PROCIENCIA
PROGRAMA PARAGUAYO PARA EL DESARROLLO DE LA CIENCIA Y TECNOLOGÍA

UPA
UNIVERSIDAD PARAGUAYO ALEMANA
HEIDELBERG - ASUNCIÓN

A Do-It-Yourself water monitoring approach:

Autonomous surface vehicle for WSP monitoring

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1. Introduction

1. Introduction

¿Reality of wastewater infrastructure in Paraguay?

– Although technically well-designed, currently degraded and not functioning as initially planned.

1. Introduction

¿Reality of wastewater infrastructure in Paraguay?

- Although technically well-designed, currently degraded and not functioning as initially planned.
- Constant threat for public health and environment.

abc NOTICIAS EDICIÓN IMPRESA NACIONALES DEPORTES ESPECTÁCULOS ESPE

15 DE FEBRERO DE 2018 15:53

Imputan a directivos de ESSAP por contaminar arroyo

Por Carlos Avalos, corresponsal

Fiscalía imputó a directivos de la Empresa de Servicios Sanitarios del Paraguay (Essap) por supuestamente contaminar el arroyo Espinillo, de la compañía Pindoty de Coronel Oviedo, departamento de Caaguazú.

Me gusta 926 G+ Compartir Aa

La alcantarilla por donde la sale el agua podrida de la ESSAP y cae al arroyo espinillo./ Carlos Avalos, ABC Color

La Fiscal Ambiental de Coronel Oviedo, **Abog. Marta Leiva**, presentó acta de imputación contra los gerentes de la aguatera estatal, **José Asereto** y **Oscar Vazzó**, por verter supuestamente desechos cloacales desde la planta de tratamiento hasta el arroyo Espinillo, de la compañía Pindoty.

ETIQUETAS

IMPUTACIÓN CONTAMINACIÓN ESSAP

1. Introduction

¿Reality of wastewater infrastructure in Paraguay?

- Although technically well-designed, currently degraded and not functioning as initially planned.
- Constant threat for public health and environment.
- Lack of monitoring data, both quantity an quality.

1. Introduction

Traditional monitoring approach:

- Characterization of incoming wastewater and pond effluent
- Samples taken at low temporal resolution (e.g., each 2 weeks)
- Focus on compliance of environmental regulations
- Limited availability of internal monitoring data on operational performance

→ **Internal processes have a mayor impact on treatment performance**

→ **Autonomous Surface Vehicle (ASV) is a promising technology**

1. Introduction

Objective:

1. Navigating autonomously along a predefined trajectory based on geographic coordinates
2. Performing measurements at different locations and depths within the pond

Additional design guidelines defined by context of developing countries:

- Use of low-cost and commonly available construction materials
- Use of low-cost electronics and software for the autonomous navigation capability
- Flexible and low-cost set-up of measurement devices
- Easy to transport

2. Autonomous Surface Vehicle for WSP monitoring

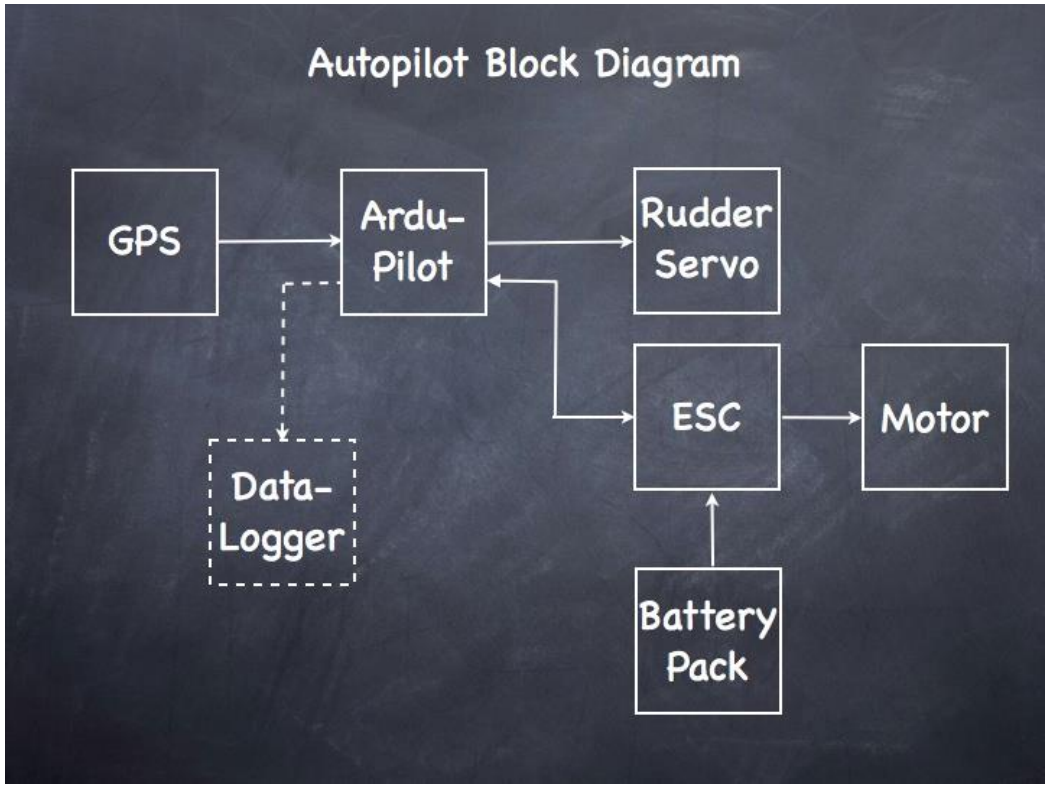
Where to start? DIYdrones community

https://diydrones.com/group/arduboat-user-group

https://diydrones.com/profiles/blogs/ardupilot-goes-into-the-water

2. Autonomous Surface Vehicle for WSP monitoring

How does it work?

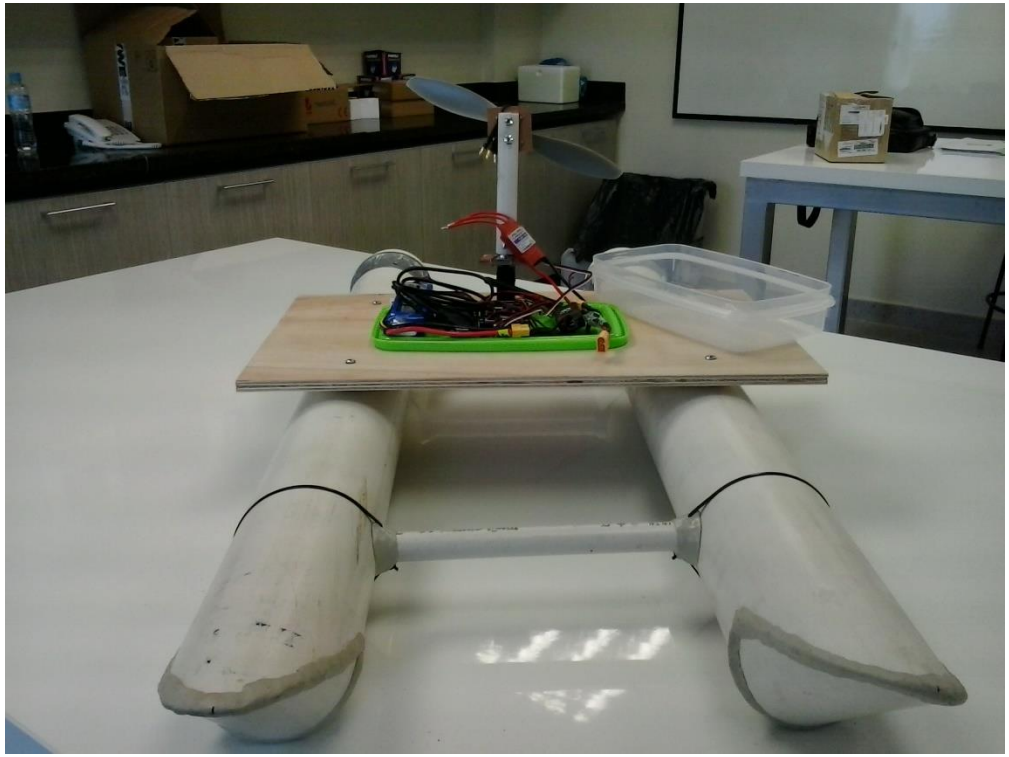


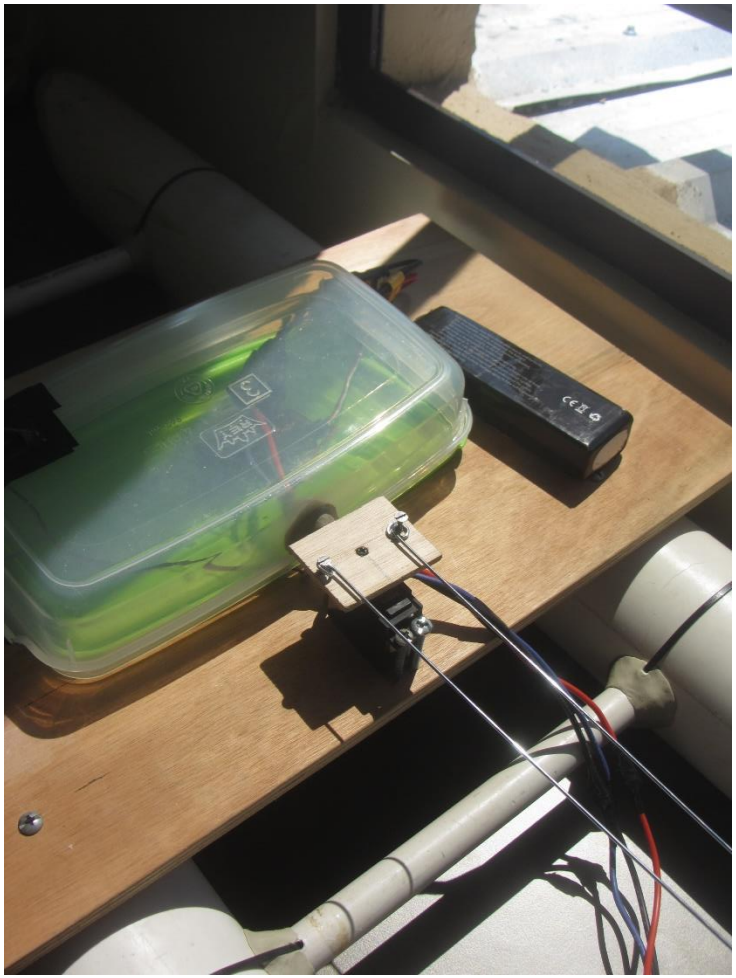
https://3dr.com/support/pixhawk/

http://ardupilot.org/

2. Autonomous Surface Vehicle for WSP monitoring

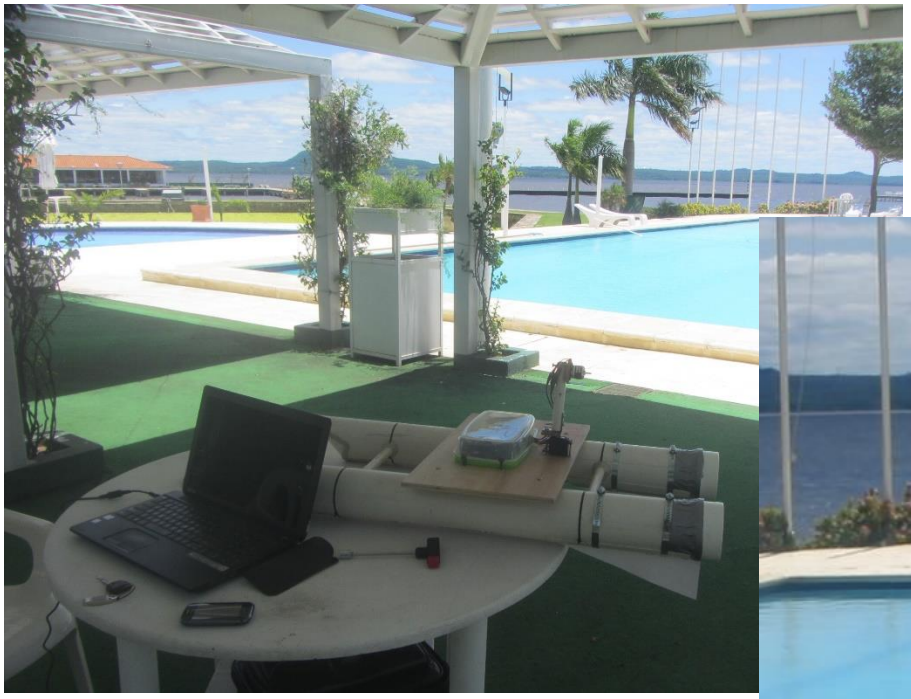
How did we get started?

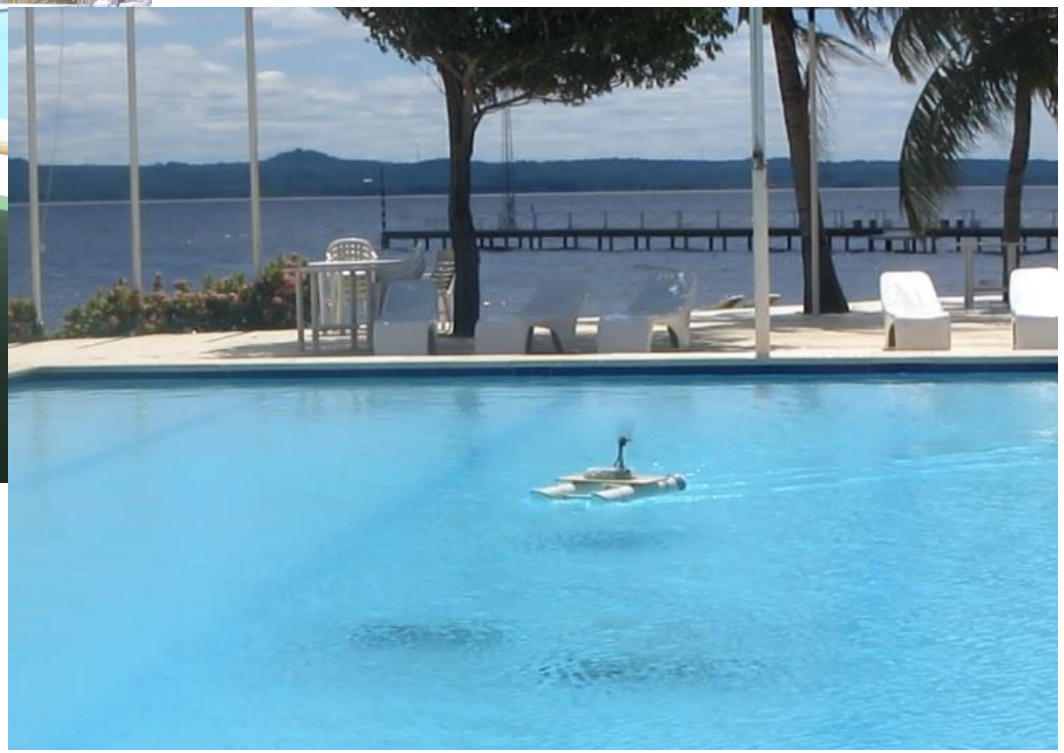




2. Autonomous Surface Vehicle for WSP monitoring

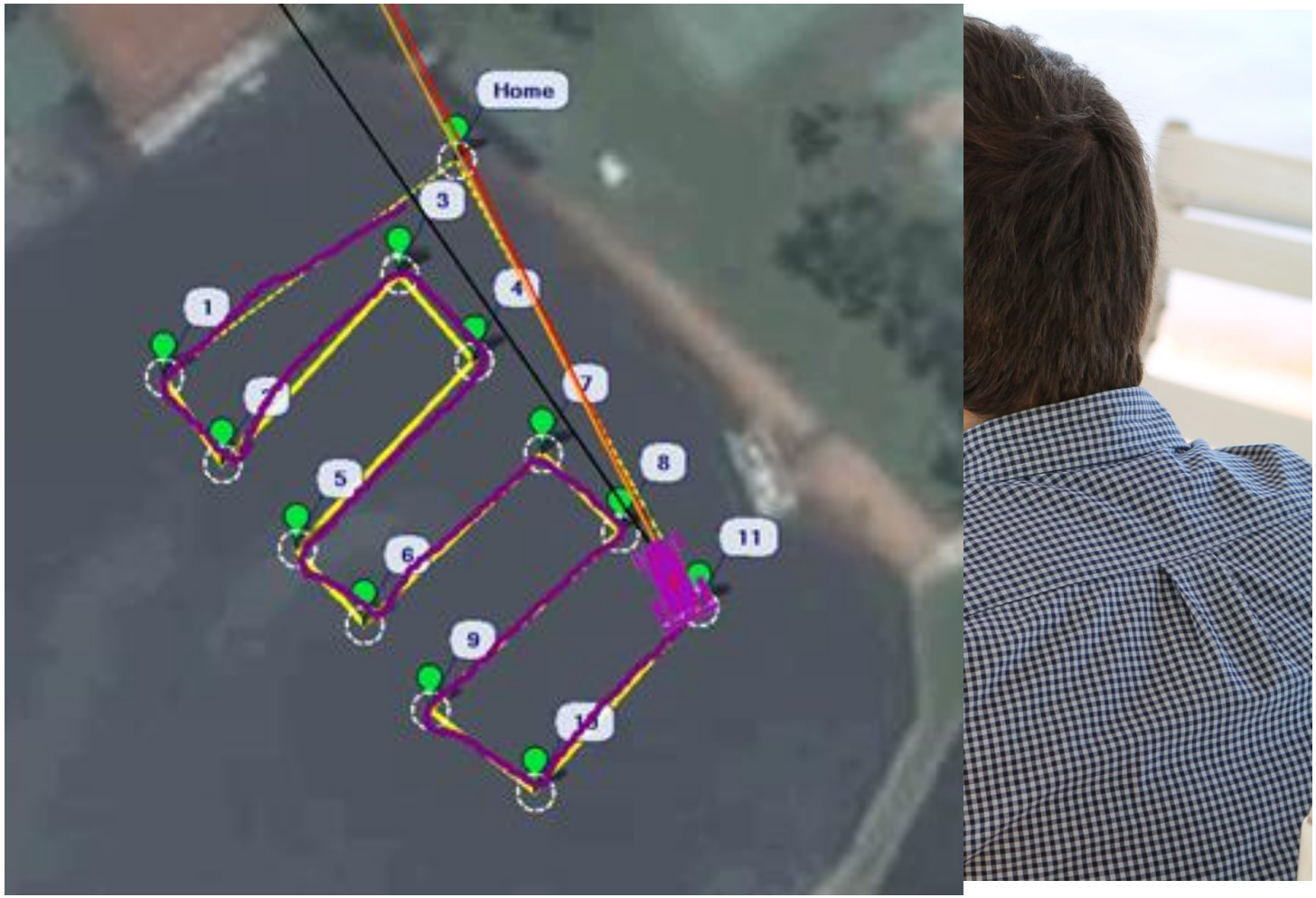
How did we get started?





2. Autonomous Surface Vehicle for WSP monitoring

PROTOTYPE 1



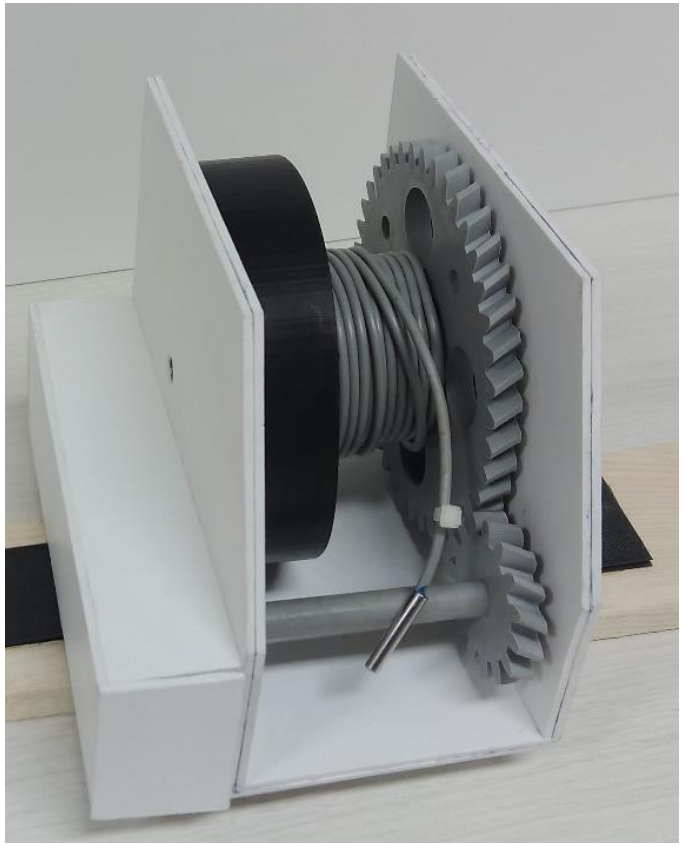
2. Autonomous Surface Vehicle for WSP monitoring

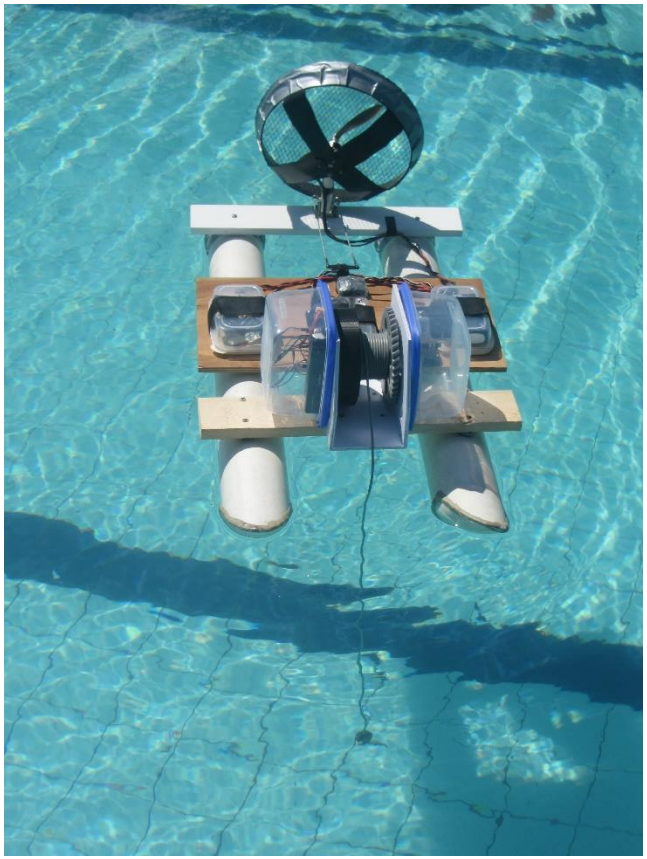
PROTOTYPE 1 (FEB 2016)

2. Autonomous Surface Vehicle for WSP monitoring

PROTOTYPE 1 (FEB 2016)

"The most difficult (autonomous navigation) has been done…Now only adding a winch system and we are ready to start the measurements!"



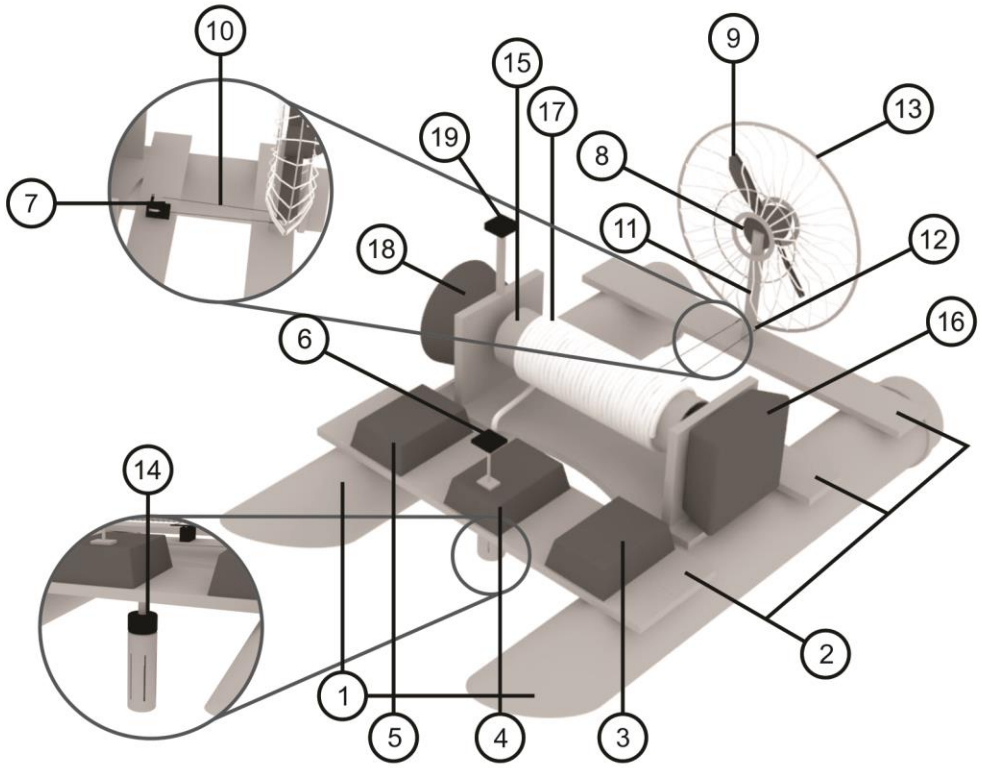


2. Autonomous Surface Vehicle for WSP monitoring

PROTOTYPE 2 (DEC 2016)

2. Autonomous Surface Vehicle for WSP monitoring

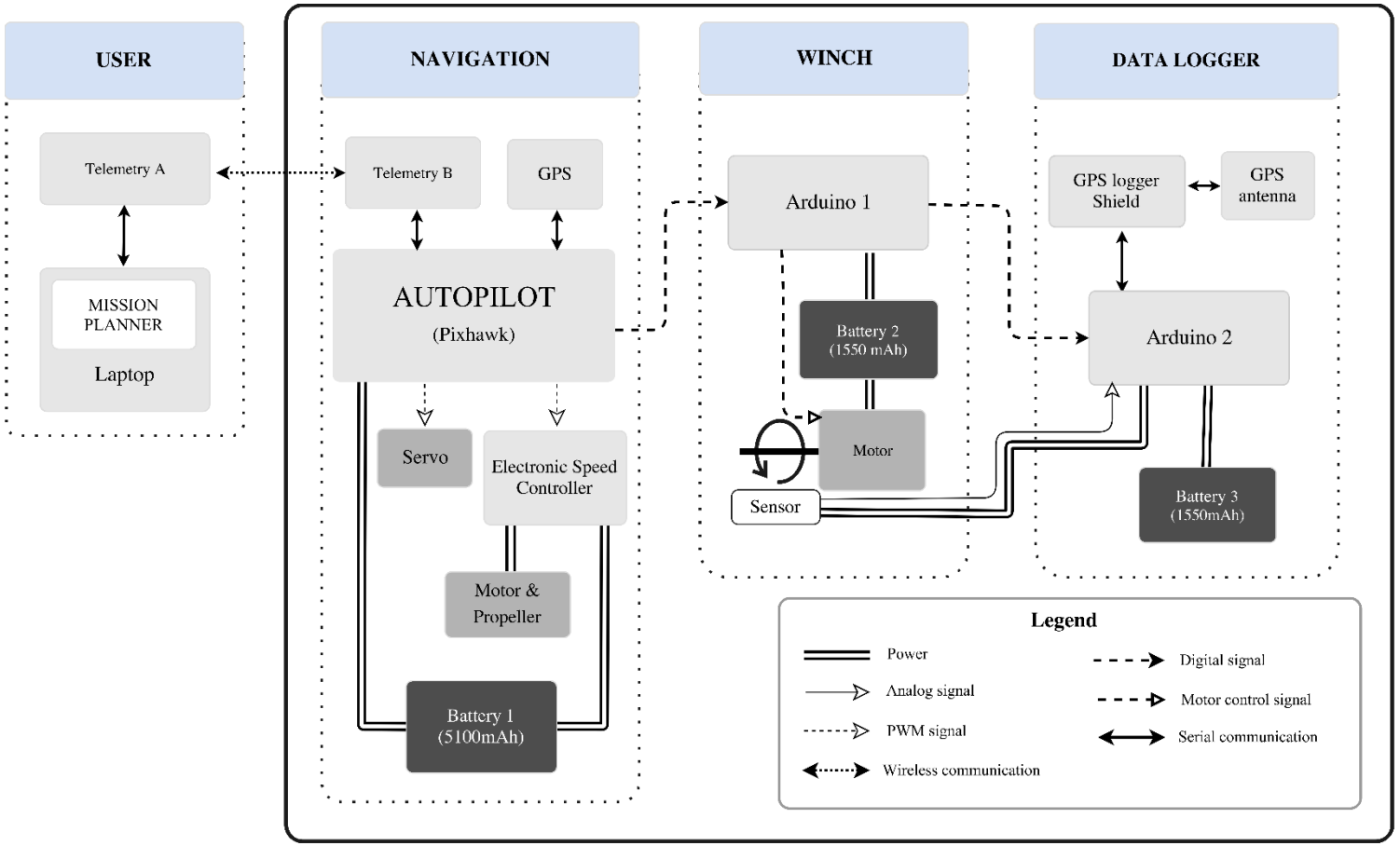
PROTOTYPE 2 (DEC 2016)



1) Ø 150 mm PVC pipes
2) Plywood
3) Battery
4) Autopilot
5) Telemetry Radio
6) GPS + compass
7) Steering servo
8) Brushless DC motor
9) Propeller
10) Ø 2mm Steel rod
11) Ø 20 mm PVC pipe
12) Furniture caster
13) Safety cage
14) Environmetal sensor
15) Ø 150 mm PVC pipe
16) Window lift motor + Arduino
17) Sensor cable
18) GPS datalogger + Arduino
19) External GPS antenna

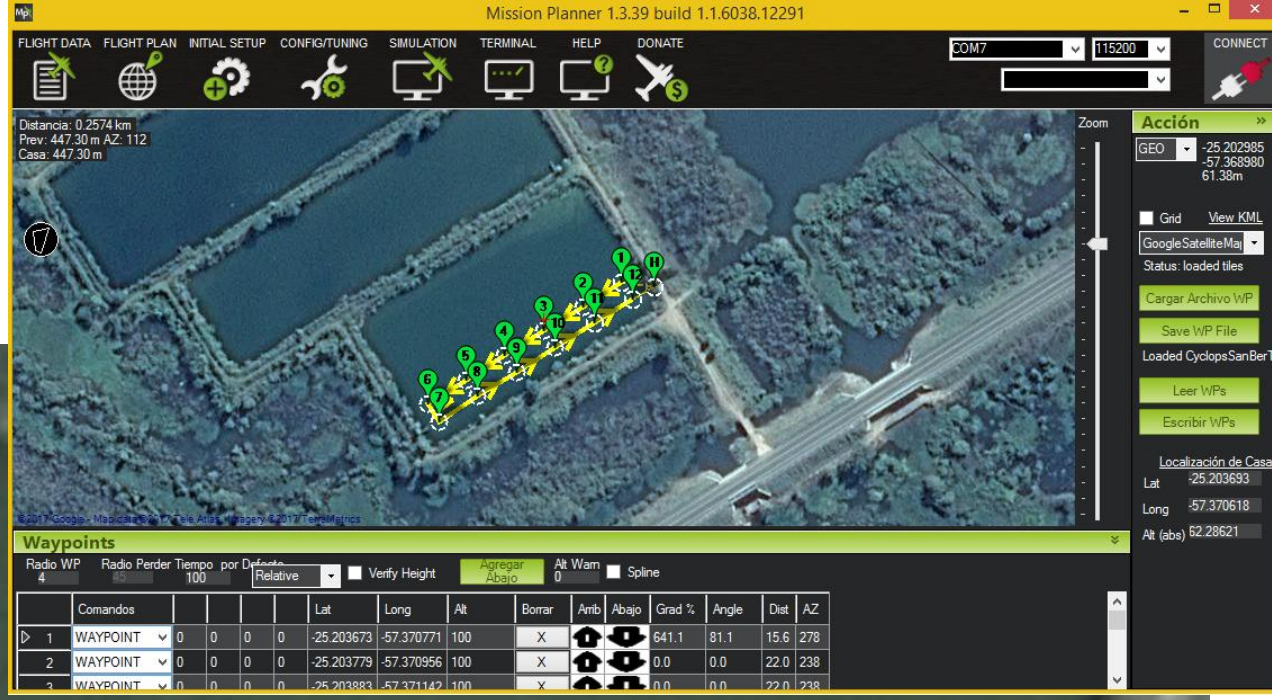
2. Autonomous Surface Vehicle for WSP monitoring

PROTOTYPE 2 (DEC 2016)



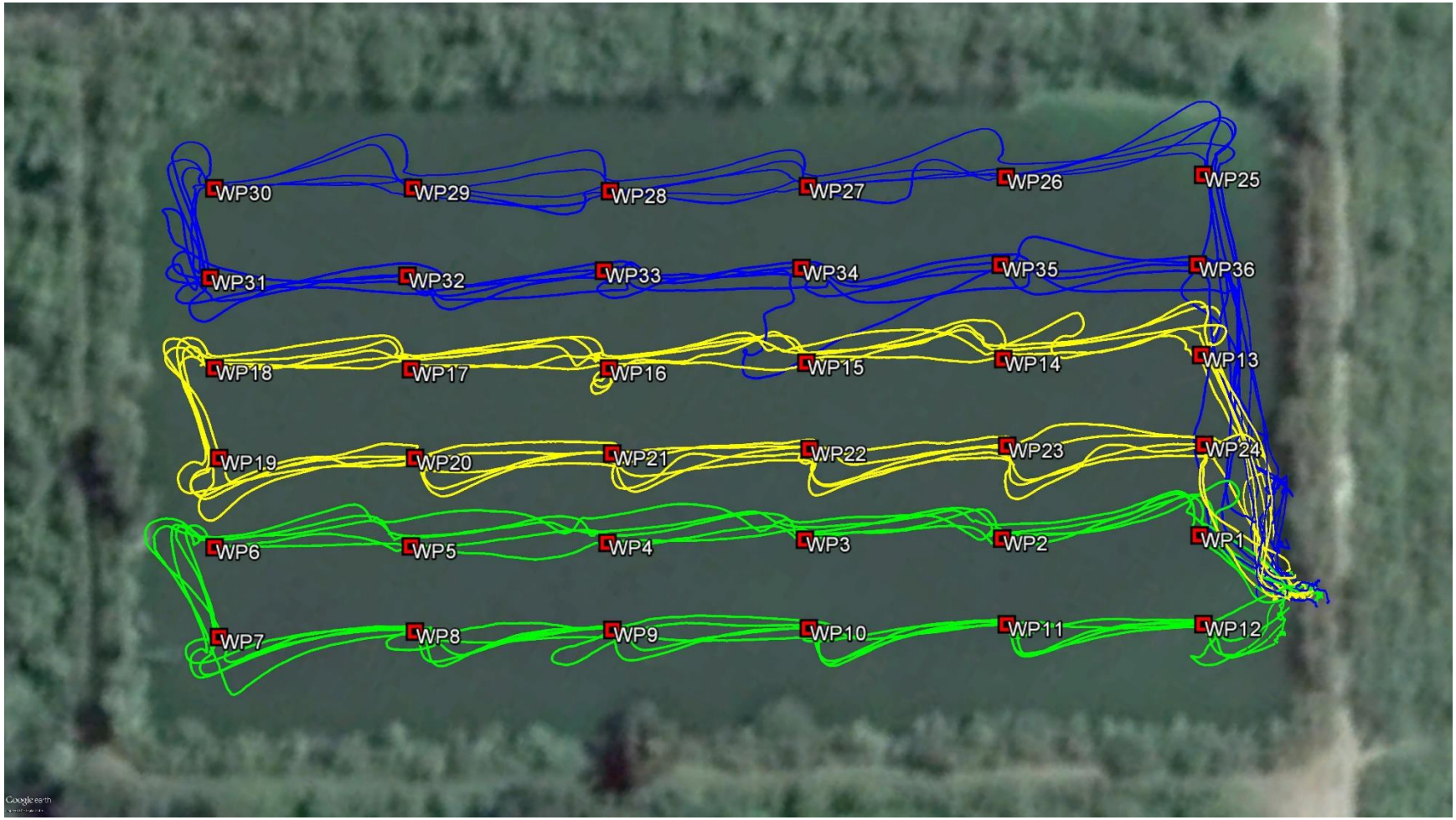
2. Autonomous Surface Vehicle for WSP monitoring

PROTOTYPE 2 (DEC 2016)


Mission Planner 1.3.39 build 1.1.6038.12291
FLIGHT DATA
FLIGHT PLAN
INITIAL SETUP
CONFIG/TUNING
SIMULATION
TERMINAL
HELP
DONATE
COM7
115200
CONNECT
Distancia: 0.2574 km
Prev: 447.30 m AZ: 112
Casa: 447.30 m
Zoom
Acción
GEO
-25.202985
-57.368980
61.38m
Grid
View KML
GoogleSatelliteMap
Status: loaded tiles
Cargar Archivo WP
Save WP File
Loaded CyclopsSanBer
Leer WPs
Escribir WPs
Localización de Casa
Lat -25.203693
Long -57.370618
Alt (abs) 62.28621
Waypoints
Radio WP 4
Radio Perder Tiempo por Defecto 100
Relative
Verify Height
Agregar Abajo
Alt Warn 0
Spline
Comandos
Lat
Long
Alt
Borrar
Arrib
Abajo
Grad %
Angle
Dist
AZ
1 WAYPOINT 0 0 0 0 -25.203673 -57.370771 100 X 641.1 81.1 15.6 278
2 WAYPOINT 0 0 0 0 -25.203779 -57.370956 100 X 0.0 0.0 22.0 238


WP6
WP5
WP4
WP3
WP2
WP1
WP7
WP8
WP9
WP10
WP11
WP12

2. Autonomous Surface Vehicle for WSP monitoring

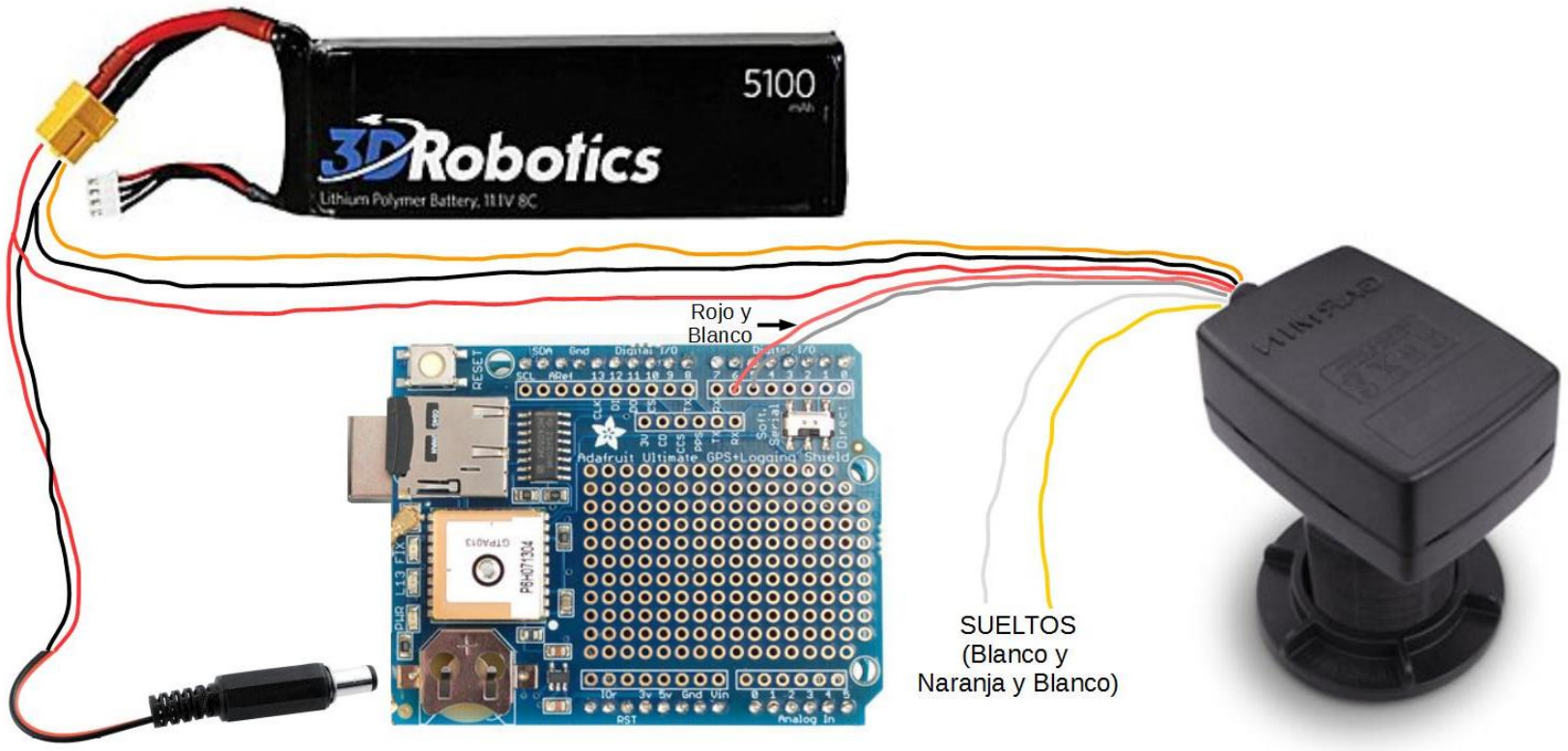


2. Autonomous Surface Vehicle for WSP monitoring

3. Application 1: bathymetric survey

3. Application 1: bathymetric survey

Hardware



3. Application 1: bathymetric survey

Software

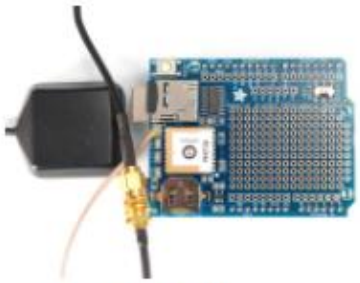
OK_Sonar_GPS | Arduino 1.6.7

File Edit Sketch Tools Help

OK_Sonar_GPS

```
  }
GPS.parse(GPS.lastNMEA());  //Once you get a good NMEA, parse it
NMEA1=GPS.lastNMEA();       //Once parsed, save NMEA sentence into NMEA1
//while(!GPS.newNMEAreceived()) {  //Go out and get the second NMEA sentence, should be different type than the first one read above.
//  c=GPS.read();
//  }
//GPS.parse(GPS.lastNMEA());
//NMEA2=GPS.lastNMEA();
a=0;
  Serial.println(NMEA1);
  //Serial.println(NMEA2);
  Serial.println("");
  dataFile.println(NMEA1);
  //dataFile.println(NMEA2);
  dataFile.flush();
}

void clearGPS() {  //Since between GPS reads, we still have data streaming in, we need to clear the old data by reading a few sentences, and discarding these
 mySerial.listen();
while(!GPS.newNMEAreceived()) {
  c=GPS.read();
  }
GPS.parse(GPS.lastNMEA());
while(!GPS.newNMEAreceived()) {
  c=GPS.read();
  }
GPS.parse(GPS.lastNMEA());
}
```

3. Application 1: bathymetric survey



Adafruit Ultimate GPS Logger Shield

Adafruit's Ultimate GPS, now in Arduino shield format

- Overview
- Shield Headers
- Direct Connect
- Soft Serial Connect
- Parsing Data
- SD Logging
- Built In Logging
- LOCUS Parser
- Antenna, Battery and More!
- Downloads

http://www.toptechboy.com/arduino-lessons/

Arduino Lesson 22: This lesson presents step-by-step instructions on creating a GPS tracker. This is first part of project, and will be completed in Lesson 23.

Arduino Lesson 23: This lesson presents step-by-step instructions on creating a GPS tracker with data logging capability.

Arduino Lesson 24: Understanding NMEA Sentences, and formatting GPS coordinates properly for display in Google earth.

Arduino Lesson 25: Displaying your GPS data files in Google Earth.

Arduino Lesson 26: Creating a Rugged Prototype Using Wire Wrapping.

Arduino Lesson 27: Use Wire Wrapping to Create a Portable GPS Data Logger that can be Displayed on Google Earth.

Online tutorials

3. Application 1: bathymetric survey

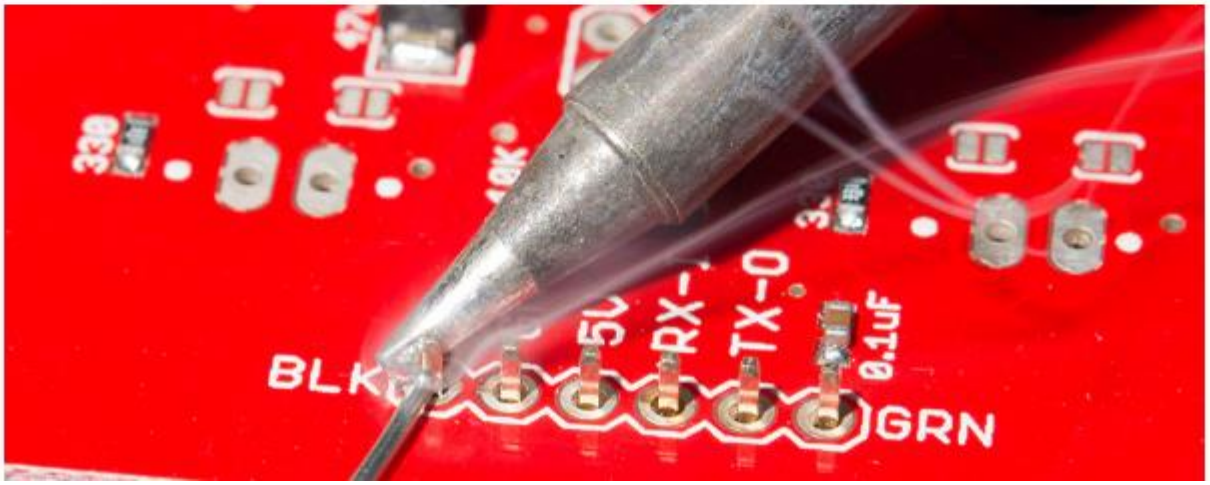
How to Solder: Through-Hole Soldering

CONTRIBUTORS: JOEL_E_B

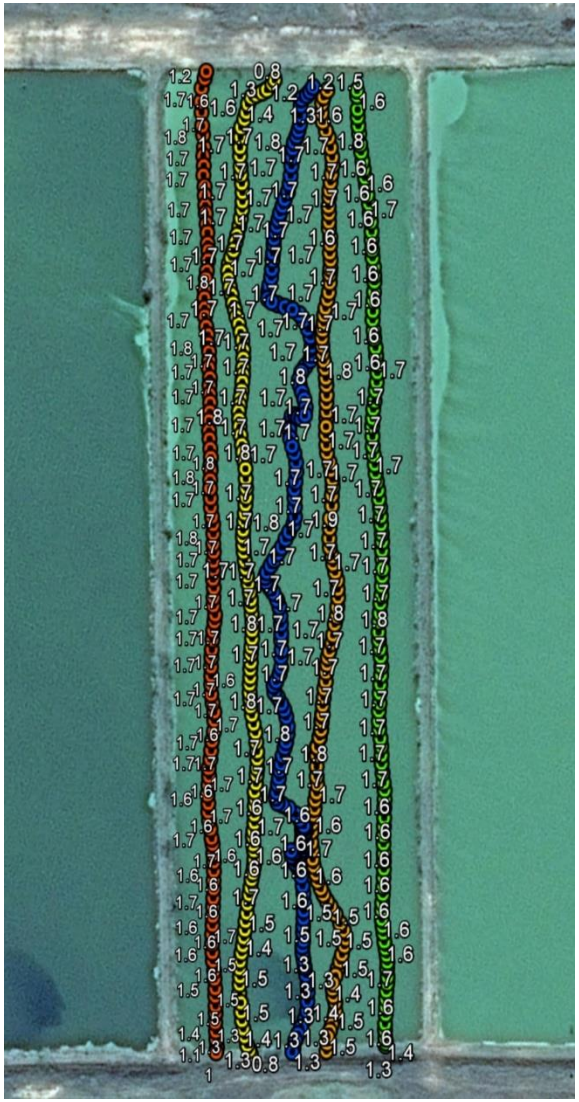
FAVORITE 28 SHARE

Introduction

Soldering is one of the most fundamental skills needed to dabble in the world of electronics. The two go together like peas and carrots. And, although it is possible to learn about and build electronics without needing to pick up a soldering iron, you'll soon discover that a whole new world is opened with this one simple skill. We here at SparkFun believe that soldering should be a skill in everyone's arsenal. In a world of increasing technological surroundings, we believe it is important that people everywhere be able to not only understand the technologies they use everyday but also be able to build, alter, and fix them as well. Soldering is one of many skills that will empower you to do just that.

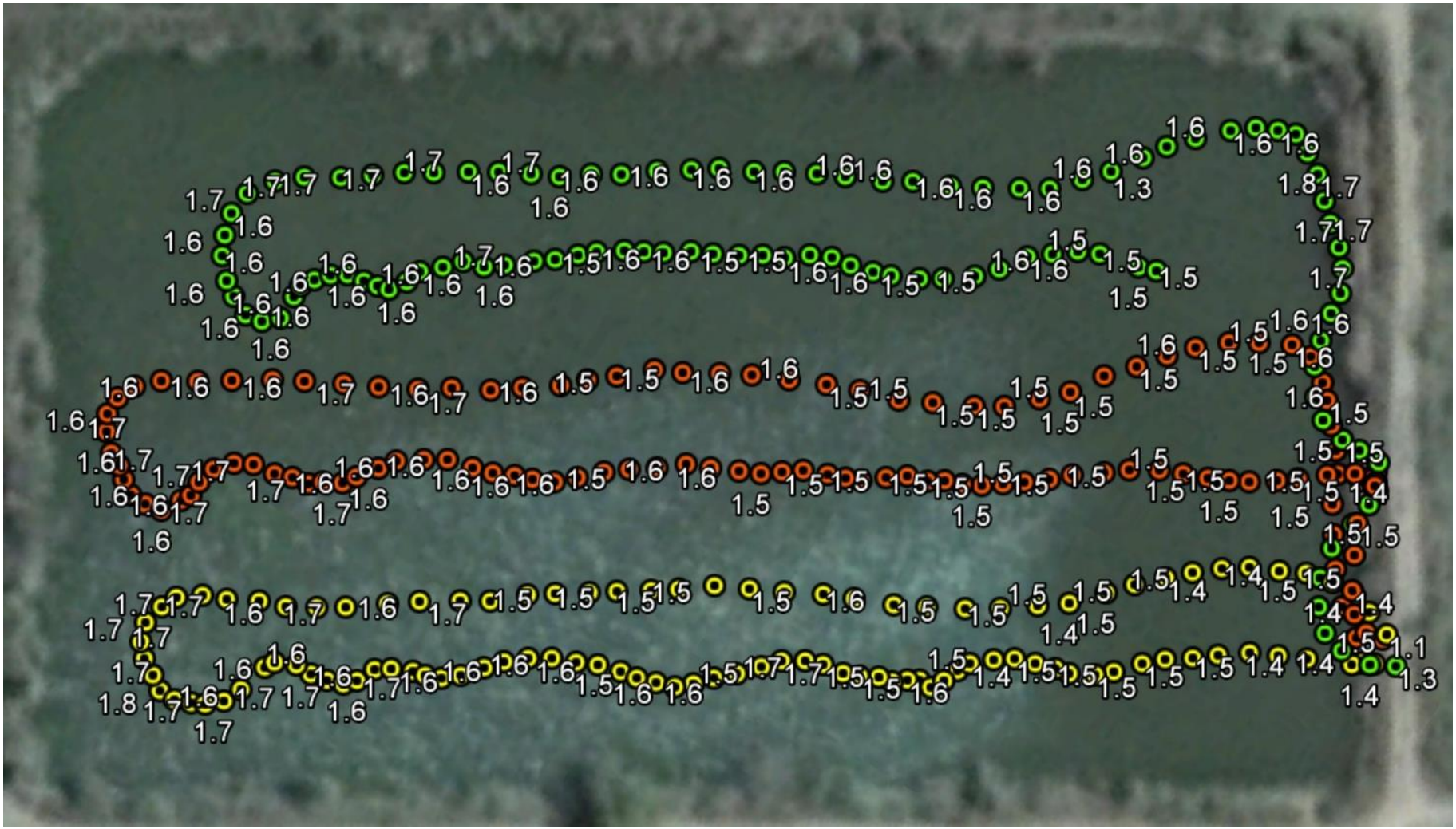


3. Application 1: bathymetric survey



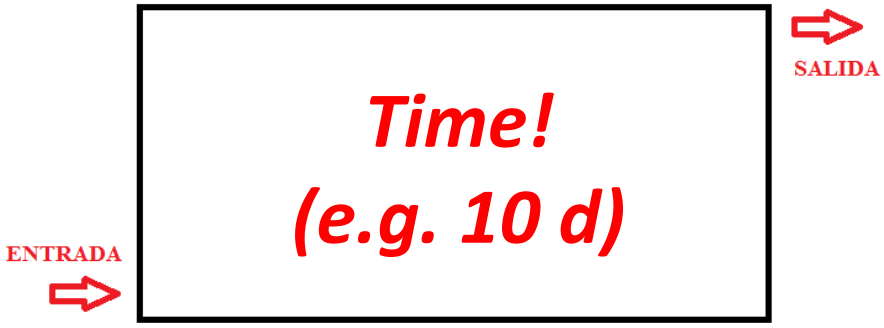
```
$GPRMC,160807.000,A,2526.0051,S,05629.5543,W,0.98,203.29,221216,,,D*6B
$SDDBT,5.8,f,1.7,M,0.9,F*04

$GPRMC,160811.000,A,2526.0061,S,05629.5547,W,1.05,200.53,221216,,,D*60
$SDDBT,5.6,f,1.7,M,0.9,F*0A
```

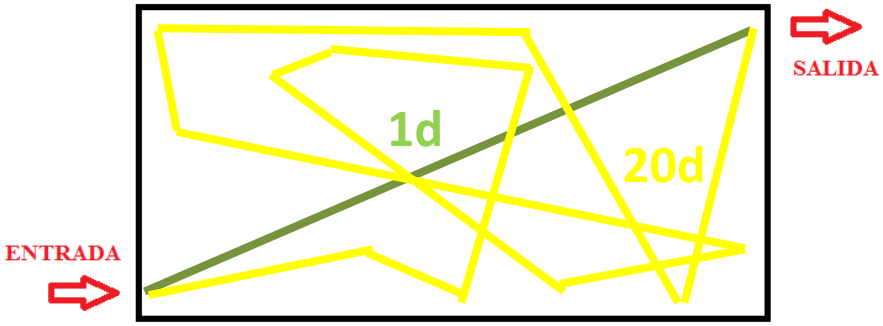
3. Application 1: bathymetric survey



4. Application 2: tracer concentration mapping

Residence time is a key variable for WSP performance evaluation.





4. Application 2: tracer concentration mapping

MSc Thesis Sharon Delaere – Experimental WSP UCA (2010, Paraguay)

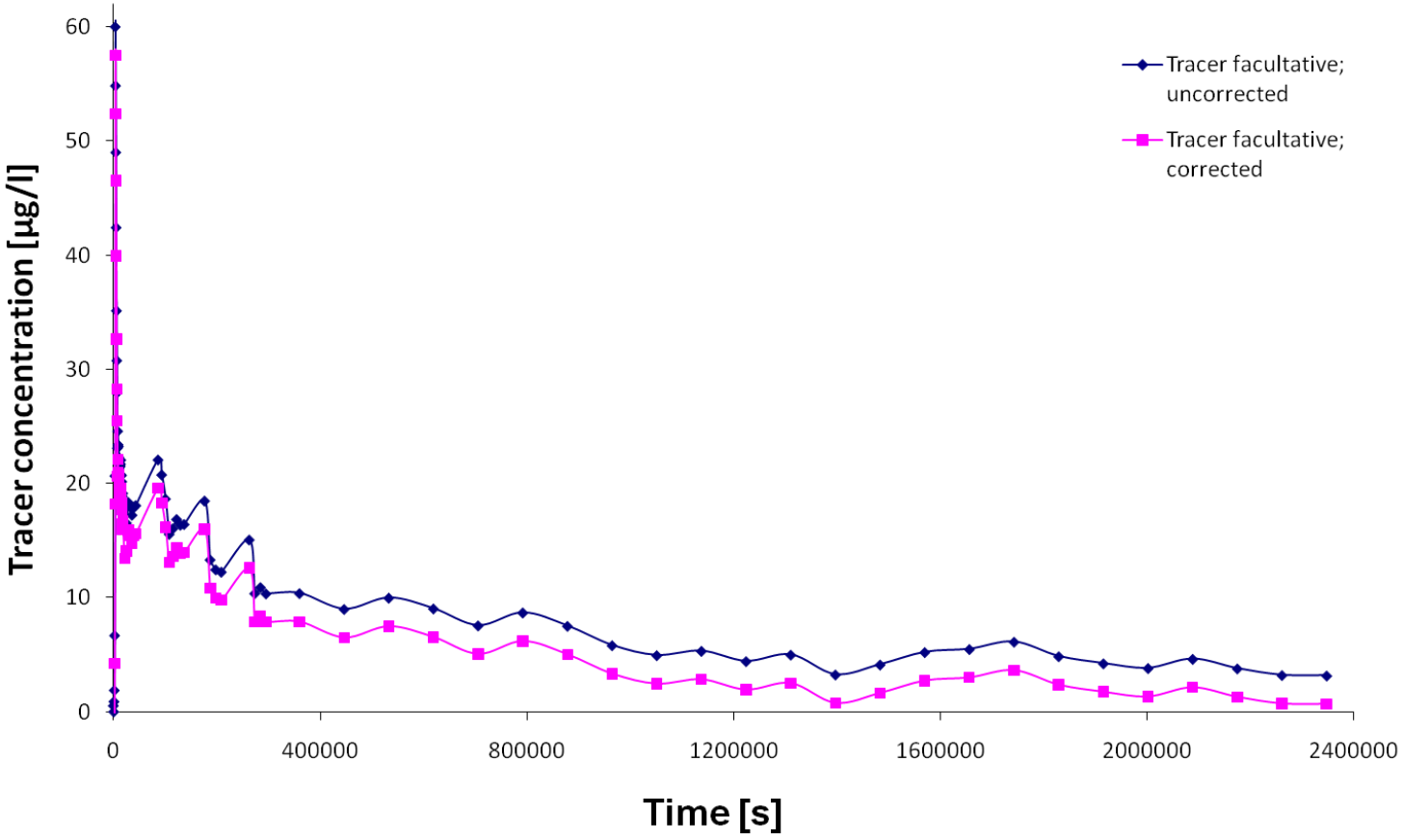
(1)

(2)

(3)

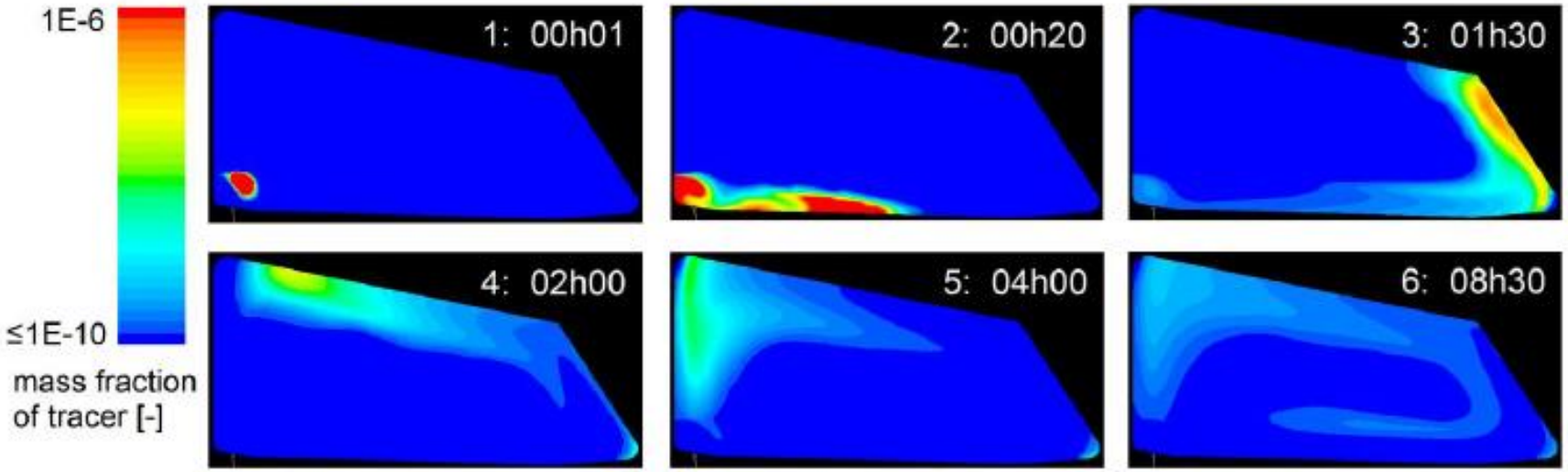
4. Application 2: tracer concentration mapping

MSc Thesis Sharon Delaere – Experimental WSP UCA (2010, Paraguay)



4. Application 2: tracer concentration mapping

PhD Thesis Andrés Alvarado - WSP Cuenca (Ecuador)

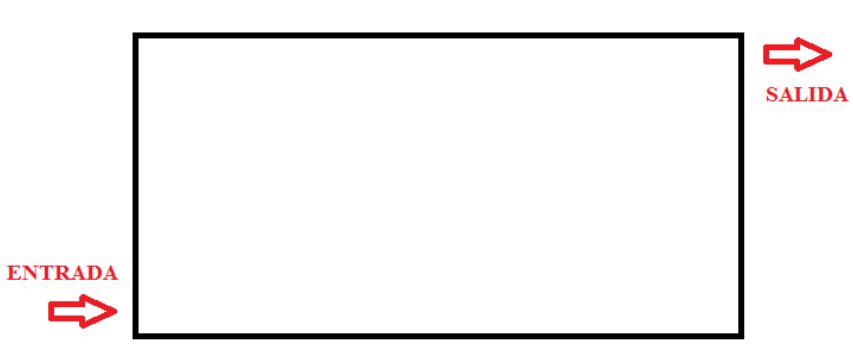


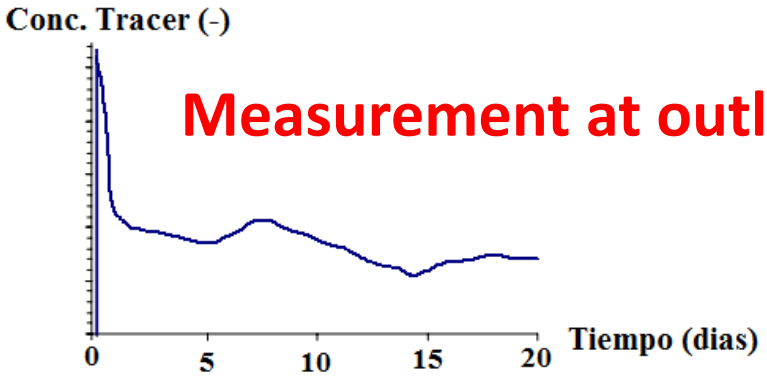
3.1. Tracer experiment observations

In general terms, due to the vast size of the pond, the tracer movement through the water body was visible only for the first 30 minutes after the injection; this period, however, was sufficient to visualize that the bulk mass of tracer instead of spreading over the pond domain, it immediately moved to the right lateral side of the pond in direction to the right bottom corner (Figure 2). This behavior presumed a short circuit and a strong circular pattern of the tracer around the pond which is typical for this type of hydraulic systems without baffle structures (Shilton *et al.*, 2008). In addition, a minor but visible amount of tracer remained in the corner closest to the inlet pipe, indicating a stagnant zone.

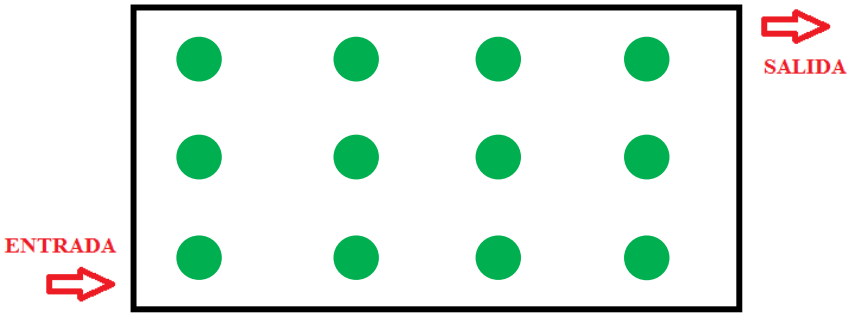
4. Application 2: tracer concentration mapping

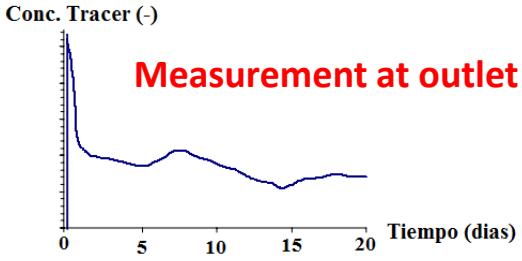
Traditional approach to tracer test:





Metodology in research Project 14-INV-279:



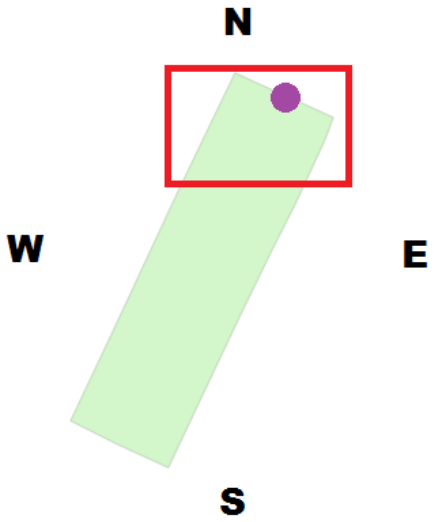


+ INTERNAL POINTS!

4. Application 2: tracer concentration mapping

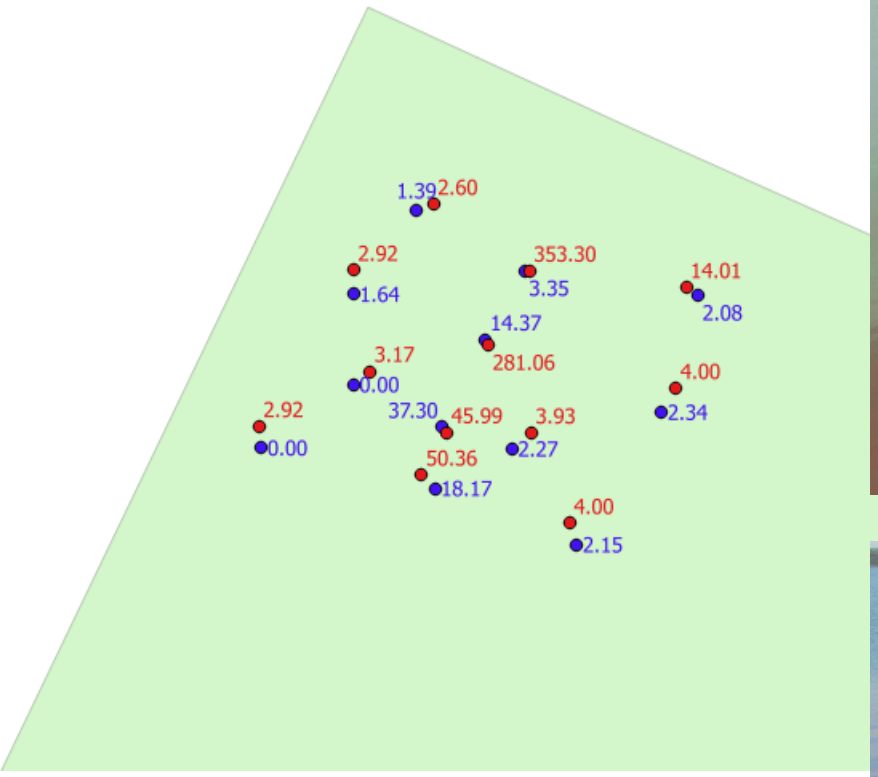
Tracer concentration mapping in Coronel Oviedo

Injection of tracer (10:50)



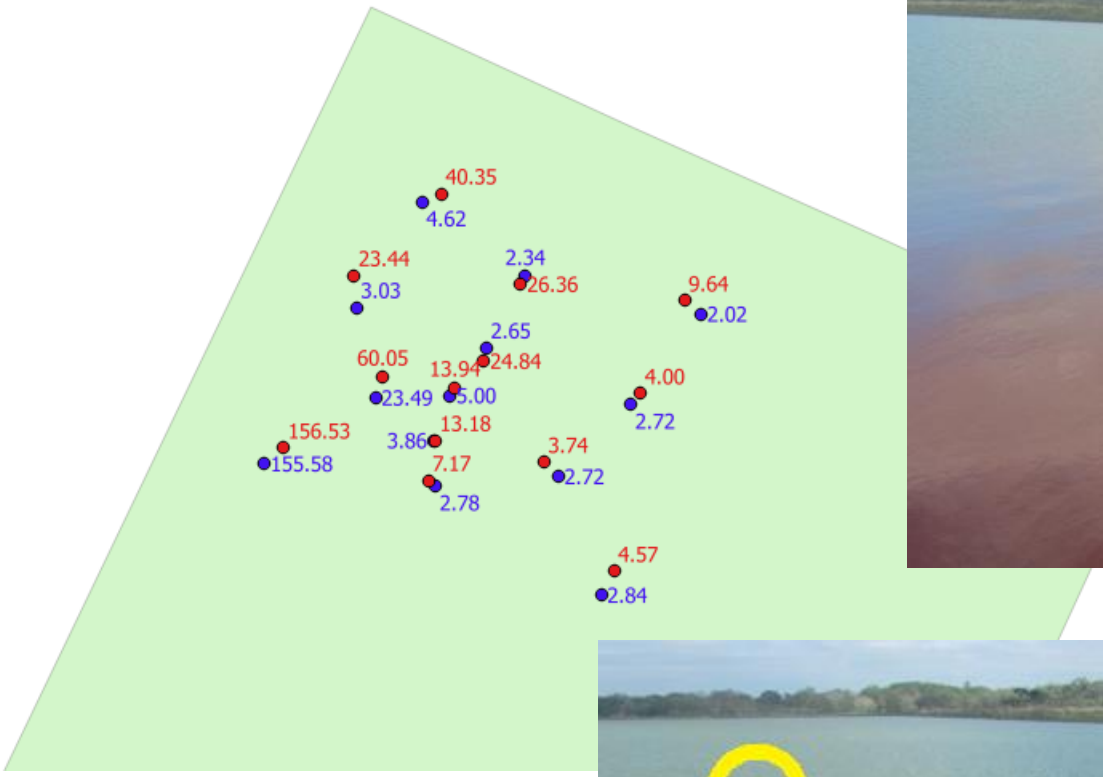
Tracer concentration mapping in Coronel Oviedo

First tour (10:56)



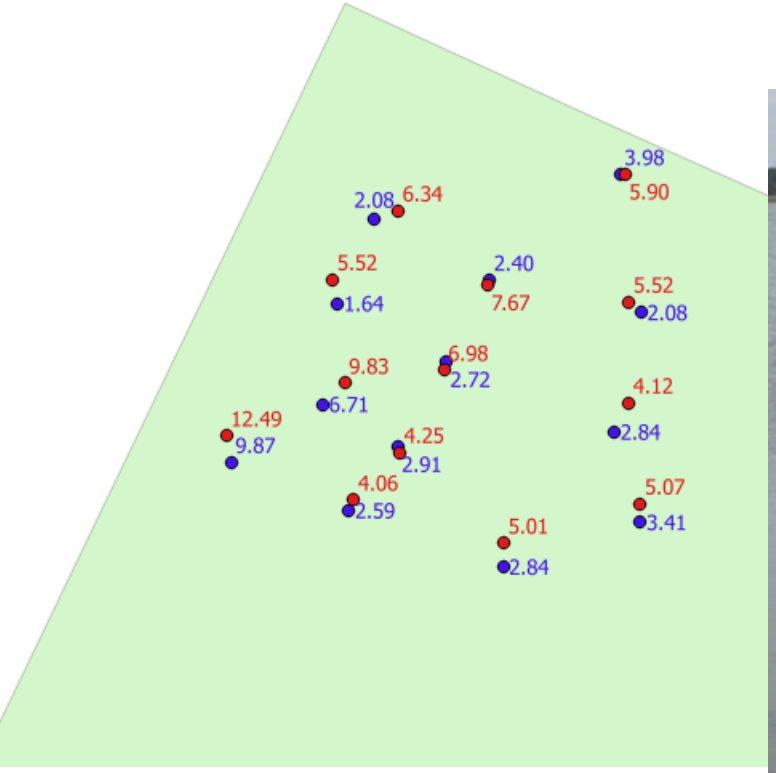
Tracer concentration mapping in Coronel Oviedo

Second tour (11:21)



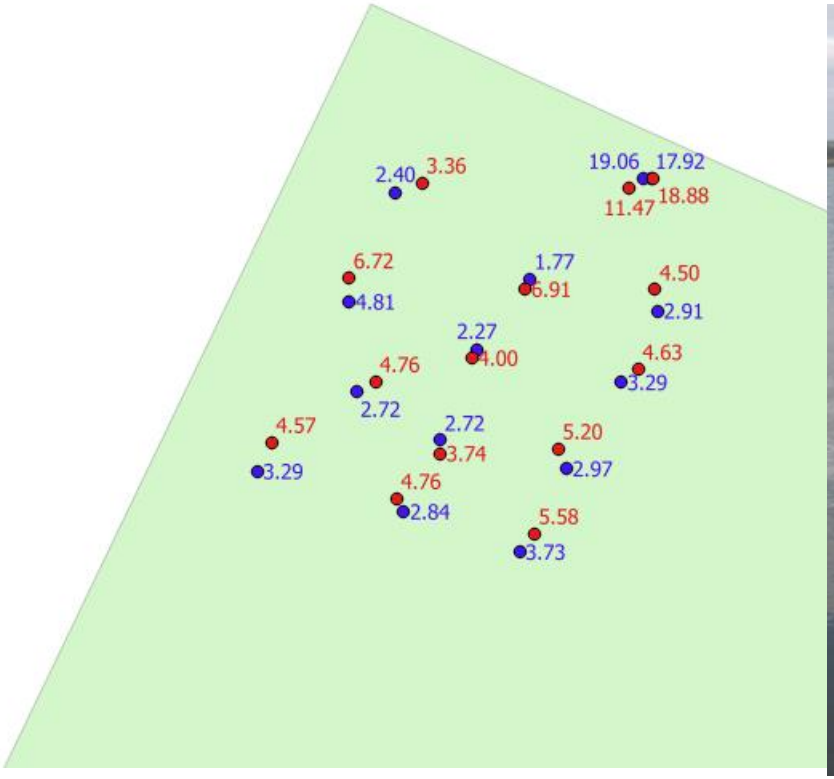
Tracer concentration mapping in Coronel Oviedo

Third tour (11:45)



Tracer concentration mapping in Coronel Oviedo

Fourth tour (12:15)



5. Conclusion & recommendations

Conclusions

- Generalized lack of monitoring data in developing countries
- Multipurpose ASV for WSP monitoring: flexible and low-cost (1.350$)
- Suggested improvements for Prototype II:
  - *Endurance*
  - *Winch system*
  - *Real-time monitoring*
- Variety of potential monitoring applications
- Do-It-Yourself and open-source approach opens new opportunities

5. Conclusion & recommendations

Recommendations

- Follow the innovators. It´s all on the web (e.g., twitter, blogs, etc.).
- Cooperate with the local Maker´s

FAB LAB

5. Conclusion & recommendations

Useful links:

- **http://intcatch.eu/** IntCatch uses AI and autonomous boat drones equipped with water quality sensors to monitor and test water quality in four rivers and lakes across Europe (Horizon 2020).

- **https://www.thethingsnetwork.org/** The Things Network is building a network for the Internet of Things by creating abundant data connectivity, so applications and businesses can flourish.
- **http://lacuna.space/** Low-cost, simple and reliable global connections to sensors and mobile equipment.

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Preguntas?

E. Caligaris, E. Mereles, A. Cuppens

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