Satellite Ocean Tracking Currents for Marine Searching and Rescue
Aekjira Kuyyakanont & Phongsakorn Meemak
Kyushu Institute of Technology
The five oceans are:

- Atlantic Ocean
- Pacific Ocean
- Arctic Ocean
- Southern Ocean
- Indian Ocean

71% of the Earth is ocean.
What is Ocean Currents?

Why is it important to observe the ocean currents?

Marine accident: Ship sinking
Aircraft accident: Aircraft Crash
Marine accident: Oil/Chemical Spill
Objectives

❖ Primary Objectives
• To predict ship/airplane positions in the ocean in emergency situation
• To analyze oil/chemical spill movement direction.

❖ Secondary Objective
• To monitor the ocean current changing for the Earth’s climate
Key Performance Parameters

- To acquire the Sea Surface Temperature (SST) using infrared camera
- To update the data every hour

### How hypothermia affects most adults

<table>
<thead>
<tr>
<th>Water Temperature (Fahrenheit)</th>
<th>Exhaustion or Unconsciousness</th>
<th>Expected Time of Survival</th>
</tr>
</thead>
<tbody>
<tr>
<td>32.5 degrees</td>
<td>Under 15 minutes</td>
<td>Under 15 to 45 minutes</td>
</tr>
<tr>
<td>32.5 to 40 degrees</td>
<td>15 to 30 minutes</td>
<td>30 to 90 minutes</td>
</tr>
<tr>
<td>40 to 50 degrees</td>
<td>30 to 60 minutes</td>
<td>1 to 3 hours</td>
</tr>
<tr>
<td>50 to 60 degrees</td>
<td>1 to 2 hours</td>
<td>1 to 6 hours</td>
</tr>
<tr>
<td>60 to 70 degrees</td>
<td>2 to 7 hours</td>
<td>2 to 4 hours</td>
</tr>
<tr>
<td>70 to 80 degrees</td>
<td>2 to 12 hours</td>
<td>3 hours to indefinite</td>
</tr>
<tr>
<td>Over 80 degrees</td>
<td>Indefinite</td>
<td>Indefinite</td>
</tr>
</tbody>
</table>
Attitude Determination and Control System

- Three Reaction Wheels
- Three Magnetic Torquers
- Power Consumption: < 4.5W
- Maximum Torque: 1.4 mNm
- 1° 3-axis-pointing accuracy

Imaging Payloads

- Long-Wave Infrared Camera
  - Spectral Range: 8-14 um
  - Array Size: 640x480 pixels
  - Pixel Pitch: 17 um
  - Power Consumption < 3.6W
  - Focal Length: 50mm
- Mid-Wave Infrared Camera
  - Spectral Range: 3.7-4.8 um
  - Array Size: 640x512 pixels
  - Pixel Pitch: 15 um
  - Power Consumption < 8.4W
  - Focal Length: 19-275mm

Structure

- Dimension: 100mm x 100mm x 340.5mm
- Mass: 390 g
- Interfaces: All standard deployment PODs

Command and Data Handling

- Power Consumption < 1W
- 32-bit Microcontroller
- 4 GB flash memory for data

Imaging data: 2000 images

Communication System

- S-Band
  - Power Consumption: < 5 W
  - Transmission data rates up to 2 Mbps.
- UHF/VHF
  - UHF Downlink, VHF uplink

Electrical Power System

- The power from solar cell ~20 W
- The nominal output voltages are 3.3V, 5V, 12V
- Lithium-ion batteries, 3900mAhr, nominal voltage 8.4V
- Batteries protection and current limiter

Source: Clyde Space
Ground Resolution

**Mid-Wave Infrared Camera**

**Orbital Parameter**
- Altitude: 550 km
- Inclination: 98°

**Ground Resolution**
- 492 m²

**Image size**
- 314.8km x 251.9km at nadir pointing
Concept of system operation

- LWIR operation
- MWIR operation

LWIR will operate during day side
MWIR will operate during night side
Satellite infrared radiometers for SST

MODIS sensor

AVHRR sensor

Envisat Satellite
Broad swath (~ 500km)
~1km² resolution

Suomi NPP Satellite
Broad swath (> 3000km)
~0.75km² resolution

NOAA19 Satellite
Broad swath (> 3000km)
~1km² resolution

VIIRS sensor

ATSR sensor
Bird Ground Station Network

- Japan
- Ghana
- Nigeria
- Bangladesh
- Mongolia
- Taiwan
- Thailand
- Bhutan
- Philippine
- Malaysia
Orbit/Constellation Description

Global Positioning System Constellation
- 24 satellite GPS constellation
- Six orbit planes
- 55° inclination
- 60° right ascending node of each orbit

Drifter Buoys Data:

- Sea Surface Temperature
- Air pressure
- Wind
- Salinity
- Subsurface Temperature
Cruise Weather Ships

Wind Velocity
Wave Height
Sea Surface Temperature

Source: www.livecruiseshiptracker.com
Concept of Operation
How to predict the object direction?

Oil rig explosion

Source: CNN

Source: Dailymail
How to predict the object direction?
Implementation Plan

The estimated cost for S-band Ground station is ~50k USD per ground station.
The estimated cost for design phase is 1.33M USD and launch phase is 3.6 M USD.

Organization and Management

Implementation Plan

- Kyutech
- BBM System Design
- Preliminary
- EM System
- Space Environment
- Critical Design
- Flight Model Fabrication
- Space Environment testing, PM integration
- Launch & Integration
- Thermal Vacuum Chamber
- Vibration Machine
- Clean Room
- Source: cent.ele.kyutech.ac.jp

Bird Ground Station Network

Source: cent.ele.kyutech.ac.jp
Thank you for your attention

Question?
Appendix
Sea Surface Temperature Algorithm

- The form of the daytime and night-time algorithm for measurements in the long wave atmospheric window is:

\[ \text{SST} = c_1 + c_2 \times T_{11} + c_3 \times (T_{11}-T_{12}) \times T_{\text{sfc}} + c_4 \times (\sec(\theta)-1) \times (T_{11}-T_{12}) \]

where \( T_{11} \) are brightness temperatures measured in the channels at n mm wavelength, \( T_{\text{sfc}} \) is a ‘climatological’ estimate of the SST in the area, and \( \theta \) is the satellite zenith angle.

- The MODIS night-time algorithm, using two bands in the 4mm atmospheric window is:

\[ \text{SST4} = c_1 + c_2 \times T_{3.9} + c_3 \times (T_{3.9}-T_{4.0}) + c_4 \times (\sec(\theta)-1) \]

Note, the coefficients in each expression are different. They can be derived in three ways:

- empirically by regression against SST values derived from another validated satellite instrument
- empirically by regression against SST values derived surface measurements from ships and buoys
- theoretically by numerical simulations of the infrared radiative transfer through the atmosphere

Source: Satellite Oceanography: Sea-Surface Temperature and Climate Data Records
Peter J Minnett Rosenstiel School of Marine and Atmospheric Science, University of Miami, USA