Penguinfy

Oceanic Internet via low cost adaptive mesh system

Abstract

Penguinfy is a low cost adaptive oceanic internet and intranet platform that utilizes the Penguinfy modular nodes to create a mesh network with disruption tolerant networking architecture, assisted with an array of modular plug & play sensors, all overseen by a standalone software that, with the assistance of NASA datasets, provides its own communication services, weather reports, and hazard alerts for its users. The high costs of use, deployment and maintenance of current offshore communication services inspired the creation of Penguinfy, delivering an array of free and low cost solutions for the offshore maritime environment.

Introduction

Penguinfy represents our team's take on the Internet on the Earth's Ocean challenge.

The exponential growth of the maritime industry created a high demand of communication services on offshore locations due to the high costs of current satellite and dial up services, and the high costs of the hardware associated with it, which alienate a vast number of users.

Using the wifi technology + disruption tolerant network architecture + mesh technology set by arduino based nodes, Penguinfy creates an offshore intranet that, with the Penguinfy standalone software, provides the following free services: text based and push to talk communication services, weather updates and hazard reports. Penguinfy nodes will also serve as a bridge to optional satellite connections but to a lower cost of access due to the elimination of the need of expensive satellital hardware.

All the paid services of Penguinfy will be handled with Penguinfy Duffle Coins, the system's own currency, that can be purchased and earned by its users by sharing their own internet connection with other Penguinfy users available on their current mesh. Also, Penguinfy users equipped with Satellite access can provide ad-hoc connection to other uses and earn revenue for it.

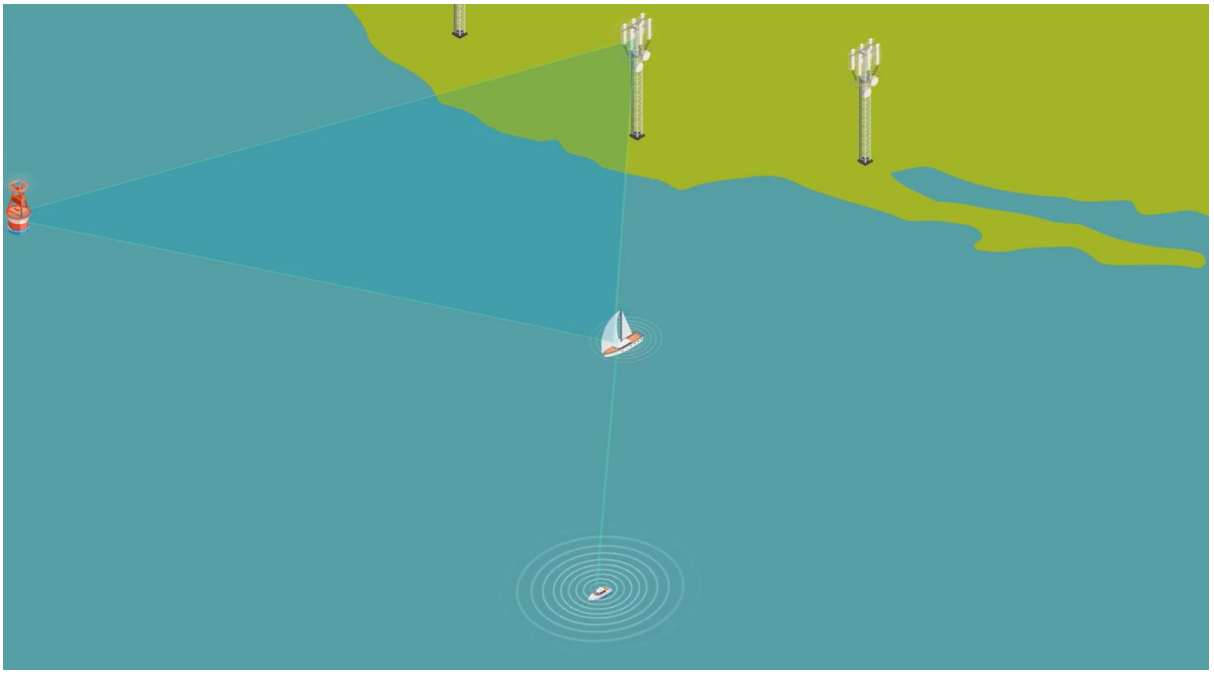
Originally conceptualized as an autonomous buoy network, Penguinfy became an adaptive node that can be deployed on the following environments: embarcations, oil rigs, remote islands, offshore buoys and traveling buoys manufactured with recycled components.

The utilization of solar cells make the Penguinfy nodes completely independent of the selected environment, if needed.

With the addition of modular sensors, the Penguinfy nodes will recollect a vast amount of data that, with the aid of Nasa data sets, will provide accurate information about weather, currents, contamination, ph Levels, Oxigen and potential hazards, all valuable data that will be used by the users utilizing the Penguinfy service.

Taking in consideration the system's environmental impact, Penguinfy aims to utilize recycled materials for the node's case and the traveling buoy module, which has its own recovery protocol for repurposing of defective equipment.

1.0 - The Penguinfy Node



1.1 - Designing the Penguinfy Node

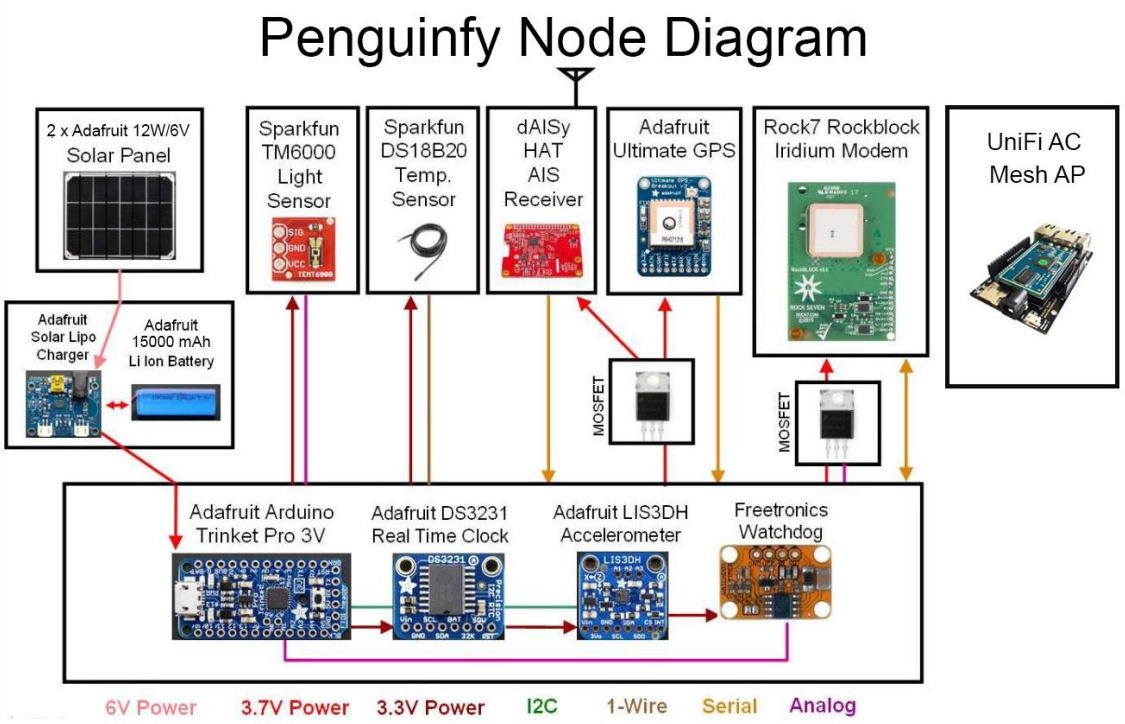
For the design of the Penguinfy node, we utilized economic mainstream technology and long range mesh network architectures. Penguinfy will provide schematics freely for all the maritime environment.

The material suggested to manufacture a Penguinfy node housing is **HDPE** High Density Polyethylene

Properties: Stiffness, strength, toughness, resistance to chemicals and moisture, permeability to gas, ease of processing, and ease of forming.

1.2 - Components and schematics

Proposal of the Penguinfy node hardware



2x Adafruit Solar Panel 6V/2W (Energy) cost 30 usd
Size: 4.4" x 5.4" / 110mm x 140mm
Weight: 3 ounces / 90 grams
Cell type: Monocrystalline
Cell efficiency: 19%+
2.27 Watts Peak Power
USB / DC / Solar Lithium Ion/Polymer charger - v2 Cost 15 usd
3.7V/4.2V Lithium Ion or Lithium Polymer battery charger
Charge with 5-6V DC, USB or 6V solar panel
Automatic charging current tracking for high efficiency use of any wattage solar panel
Use any 6V solar panel (6V seems to work best, 5.5V may work, 5V does not work)
Three color indicator LEDs - Power good, Charging and Done

Memory adafruit 5000mah cost 25 usd
5000mAh lithium ion battery, a charging circuit

Adafruit PiRTC - Precise DS3231 Real Time Clock cost 15 usd

Product Dimensions: 21.3mm x 20.0mm x 13.6mm / 0.8" x 0.8" x 0.5"
Product Weight: 2.7g / 0.1oz

HDD 1 Tera Solid State cost 130 usd

Sparkfun TM6000 (Light Sensor) cost 12 usd
Adapted to human eye responsivity
Wide angle of half sensitivity ϕ = ± 60°
SMD style package on PCB technology
Suitable for IR reflow soldering

Sparkfun DS18B20 (Temperature Sensor) cost 5 usd
Unique 1-Wire interface requires only one port pin for communication
Multidrop capability simplifies distributed temperature sensing applications
Requires no external components
Can be powered from data line.
Power supply range is 3.0V to 5.5V
Zero standby power required
Measures temperatures from -55°C to +125°C. Fahrenheit equivalent is -67°F to +257°F
±0.5°C accuracy from -10°C to +85°C

dAISy AIS Receivers (connection antenna) cost 65 usd
The circuit board of the dAISy AIS Receiver exposes several signals on an unpopulated 0.1” header. Advanced users can use these pads to connect the auxiliary serial port of dAISy with other devices like for example WiFi and Bluetooth modules

Adafruit ultimate GPS (GPS info) cost 40
Satellites: 22 tracking, 66 searching
Patch Antenna Size: 15mm x 15mm x 4mm
Update rate: 1 to 10 Hz
Position Accuracy: < 3 meters (all GPS technology has about 3m accuracy)
Velocity Accuracy: 0.1 meters/s
Warm/cold start: 34 seconds
Acquisition sensitivity: -145 dBm
Tracking sensitivity: -165 dBm
Maximum Velocity: 515m/s

Rock7 iridium modem (modem Satelital) cost 230 USD mensual 90 usd 500 credits. 1 credit = 50 bytes
Plug and play satellite communication
Available as a PCB or encapsulated product
• Full 2-way communication system
• Integrated antenna and power conditioning
• Optional external antenna connector (Naked only)
• Truly global operation, using the Iridium
satellite network

• Data arrives via e-mail, or directly to your
own web-service

Adafruit LIS3DH Triple-Axis Accelerometer cost 25 usd
Wide supply voltage, 1.71 V to 3.6 V
Independent IOs supply (1.8 V) and supply voltage compatible
Ultra low-power mode consumption down to 2 µA
±2g/±4g/±8g/±16g dynamically selectable full scale
I 2C/SPI digital output interface
16 bit data output
2 independent programmable interrupt generators for free-fall and motion detection
6D/4D orientation detection
Free-fall detection
Motion detection
Embedded temperature sensor
Embedded self-test
Embedded 96 levels of 16 bit data output FIFO
10000 g high shock survivability
ECOPACK® RoHS and “Green” compliant

Watchdog Timer cost 10 usd
Watches for microcontroller activity
Resets your project if it locks up or stops responding
5 minute (default) or 1 minute timeout interval
Green LED to show heartbeat activity
Red LED to show watchdog timeout
Dimensions 22mm x 15mm x 4mm
0.84mA continuous current draw at 3.3V supply
1.75mA continuous current draw at 5V supply

Wifi Modem cost 90 usd
UniFi AC Mesh AP cost 100 usd
Nano Station M5
Dimensions 164 x 72 x 199 mm (6.46 x 2.83 x 7.83")
Weight 900 g (1.98 lbs)
Power Supply (PoE) 24V, 0.5A Max.
Power Consumption 6.5W
Power Method Passive PoE (Pairs 4, 5+; 7, 8 Return)
Operating Frequency 902-928 MHz Gain 8 dBi
Networking Interface (1) 10/100
Ethernet Port Processor Specs Atheros MIPS 24Kc, 400 MHz
Memory 64 MB SDRAM, 8 MB Flash Frequency 900 MHz Cross-pol Isolation 28 dB
Minimum Max. VSWR 1.3:1 Beamwidth 60° (H-pol) / 60° (V-pol) / 60° (Elevation)
Polarization
Dual Linear Enclosure Outdoor UV Stabilized Plastic Mounting Pole-Mount (Kit Included)

Penguinfy equipment concept

1.3 - Penguinfy adaptability and deployment modes

The penguinfy node can be adapted into the following environments:

1.3.2 - Stationary node

Nodes established in current embarcations, drones, submarines, airships, buoys, oil rigs, offshore island, and static landmarks.

1.3.3 - Traveling buoy node

Nodes installed in low cost drifting buoys that navigate using oceanic currents.

1.3.3.1 - Reciclable concept

Penguinfy will provide blueprints that will take advantage of disposed plastic material available worldwide.

1.3.3.2 - Defective buoy recovery protocol and re purposing

Using NASA datasets and available data on oceanic current, aided with the geo localization of the nodes, Penguinfy will provide enough information to generate an efficient recollection protocol for drifting buoys, for repairs and re deployment.

1.4 - Cost comparison

2.0 - Intranet and Internet mesh network

Penguinfy will provide access to an intranet on a mesh network with disruption tolerant network architecture. Internet service will be provided by ad-hoc link shared by Penguinfy nodes with access to satellite internet services.

2.1 - Penguinfy Internet Nodes

2.2.1 - Penguinfy provided nodes

Penguinfy will set a number of nodes on it's different deployment environments with Satellite Internet equipment, to provide a paid ad-hoc internet connection with Penguinfy users. Penguinfy will aim to achieve partnerships with satellite internet and land service providers to lower access costs.

Increasing the number of coastal and offshore nodes, the Penguinfy system will become less dependant of satellite connection, lowering the cost of internet access on offshore environment as the users adopt the system.

2.2.2 - Penguinfy Users with Satellite equipment

Users with Satellite equipment can choose to use Penguinfy to provide Internet through and ad-hoc connection to other Penguinfy users on the reach of their current mesh network. This is a commercial opportunity for such users, as they can generate revenue for the ad-hoc service, and even if the access costs may vary it still lowers the access price to Satellite Internet Services, by using a cheaper equipment to achieve the Satellital link.

2.2 - The Mesh Network

The system will be based on a mesh network built following the LoRaWAN protocol. This protocol enables slow speed data transmission with a long range and low power consumption. The mesh network is designed to function as the backbone that will support the other parts of the sensors' net.

We chose a mesh network for two fundamental reasons. First, a mesh network may be dynamically reconfigured. This enables the network to continue working even if one of the transceivers crashes, with almost no downtime. Second, a mesh network is scalable. It requires low setup costs and allows for easy expansion and servicing.

The power of the transceivers should be around 35 dBm to ensure sufficient coverage.

The Penguinfy Node's antenna will be connected to a transceiver unit that will encode the data into TCP/IP protocol. This unit will send packets to a redundant storage system which will ensure that the information is safely stored and backed up. This information may be used in research experiments, providing extremely valuable input.

3.0 - The Penguinfy software

Penguinfy will have the Penguinfy control program for the nodes, a backend software that allows the system's administrators to manage the penguinfy nodes and a mobile app for the Penguinfy users.

3.1 - Penguinfy node's software

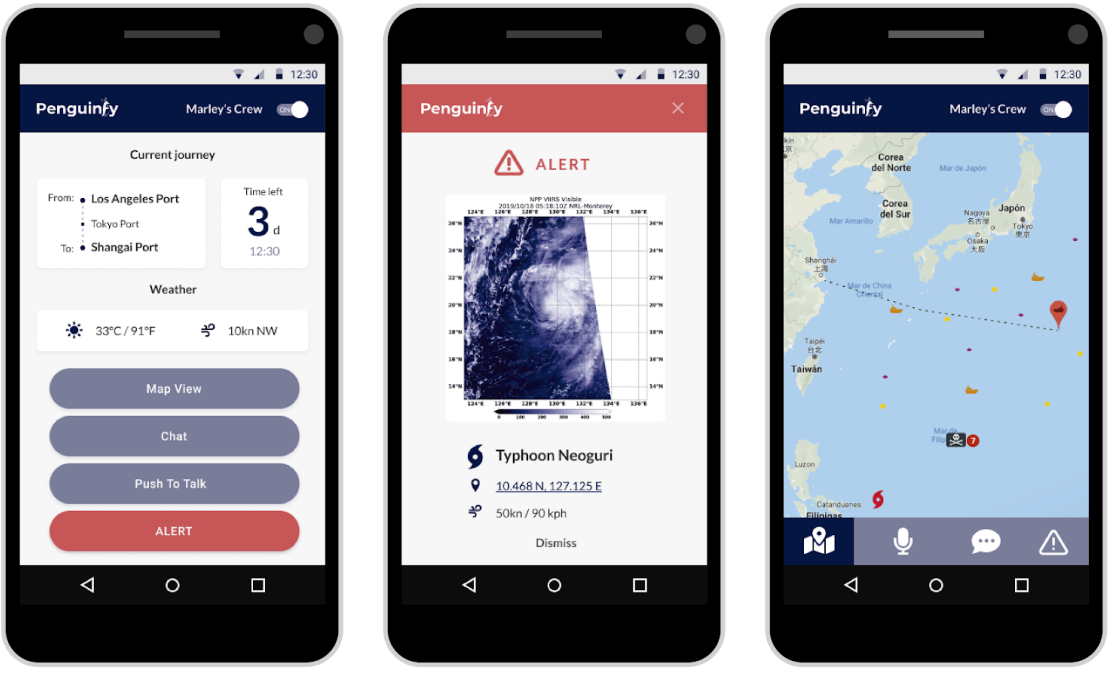
Software that manages all the Penguinfy node components creating the mesh network, provides node data, status, and serves as a bridge for Satellite Internet equipment for ad-hoc connections on the Penguinfy network.

3.2 - Backend

The software that will be used by the Penguinfy system administrators to oversee the status and locations of all the Penguinfy nodes, it will also provide access to all the data captured by the Penguinfy node sensors, and manage the transaction of Duffle Coins.

3.3 - The Penguinfy App

This app allows its users to manage its Penguinfy node granting access to the system and all the services provided by it.



3.4 - Penguinfy Services

3.4.1 - Free services

Penguinfy will provide the following free services: text and push to talk communication between Penguinfy nodes, weather and navigational data gathered by the system's sensors and the Nasa datasets, and hazard alerts between the Penguinfy users.

3.4.2 - Paid services

Users of the Penguinfy system can purchase the Penguinfy Duffle Coins, the system's currency, to gain access to internet services provided by properly equipped Penguinfy nodes on the mesh.

Every Duffle Coint = 1MB, you gain 0.02 coin re-transmitting

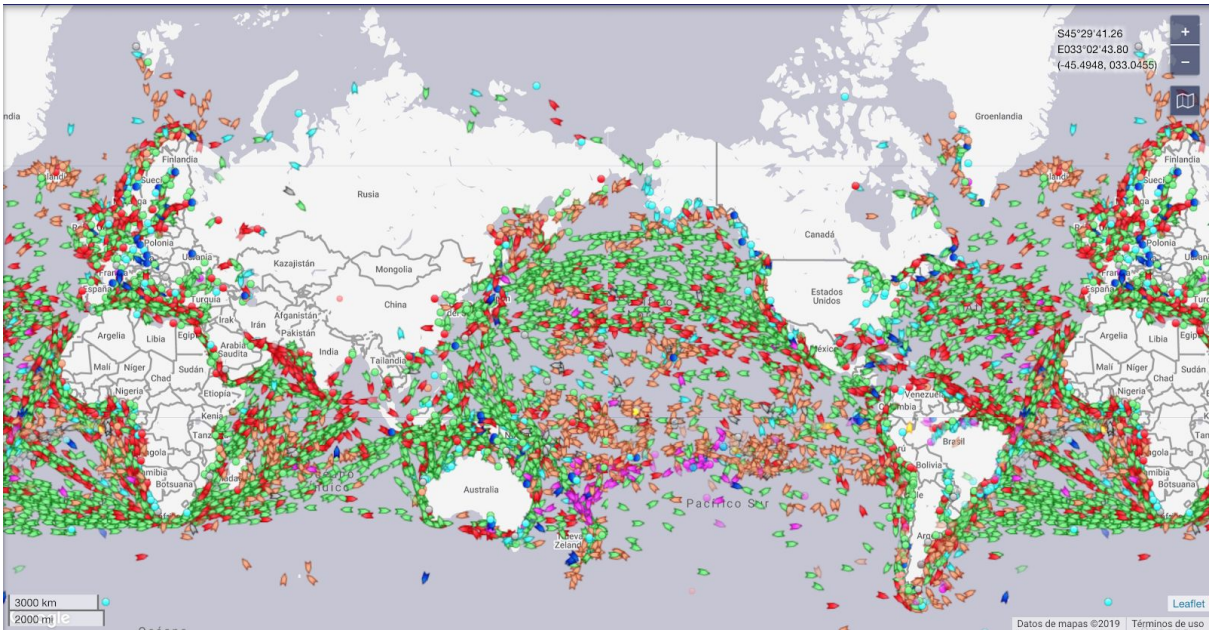
4.0 - Use of NASA datasets

All the weather and navigational data provided by NASA and other open sources will be used to enhance the reports generated by the info captured by the Penguinfy node sensors, providing valuable data for the Penguinfy Users

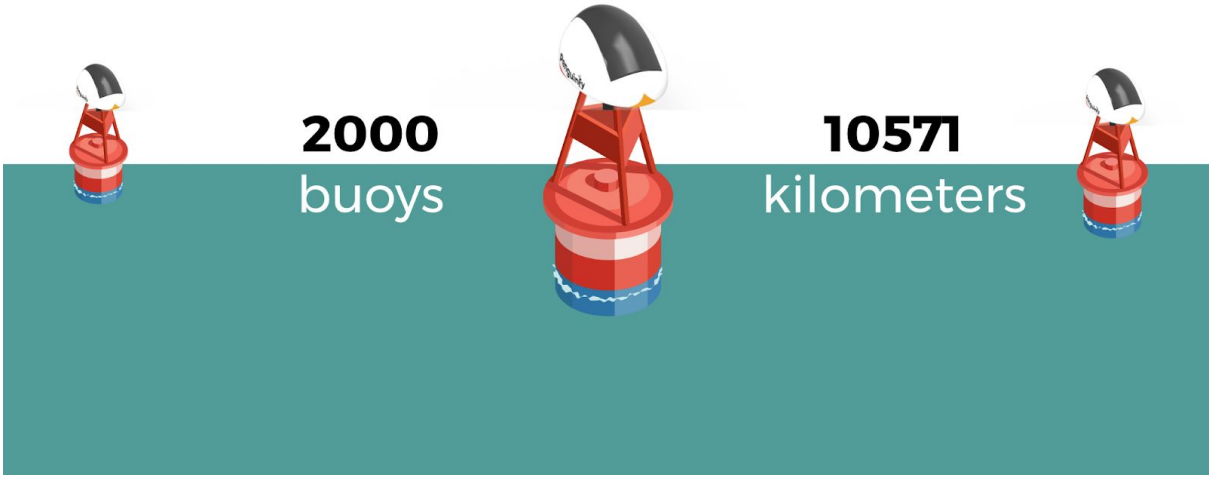
5.0 - Case study: The Los Angeles - Shanghai maritime route

We chose to analyze the implementation of Penguinfy on the Los Angeles - Shanghai maritime route. It is the most transited route in the world; it covers the Pacific Ocean with a traffic of more than 20,000 ships per year on a distance of 10,574 km between the two ports.

Also, there is a vast number of maritime offshore buoys and other fixed locations that will provide an adequate environment to deploy the Penguinfy system.



https://www.marinetraffic.com/en/ais/home/centerx:138.0/centery:35.7/zoom:2



5.1 - Needed nodes and algorithm

Using the following formula we estimated that approximately 2000 Penguinfy nodes are needed to cover the Los Angeles - Shanghai route with the full efficiency of the system.

*(distance / AP range) * 5*

6.0 - In conclusion

The Penguinfy system is set by existing technology used in a creative way, that allows its users a low cost internet access on an offshore environment thanks to the accessible hardware powering the Penguinfy nodes.

Even without the possibility of internet access, Penguinfy still provides valuable services to all its users with the creation of its own intranet and free services.

Every single node added to the Penguinfy network will increase the service reach and improve the quality of its signal. Our goal is to have enough Penguinfy nodes on the system in order to lessen the need for Satellite internet connection equipment, expanding the reach of the mesh through far offshore environments.

The possibility of such an accessible communication and internet system is the motif and dream fueling the Penguinfy team.

7.0 - Penguinfy Sources

- Adafruit Solar Panel
  https://github.com/VoltaicEngineering/Solar-Panel-Drawings/blob/master/Voltaic%20Systems%202W%206V%20112x136mm%20DRAWING%20CURRENT%202017%207%2020.pdf
- Temt6000
  https://www.sparkfun.com/datasheets/Sensors/Imaging/TEMT6000.pdf
- DS1820
  https://cdn.sparkfun.com/datasheets/Sensors/Temp/DS18B20.pdf
- Daysi AIS receiver
  https://wegmatt.com/
- Adafruit ultimate GPS
  https://www.adafruit.com/product/746
- Polymer Charger
  https://learn.adafruit.com/usb-dc-and-solar-lipoly-charger/using-the-charger?view=all#downloads
- adafruit memory
  https://www.adafruit.com/product/1565
- Adafruit PiRTC - Precise DS323
  https://www.adafruit.com/product/4282
- Adafruit LIS3DH
  https://cdn-shop.adafruit.com/datasheets/LIS3DH.pdf

- Watchdog
  https://www.freetronics.com.au/products/watchdog-timer-module#.XauM1uhKiMo
- Nano Statio m5
  https://dl.ubnt.com/datasheets/nanostationm/nsm_ds_web.pdf
- HDD 1TB
- Nasa datasets
  https://pmm.nasa.gov/data-access/downloads
- Ocean Life Detection on Alien Worlds
  https://techport.nasa.gov/view/93681

8.0 - Penguinfy Github repository

https://github.com/lucascog/penguinfy

9.0 - The Penguinfy team

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