SeaNet

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Chapter 1

Introduction

1.1 Why We Need Another Way to Connect

All the communication across the oceans are carried by expensive satellite links that can provide only low speed connections. Furthermore not all the globe is covered by this technology. We need to find an alternative to connect people who lives or works on remote islands, ships and oil platforms.

1.2 Our Idea

Our team chose to work on the Internet in the ocean challenge. We worked on a solution that does not imply the use of satellite link. The main idea is to use drones to carry radio equipment upon ships so that they can connect to each other and create a mesh network. Ground stations will act as internet gateways, providing high speed connectivity to the mesh.

1.3 Scenario

Since we need to cover many type of locations we need to adapt the technology to various scenarios.

1.3.1 Cargo, Oil and Big Cruise Ships

This kind of ships can carry heavier payloads and have the capability to provide the energy required for powering the equipment. Our idea was to carry on these type of ships the drone-based technology that allows long distance/line of sight radio link.

1.3.2 Oil Platform and Islands

Ground stations will be placed on the shore and will be directly connected to the mesh network.

1.3.3 Small ships

Small ships are not capable of providing the required energy and storage space to carry the full drone equipment, so they will only carry the antennas and connect to very close other small ships (25.5km max) or mid distance big ones (79,8km max).

Figure 1.1: Network Overview

Chapter 2

Equipment

2.1 Introduction

The main problem of high speed link is that they need line of sight for optimal transmission. Since the earth is spherical and ships cruise on average at 100 kilometers of distance one from another [Fig. 2.3], this represents a big problem. We need to raise the antennas to a location where our equipment can operate, that's why we chose to use drones to carry it at 500 meters height. At that height the line of sight is of about 150 kilometers (2.1), enough for our aim. Each drone is equipped with at least two antenna systems.

$$LineOfSight = 3.57 * (\sqrt{(h1)} + \sqrt{(h2)}) \tag{2.1}$$

2.2 Drone

The chosen model of drone is the Griff Aviation Sherpa. That drone can carry up to 75 Kg of payload, more than enough to elevate the entire system. The drone is capable to fly at over 1000 meters of height with adverse weather conditions and a cruise speed of 50km/h. A cable is directly connected with the ship for power supply and data connection. On adverse weather conditions the drone will be able to land on a specific docking station on board of the ship. The drones will be piloted by automatic guidance systems based on GPS location.

One of the limitations is the drone's relative speed to the air. This speed is the vectorial sum of the velocity of the wind and the ship velocity. If the wind direction is the opposite to the ship's one the relative cruise velocity of the drone reduces. Sailing headwind may prevent the drone to fly and it may be necessary to recall it. On the other hand if the wind is blowing from behind it allows the drone to gain height resulting in a wider transmission and reception range, helpful to the ship itself and to others. This "wind exploiting" solution could help reduce and regulate the torque on rotor blades extending the drone's lifespan and re usability.

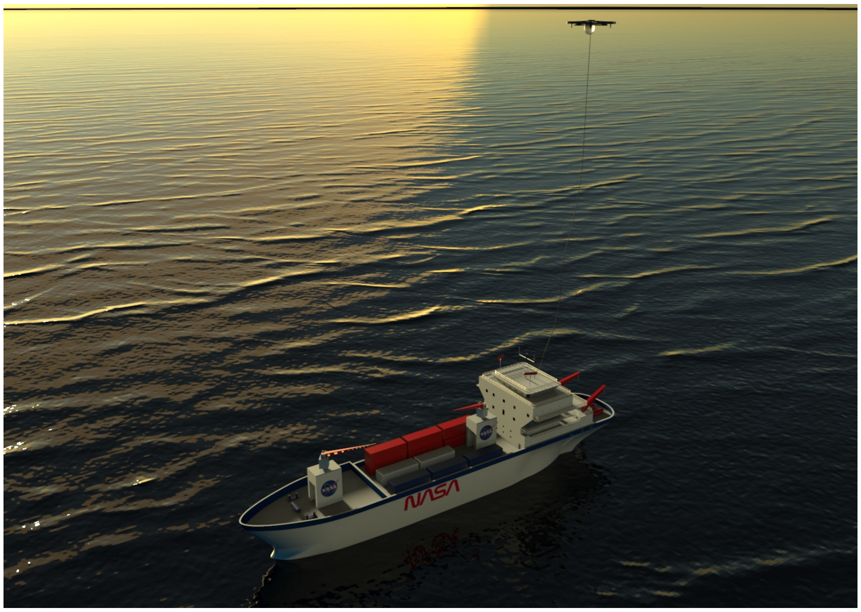

Figure 2.1: Big Ship Setup Overview

2.3 Network Equipment

2.3.1 Radio Equipment

The link is established over high capacity 5GHz microwave radio channels on line of sight. We choose the AirFiber 5XHD controller equipped with 23 dBi antennas [Fig. 2.2].

2.3.2 Antennas Orienting System

Since the radio link needs to be aligned on a straight line of sight, an automatic alignment system is needed. The idea is to put antennas on a gimbal system with 3 degree of freedom in order to change its pitch yaw. The automatic alignment procedure will first use the GPS coordinates of the peers to calculate the relative heading and then make precise and continuously adjustment by exploiting two laser pointer each collocated on-board the drones. The system will be able to automatically tracking of drones position changes and auto adjust the antennas accordingly.

Figure 2.2: Antennas Equipment

Latitude	Longitude	Link distance
43,70	-18,25	90,25361908
43,60	-21,60	65,78796017
43,50	-19,34	113,2294499
42,40	-22,61	77,49717098
43,08	-22,79	59,84313802
43,60	-23,00	112,732598
43,20	-21,00	56,68846422
45,04	-20,94	56,68846422
45,54	-20,76	116,8754374
46,94	-21,70	19,82085664
44,93	-23,53	154,1874785
44,70	-16,80	71,1357516
44,71	-15,90	98,54980609
45,35	-19,29	73,33791191
46,00	-19,13	79,91443796
45,82	-18,13	35,92200565
45,67	-17,72	135,1239847
46,03	-16,15	126,7996948
46,85	-17,30	135,1239847
47,53	-16,98	79,38470857
46,85	-19,95	50,89793547
47,17	-20,43	103,9213706
47,10	-21,80	19,82085664
42,65	-20,10	113,2294499
44,10	-16,80	124,3972796

Distances parameters	
Average	86,84655262
Maximum	154,1874785
Minimum	19,82085664

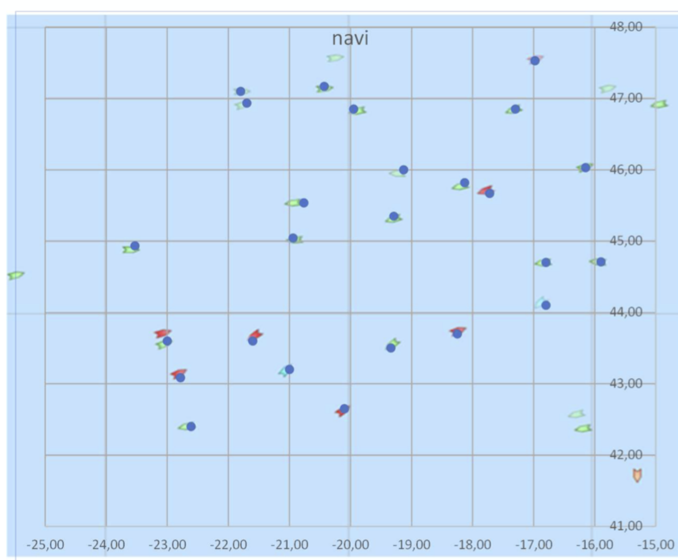

Figure 2.3: Example of ship position and relative distance

2.3.3 Total Payload

The table [Tab. 2.3.3] report the payload distribution to be carried by the drone for a total of 35 kg.

EQUIPMENT	PAYLOAD	QUANTITY
Antenna Controller	0.35 Kg	3
Antenna	3,4 Kg	3
Gimball and Laser	2,4 Kg	3
Cable	16,8 Kg	500 mt

Table 2.1: Payload Distributions

Chapter 3

Network

3.1 Topology

The network works at the layer two of the OSI model in a custom mesh mode: this allow compatibility with the existing IP infrastructures as well as handover without connection lost, since stations always keep the same IP address. The network edge, collocated in the ground stations, acts as a gateway to the internet. The main purpose is to keep the network as much decentralized as possible. Each ship will be equipped with at least two network systems that will allow the creation of a radio link with peers that could be other ships or ground stations to deliver internet to the remote location.

3.2 Layer 2 Scenario

MAC Layer is in charge of managing the mesh network routing in a completely transparent way for upper layer. The main L2 scenario are detailed described in this section.

3.2.1 Normal Operations

Network operations are based on existing mesh technologies. Each Ship-Station has at least two directional antennas to connect to other peers. Each station represents a node of the mesh network with its own MAC level address [Fig. 3.1]. Routing between ships is done using Ad-Hoc network protocol with distributed routing tables.

3.2.2 Network Discovery and Join

A Ship willing to join the network [Fig. 3.2]:

- Broadcast on shortwave packet radio (AX25) its GPS position.

- Other network members in range for the high capacity radio link catch the signal and reply back with their GPS coordinates and its network identification address.
- The ship replies back on shortwave with an ACK message that contains the nearest station address.
- Both peers start the alignment procedure for the antennas, based on the relative coordinates and the angle calculation, then using their laser system.

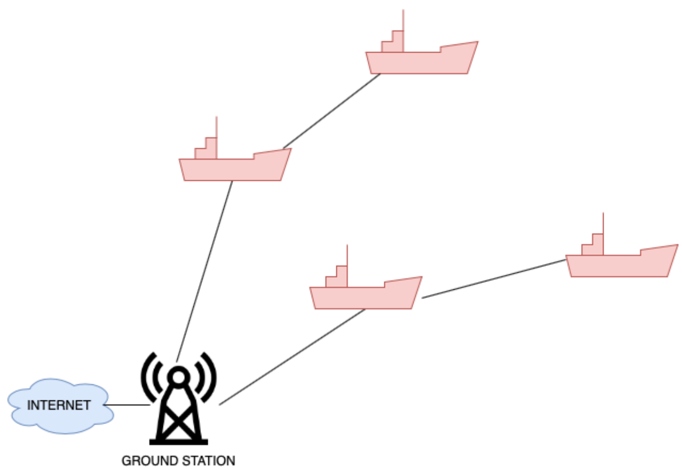

Figure 3.1: Mesh network

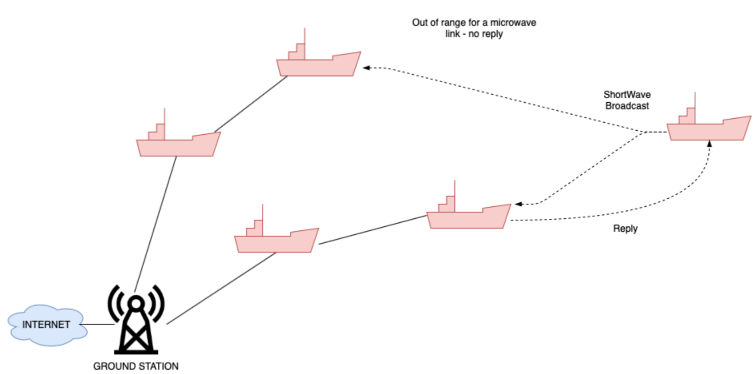

Figure 3.2: Mesh network discovery process

3.2.3 Handover

When a ship link becomes unstable for the increasing distance, it uses the secondary antenna to establish a new link with another ship [Fig. 3.3]. Since it's already connected to the network, it does not need to repeat the shortwave procedure.

- The ship sends a handover request packet to the network with its own GPS coordinates as well as its heading. The request is flooded across the network.
- Each station that receives the request compares its coordinates with the ship's one. If the distance is compatible with the maximum allowed link distance, the station replies back with its address.
- The ships send back an ACK message.
- Both peers start the antenna alignment procedure.
- The network is informed of the topology change and updates the routing table.
- The old link is closed. Note that keeping two simultaneous links avoid packet loss during the handover without the need of buffering and forwarding the arriving frames to the new peer.

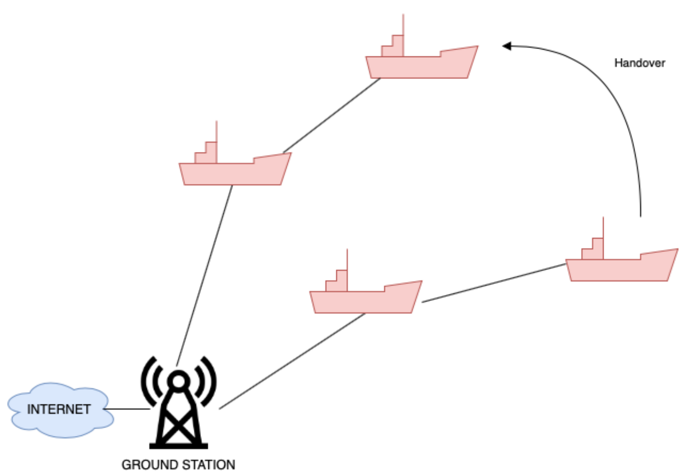

Figure 3.3: Handover

3.3 Physical Layer

Physical layer relies on commercial off-the-shelf products that exploits microwave link technology for high capacity radio bridge, see Equipment chapter.