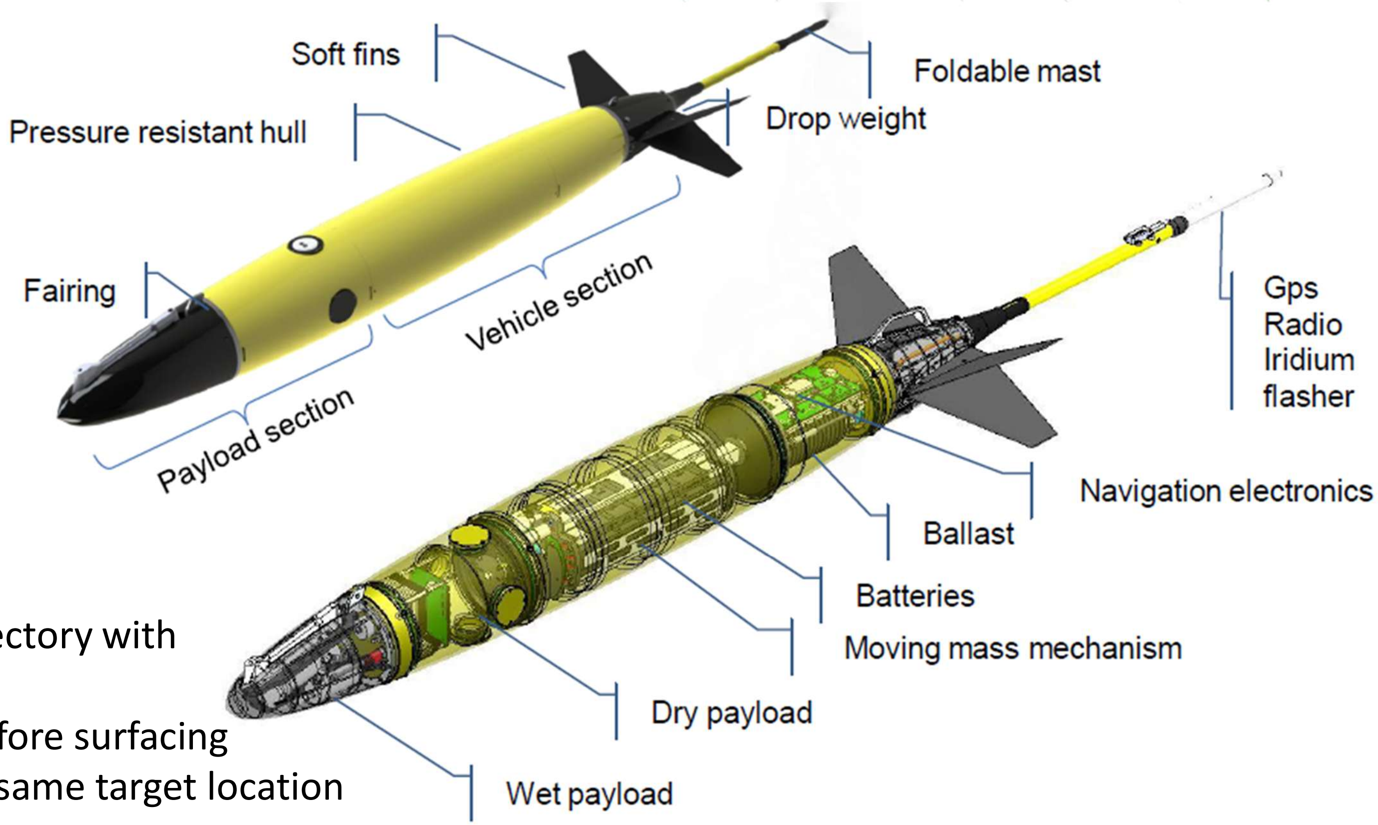
(NOAA, 2020)

Basics:

- Glider receives mission parameters
- Glider adjusts buoyancy and weight distribution to dive and surface, travelling in saw tooth pattern
- Glider completes directed numbers of dives/surfaces (Yos)
- Glider resurfaces, establishes GPS/comms, receives new mission parameters, transmits gathered data

## Technical aspects

**Gliders navigate with the help of periodic surface GPS fixes, pressure sensors, tilt sensors, and magnetic compasses.**




### Navigation mode

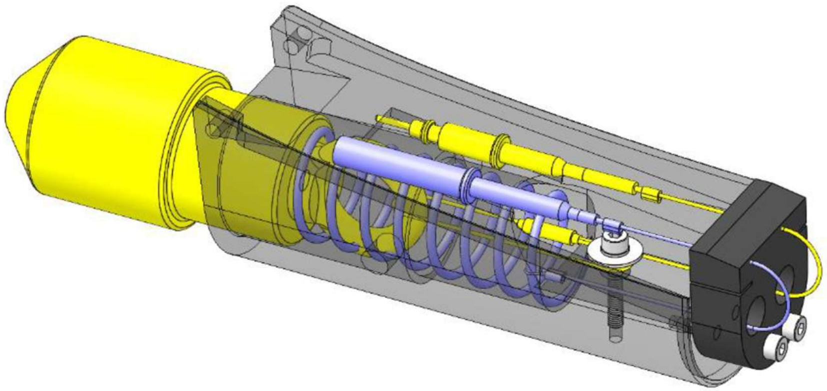
1. **WayPoint control:** follow a trajectory with different waypoints as a target
1. **Multi dives**: perform X dives before surfacing
2. **Virtual mooring**: remain at the same target location

## Safety systems

**Safety release system**

800g drop-weight

Fully autonomous:
- Pressure sensor
- Back up battery
- Decision



# Safety systems

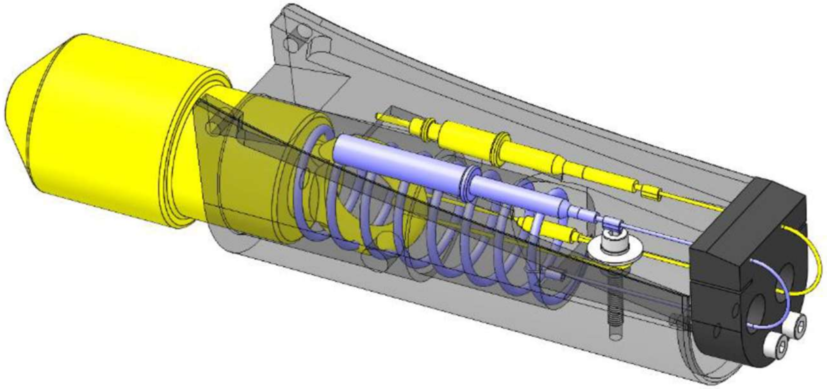
**Safety release system**

800g drop-weight

**Why do we need a drop-weight?**

Fully autonomous:

- Pressure sensor
- Back up battery
- Decision



# Safety systems

**Safety release system**

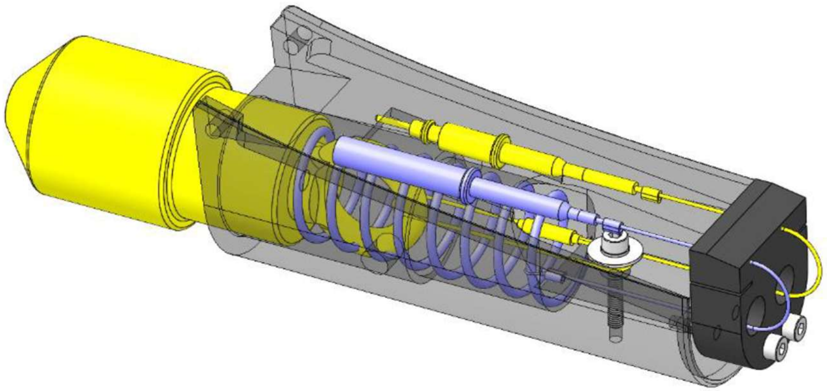
800g drop-weight

Fully autonomous:

- Pressure sensor
- Back up battery
- Decision

3 Automatic Releases:

- Deeper than 1050m
- Constant depth for more than 30min
- No vehicle life signal for more than 15min



## Safety systems

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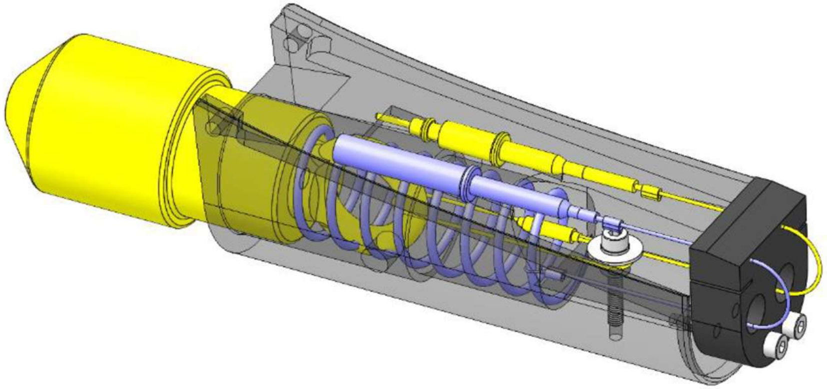
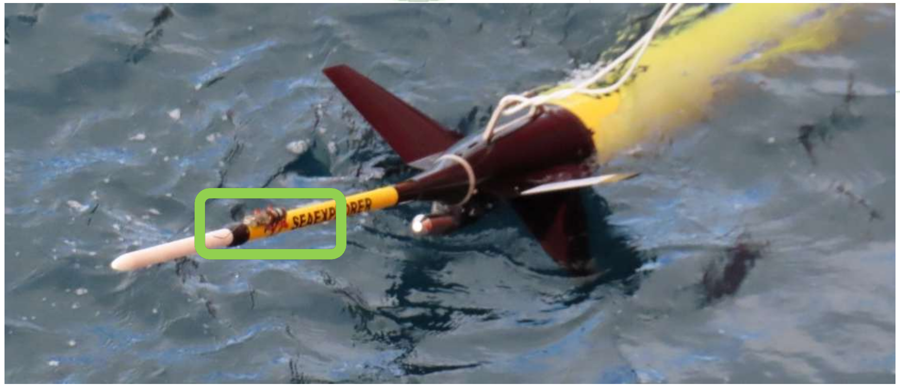


**ULB under water pinger**

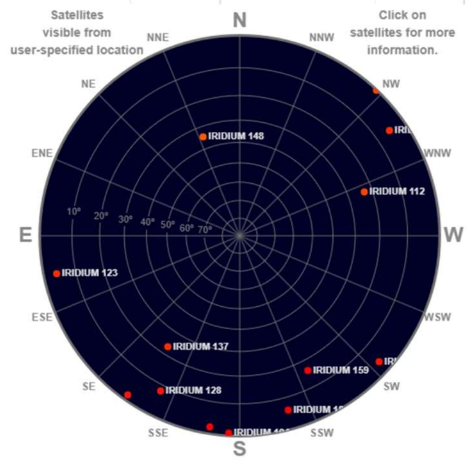
(in wet aft section)

**Argos transmitter**

(on the antenna)



# Communication & navigation system

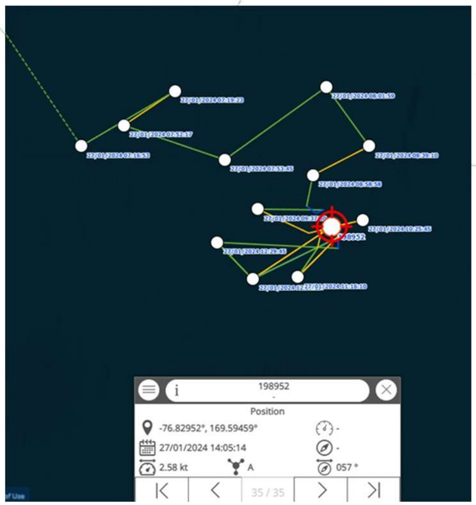



**Glider Communication** solution :

- ✓ Real-Time
- ✓ Two-way
- ✓ Remote configuration
- ✓ Data collection & GPS

**Backup tracking** solution :

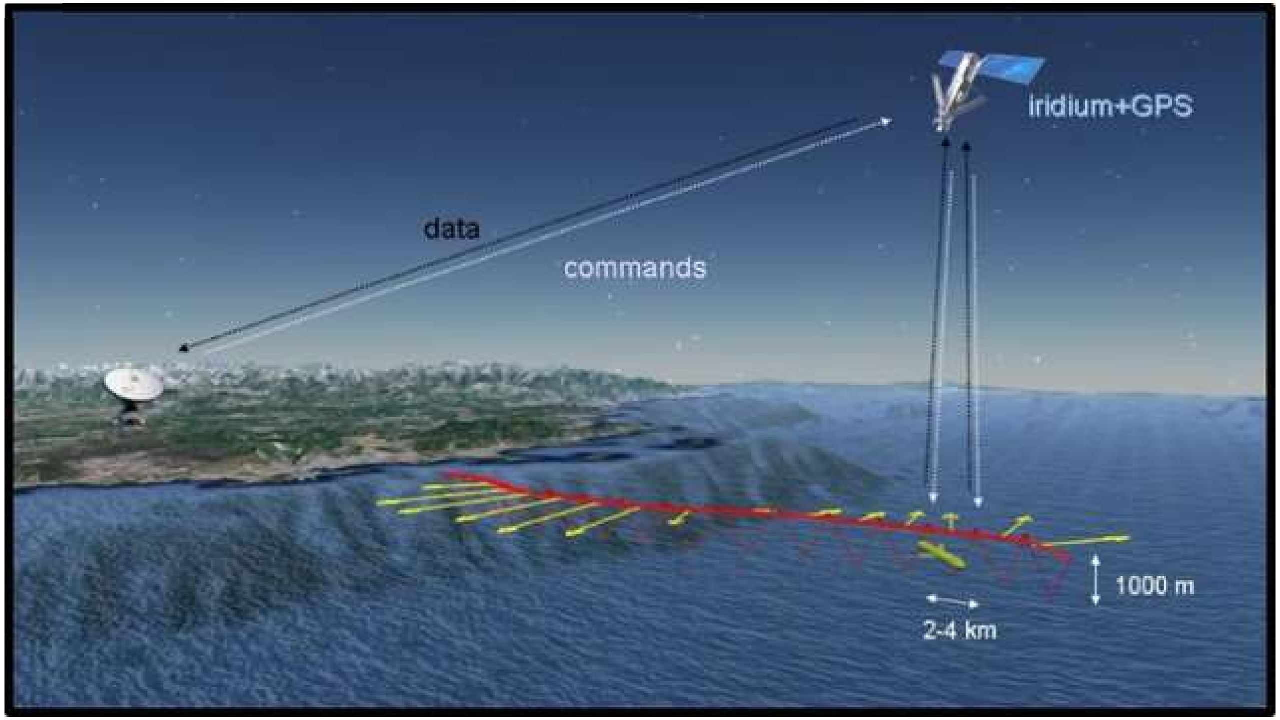
- ✓ Autonomous tracking system
- ✓ ARGOS doppler Position (GPS free)
- ✓ Assisted Recovery with Goniometer

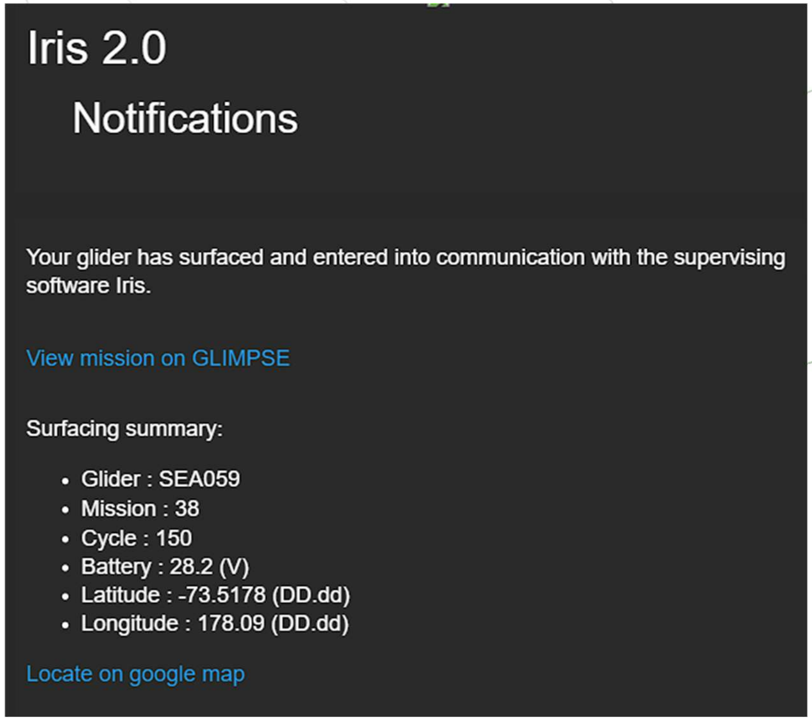


# Iridium connection

**Iridium call between shore & glider**

- Near real-time
- Download data from vehicle to server
- Iris supervision software



Iris 2.0

Notifications

Your glider has surfaced and entered into communication with the supervising software Iris.

View mission on GLIMPSE

Surfacing summary:

- Glider : SEA059
- Mission : 38
- Cycle : 150
- Battery : 28.2 (V)
- Latitude : -73.5178 (DD.dd)
- Longitude : 178.09 (DD.dd)

Locate on google map

# Ways of communication with the glider

**<u>Communication with the navigation board</u>**

**Radio**

- Serial link connection (Tera Term or Putty)
- Zmodem to download a file

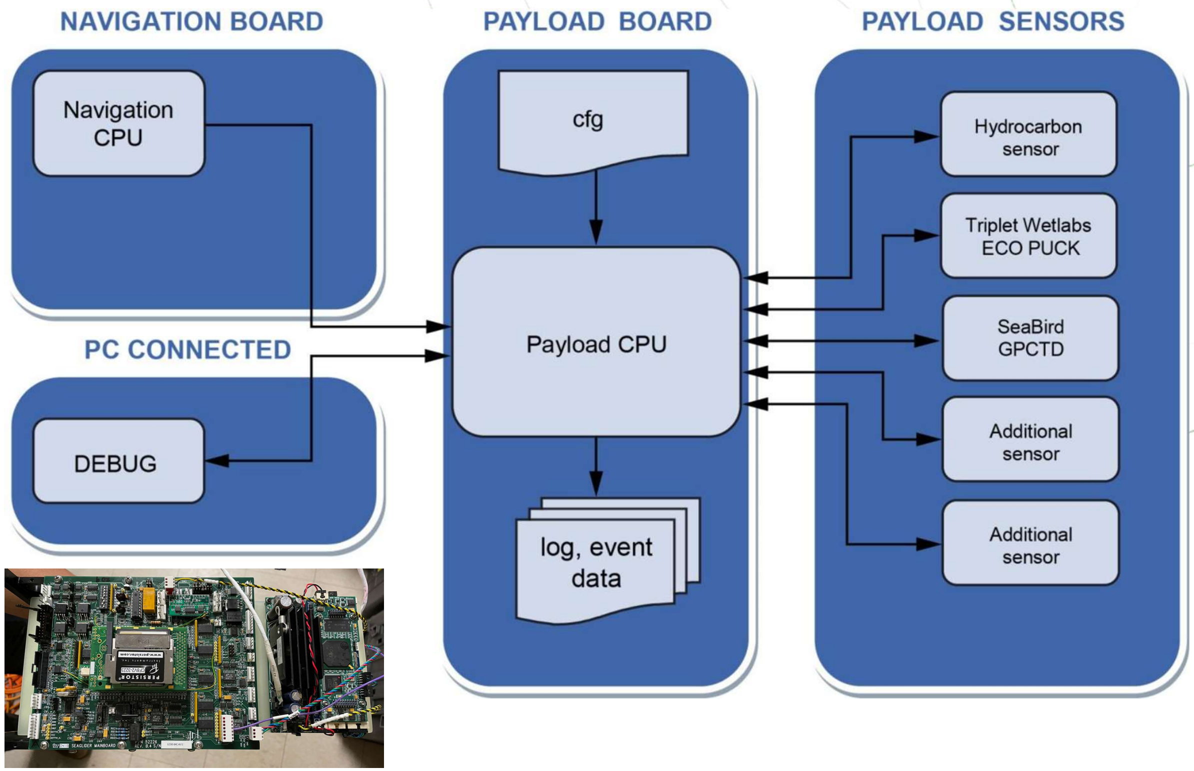
**Ethernet**

- SSH connection (Tera Term or Putty)
- FTP transfer to download a file

**Iridium**

•GLIMPSE supervision software

•Zmodem to download a file



# Ways of communication with the glider: commands

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**<u>Communication with the navigation board</u>**

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- Serial link connection (Tera Term or Putty)
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**Iridium**

•GLIMPSE supervision software

•Zmodem to download a file

## Intuitive commands available in radio or Iridium

- Control commands
  - $halt=0|1; : To put the vehicle in halt (pause)
  - $go; : To send the glider for a dive
- Navigation commands
  - $heading=45; : To set new heading
  - $pu=1020; : To set linear position (adjust ascent pitch)
  - $pd=-1020; : To set linear position (adjust descent pitch)
  - $bu=+200; : To set bladder volume (adjust ascent speed)
  - $bd=-200; : To set bladder volume (adjust descent speed)
  - $sr=2; : To set surfacing rate (number of dive between surfacings)
  - $zb=500; : To set profiles bottom depth
  - $zt=5; : To set profiles top depth in multi-dives (sr>1)
  - $zs=5; : To set profiles top depth before surfacing
  - $ym=500; : To set the max number of dives

# Ways of communication with the glider: commands

**<u>Communication with the navigation board</u>**

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**Iridium**

- GLIMPSE supervision software
- Zmodem to download a file

- Operating commands

| | |
|---|---|
| $sendNavFile=x; | : Download navigation file corresponding to the dive: x |
| $sendDataFile=x; | : Download payload file corresponding to the dive: x |
| $dst.enable=0\|1; | : Show/hide $SEADST sentence |
| $log.enable=0\|1; | : Show/hide $SEALOG sentence |
| $cbk=60; | : Call back in 60 minutes |
| $clr=xxxx; | : To acknowledge (reset) alarms (xxxx=alarm code) |
| $msk=xxxx; | : To mask alarms (xxxx=alarm code) |
| $alt.enable=0\|1; | : Turn OFF/ON the altimeter, x: value in m |
| $radio.enable=0\|1; | : Turn OFF/ON the radio |

# Ways of communication with the glider: responses

**<u>Communication with the navigation board</u>**

**Radio**

- Serial link connection (Tera Term or Putty)
- Zmodem to download a file

**Ethernet**

- SSH connection (Tera Term or Putty)
- FTP transfer to download a file

**Iridium**

•GLIMPSE supervision software

•Zmodem to download a file

**Minimum required status sentence - SEAMRS**

- Gives information on health and position of the glider

$SEAMRS,SEA002,50,5,0,291,050712,143830,4336.7905,719.0099*00;

| | |
|---|---|
| SEAMRS | : Minimum Recommended Status |
| SEA002 | : Vehicle id |
| 50 | : Mission id |
| 5 | : yo id within the mission |
| 0 | : Health status (0=ok) |
| 291 | : Batteries voltage : 29.1V |
| 050712 | : Date July 05, 2012 |
| 143830 | : GMT Time 14h38:30 |
| 4336.790 | : Latitude 43°36.790 |
| 719.009 | : Longitude 7°19.009 |

# Ways of communication with the glider: responses

**Communication with the navigation board**

**Radio**

- Serial link connection (Tera Term or Putty)
- Zmodem to download a file

**Ethernet**

- SSH connection (Tera Term or Putty)
- FTP transfer to download a file

**Iridium**

•GLIMPSE supervision software

•Zmodem to download a file

## Navigations sentence - SEANAV

- Gives information on navigation instructions

$SEANAV,1,108,-8,8,200,-200,400,10,-1,2*00;

| | |
|---|---|
| SEANAV | : Navigation sentence |
| 1 | : Always 1=remotely guided |
| 108 | : $heading: Heading to follow in degrees |
| -8 | : $pu: Pitch Up linear position in mm |
| 8 | : $pd: Pitch Down linear position in mm |
| 200 | : $bu: Ballast Up |
| -200 | : $bd: Ballast Down |
| 400 | : $zb: Dive depth in meter |
| 10 | : $zt: Top inflection depth during multi dives |
| -1 | : $alt: Altitude (> 0 : inflection driven by altitude) |
| 2 | : $sr: Surfacing rate |

# Ways of communication with the glider

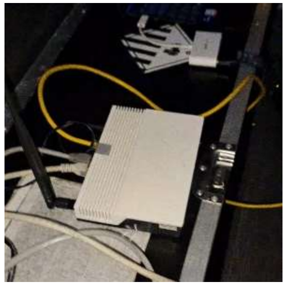
**<u>Communication with the payload board</u>**

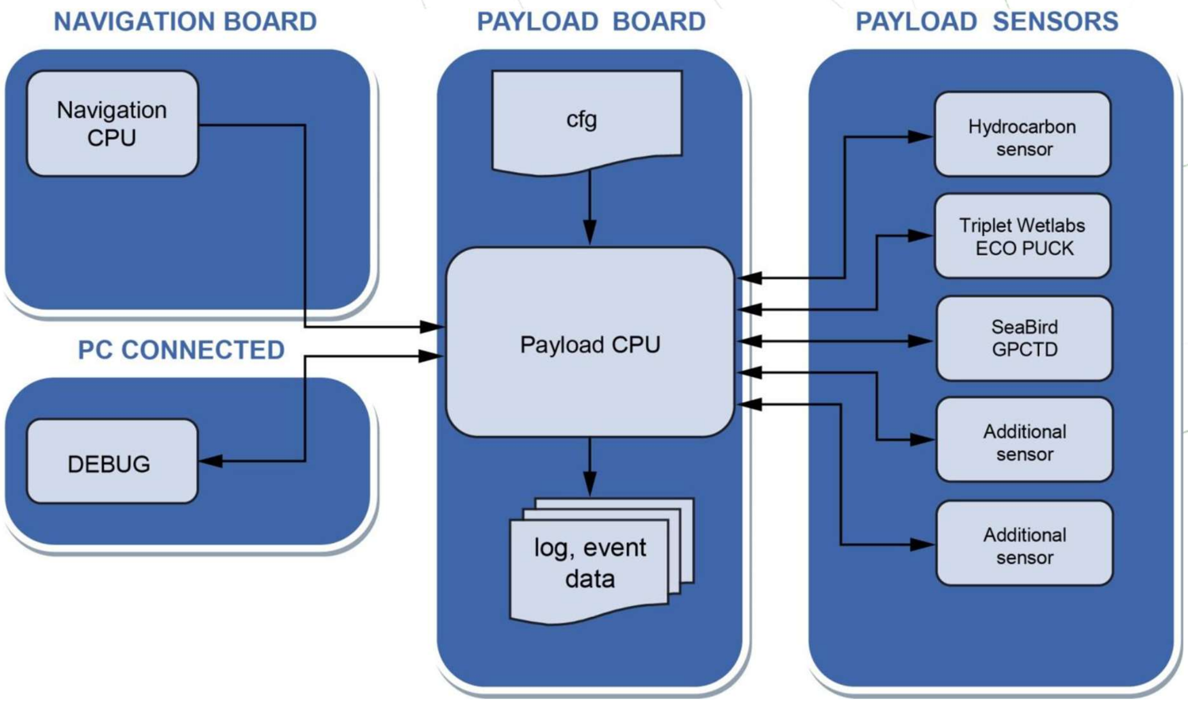
**Ethernet**

- SSH connection (Tera Term or Putty)
- FTP transfer to download a file

**Debug (serial link)**

•Payload without vehicle (payload opened)

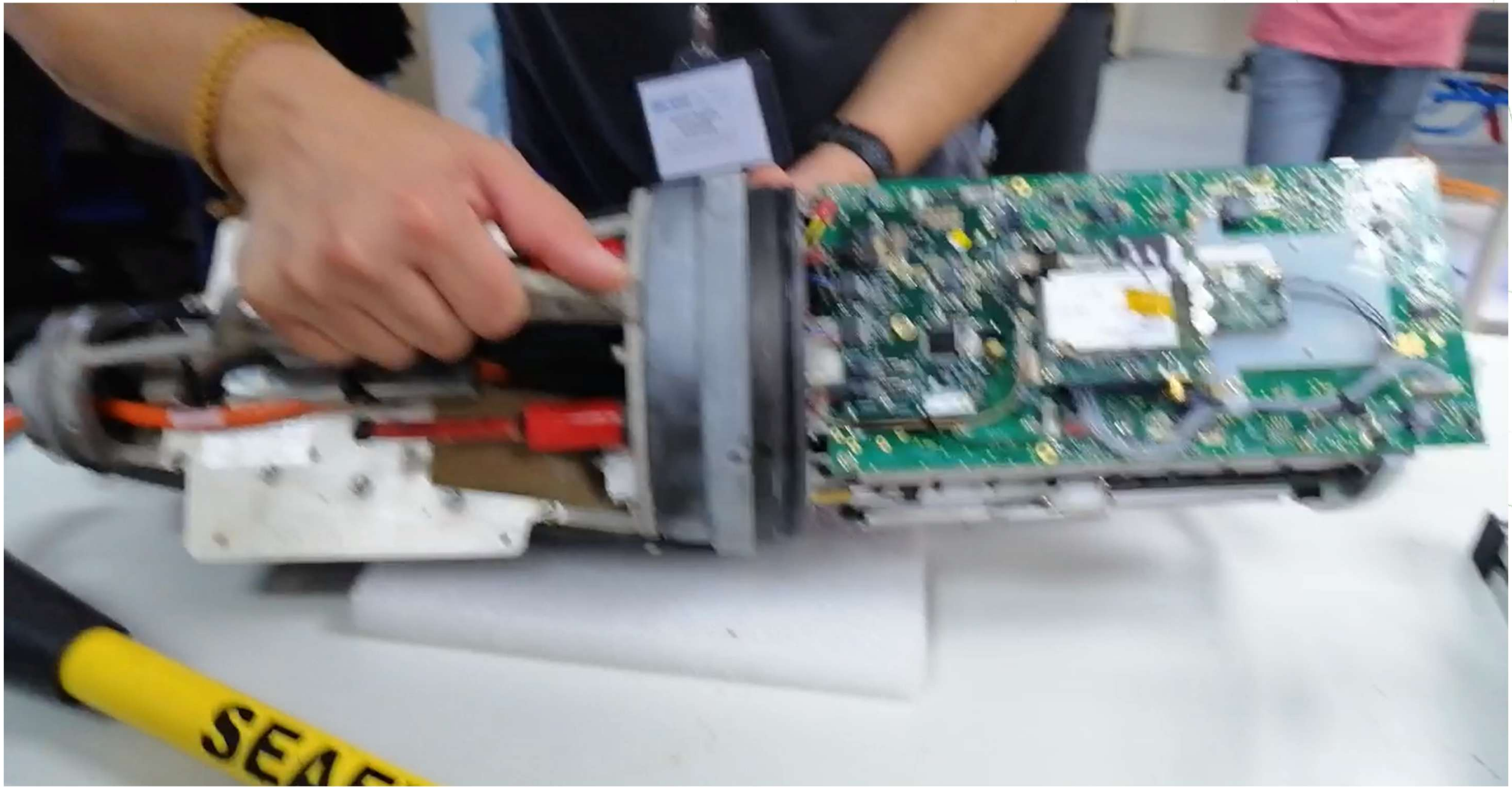




# Looking inside the glider

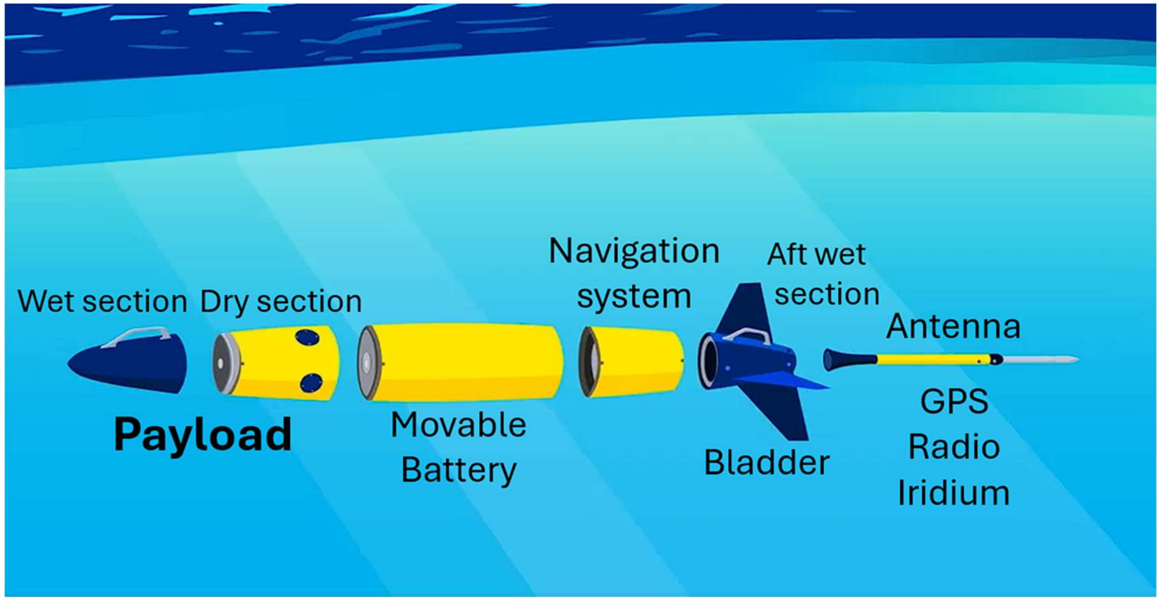
## The brain of the glider

## The brain of the glider



# Technical aspects and instrumentation

Navigation: GPS, pressure sensor, altimeter and dead reckoning




**Which sensors do you recognize?**

**Sensor Options:**

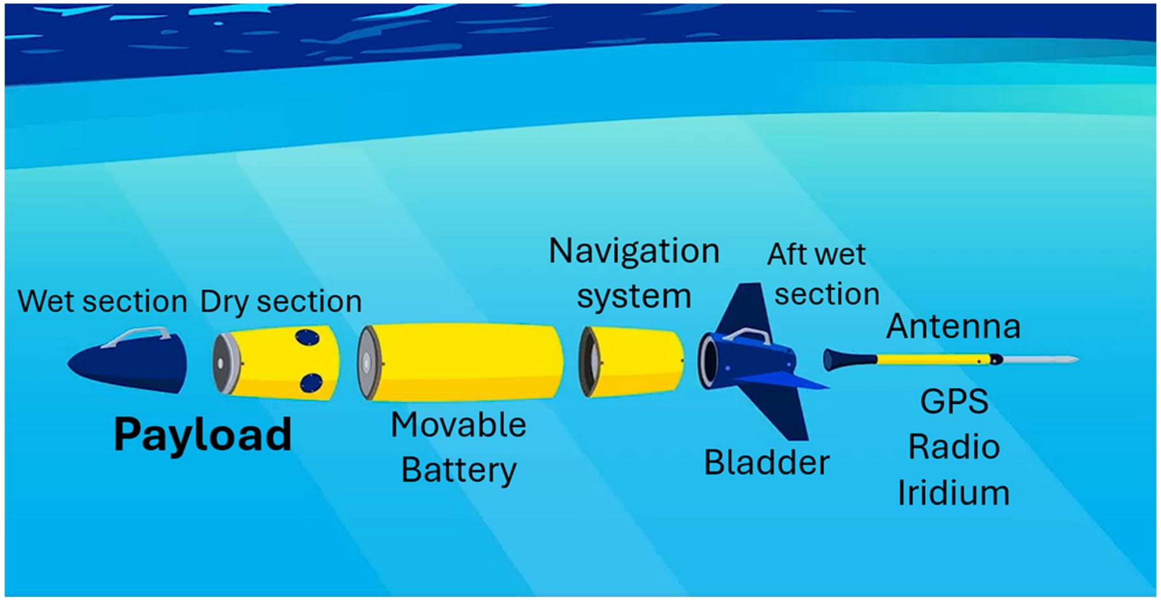
CTD Pumped or Unpumped
Dissolved oxygen
Fluorometer/bacckscatter/turbidity
Acoustic Doppler Current Profiler (ADCP)

Photosynthetically Active Radiation (PAR)
Colored Dissolved Organic Matter (CDOM)
Fluorescent DOM (FDOM)
Bio-optical (HAB detection)
Partial carbon dioxide pressure ($pCO_2$) optode
SeaFET pH
Spectrophotometer (Nitrate)

Oxygen isotope
Redox potential (oxidation-reduction)
METS (methane)
Laser in-situ scattering & transmissometry (LISST)
Micostructure turbulence
Radiometer

# Technical aspects and instrumentation

Navigation: GPS, pressure sensor, altimeter and dead reckoning




**Acoustic Modem**
**Echosounder**
**Hydrophone**

underwater positioning & data telemetry

**Sensor Options:**

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# Technical aspects and instrumentation

Navigation: GPS, pressure sensor, altimeter and dead reckoning


**Interchangeable payload**

**Acoustic Modem**
**Echosounder**
**Hydrophone**

underwater positioning
& data telemetry

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Radiometer

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Gliders have become the most versatile platform- serving as a “host” for new sensors

**Interchangeable payload: plug and play**


Biospherical MPE-PAR


Rockland’s MicroRider

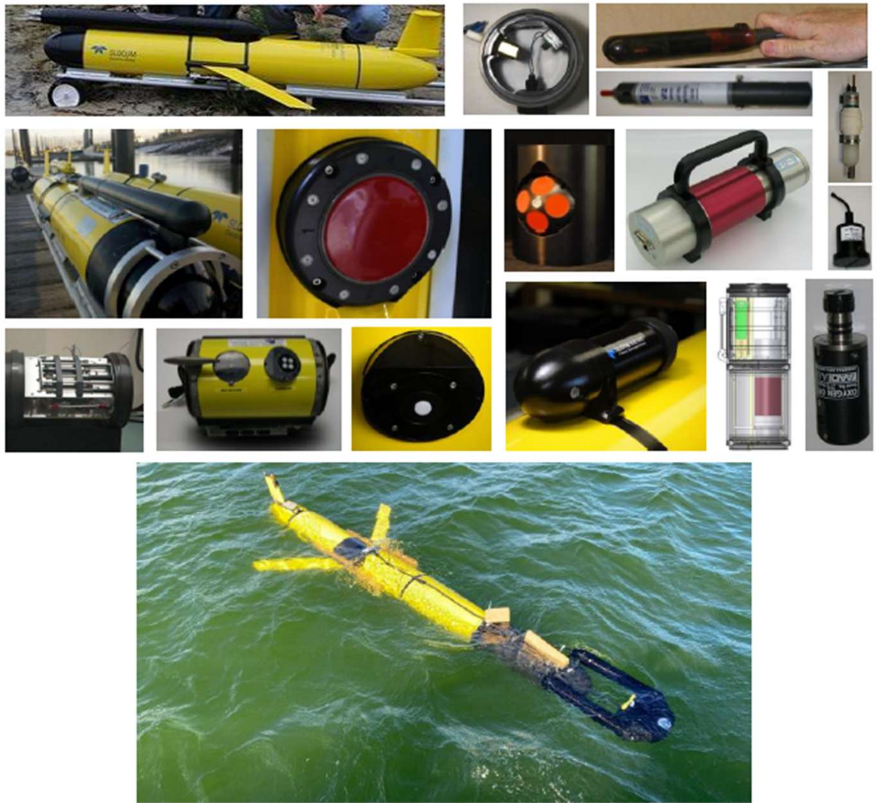
UVP6-LP sensor

Nortek ADCP

# Applications

Acoustic Modem
ADCP/DVL
Altimeter
Bathyphotometer (bioluminescence)
Beam Attenuation Meter (Transmissometer)
Conductivity, Temperature, Depth (CTD)
Echo Sounders
LISST
Nitrate
Optical Backscatter
Optical Attenuation
Oxygen
pH

Fish Tracking
Fluorometer
Hydrocarbon
Hydrophones
PAR sensor
Radiometer
Scanning Sonar
Scattering Attenuation Meter
Spectrophotometer (red tide detection)
Turbulence
Wave Spectra
Wassoc GliderCam
Wassoc Shadowgraph



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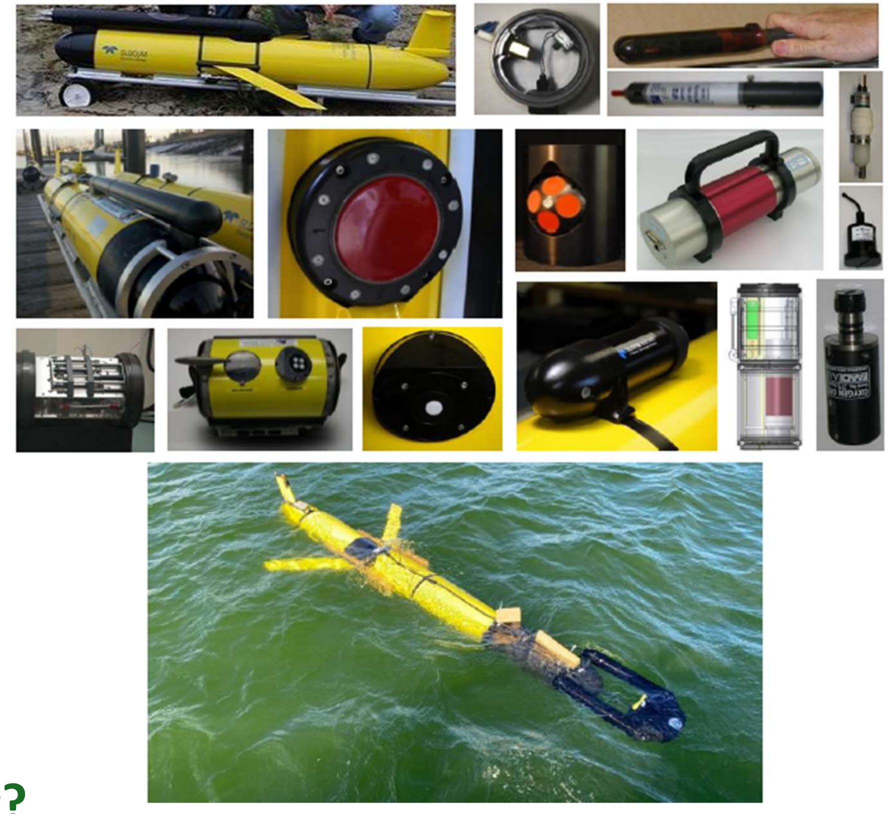

**Relevant variables for your field of interest?**

# Applications

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ADCP/DVL
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Beam Attenuation Meter (Transmissometer)
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**Relevant variables for your field of interest?**

More on that in a minute

# Questions?

# Quiz 2

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**Are You QRious?**


**https://www.menti.com/al2pkzjuc8vg**

**Which factors affect the energy efficiency of an underwater glider?**
Select the correct answer.

a) Battery type and capacity
b) Sensors installed and their power consumption
c) Mission length and sampling strategy
d) Frequency of data collection and use of the altimeter, flasher and radio
e) All of the above

## Offline quiz

**Which of the following factors affect the energy efficiency of an underwater glider?**
Select the correct answer.

a) Battery type and capacity

b) Sensors installed and their power consumption

c) Mission length and sampling strategy

d) Use of altimeter, flasher and radio

e) All of the above ✅

## Offline quiz

**What is the primary communication method used by underwater gliders to transmit data?**

a) Wi-Fi connection

b) Satellite communication at the surface ✅

c) Radio signals

d) Cellular networks at depth

e) Morse code signals

f) Bluetooth

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