Whale Ecology Observation Satellite (Kanta-kun) System

Following description on ***Whale Ecology Observation Satellite (WEOS)*** *was provided by* ***Prof. T.Hayashi, Messrs. K.Yokoyama and S.Hosokawa of Chiba Institute of Technology*** *who have developed and are operating the WEOS system very successfully .*

We launched Whale Ecology Observation Satellite (WEOS, Kanta-kun) on Dec. 14, 2002 by H2-A rocket of NASDA as one of the piggyback payloads into a polar orbit. Ecological data of whales are sent from probes attached to whales on the ocean to this satellite, which collects those data, stores in an onboard memory, and sends back at a command to a ground station.

By adoption of appropriate design and consumers' electronics parts, we manufactured the WEOS and associated system with high cost effectiveness for the development.

System Description

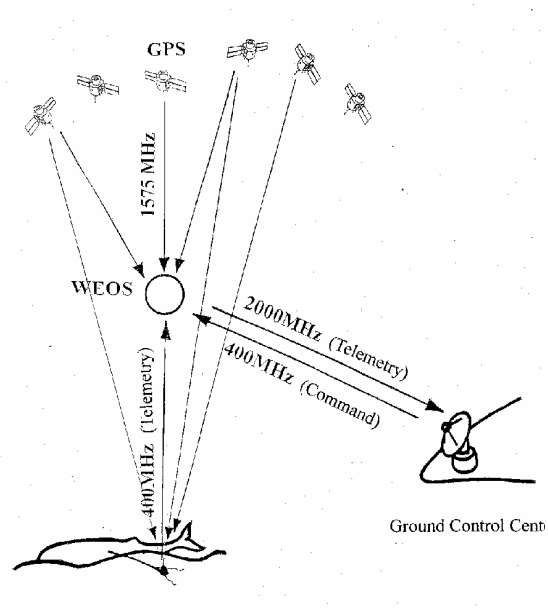

Fig. 1 Communications System

Figure 1 shows the communications system of the WEOS. The WEOS rotates around the earth on a polar orbit of 800 km high. We attach probes to many whales in various oceanic regions, which include sensors of pressure, temperature, sound etc for diving phase, and a memory unit to store the sensor data, and a GPS receiver to define the position in the surface phase for breathing. At the timing, the satellite (WEOS) receives 400 MHz wave from the probe, in which the data of latitude, longitude, and that stored in the memory together with the identification code are included.

A dynamo driven by the motion of a whale generates the electric power, which supplies to the instruments of the probe through secondary batteries.

The WEOS receives the 400 MHz wave with a PLL receiver and store the data in an onboard memory. A GPS receiver installed on the WEOS determines the own position on the orbit. In case a whale surfaces too short time period to lock the GPS receiver of the probe, the Doppler shift of the up-link precisely obtained in the PLL receiver and

several position data on the orbit sent by S-band down link telemetry allow to obtain the position of the probe through inversion analysis. When the WEOS passes over the ground control station at the Chiba Institute of Technology, it sends out a command signal to the satellite in 400 MHz, and receives the telemetry signal from the WEOS in S-band. We deliver the data retrieved at the station to relevant organizations for detailed analysis.

Brief Description of the WEOS

Table 1 shows the main parameters of the WEOS.

Table 1. Main Parameters of the WEOS

Size	Cubic: 520mmx520mmx500mm
Weight	47 kg
Attitude Stabilization	Gravity Gradient by means of a Mast of 3m long
Launch Vehicle	H2A-4, as one of the piggy-back payloads
Launch Date	Dec. 14, 2002
Orbit	Sun Synchronous
Altitude	800 km, Circular
Inclination	98.6 deg
Period	101 min
Communications	
Frequencies	S Band (Down Link Telemetry)
	UHF Band (Up Link Command)
	UHF Band (Up Link Telemetry)
Modulation	PCM-Conv. SS-BPSK (S Band)
	PCM (Bi φ)-FSK (UHF Band)
	PCM-Conv.-BPSK (UHF Band)
Antennas	Cross Dipole (S Band)
	Sleeve Dipole (UHF Band)
Power System	
Solar Cell Panel	Si-Single Crystal, Average Power 14.5 W
Secondary Batteries	Ni-Cd, 4 Ah

Figure 2 shows the configuration of the WEOS.

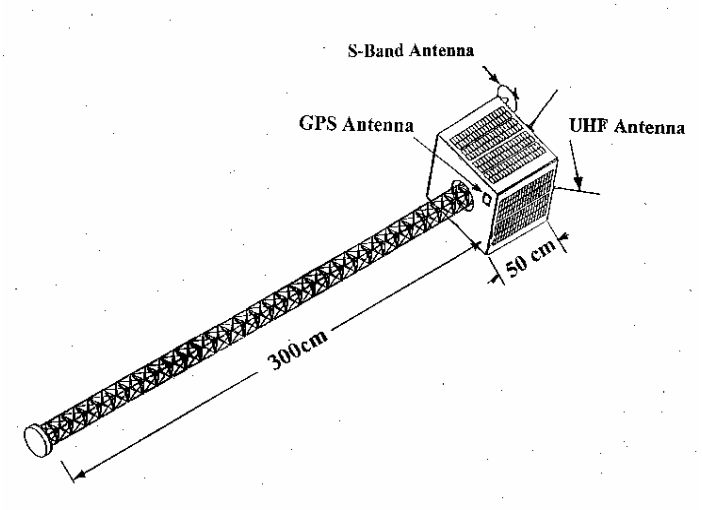

Fig. 2 Configuration of the WEOS (After the deployment of the mast)

The WEOS is composed of following subsystems:

* ***Power System***: Si Solar Cells, Ni-Cd Batteries, Charge Control Unit, and Stabilizing Converters
* ***Data Processing System***: Unified Control System with a CPU for controlling onboard instruments and attitude, decoding of command signal, collection and storage of ecological data ,housekeeping data and GPS data, formatting and coding of telemetry data, and the transmission.
* ***Demodulation System of Whale Ecological Data***: A DSP unit demodulates the susceptible signal from the probe. By using convolution code, link margin is improved.
* ***Communications System***: Consists of a UHF receiver for processing command signal and ecological data with a common hardware, and an S-Band transmitter for sending out collected and stored data in BPSK modulation and in spread spectrum system to the ground station.
* ***Onboard GPS receiver***: For positioning and timing of the WEOS.
* ***Hinge-less Mast of 3m Long***: For attitude stabilization by gravity gradient torque to keep pointing the antennas to the earth's surface.
* ***Magnetic torquer coil and 3-axis flux-gate magnetometer***: For attitude acquisition and control.
* ***Radiation Monitor***: A RAM for monitoring single event upset occurred on the orbit

Figure 3 shows the outlook of the WEOS.

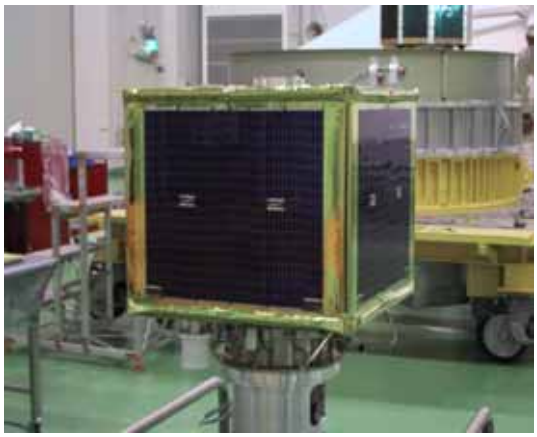

Fig.3 Picture of the WEOS

Operation of the WEOS on the Orbit

The performance of the WEOS is quite satisfactory on the orbit.

By controlling the current in the torquer coil rotation rate of 0.3 rpm acquired at the separation from the vehicle decreased to the rotation rate of 0.05 rpm in around one month after the launch. Because of the deployment of a three- meter mast with the top weight of 3kg, the WEOS established the gravity gradient stabilization mode on January 24. The antennas onboard are keeping point the earth.

After accumulation of fundamental tests for onboard and ground systems, we made an overall experiment between the WEOS and the probe on the sea surface.

Figure 4 shows the navigation course of a ship from the Takeshiba port of Tokyo to the Futami port of Ogasawara Island, obtained by sending the position data of GPS receiver to the WEOS on the ship.

We are carrying out the attachment operation of the probe near Ogasawara and Muroto in Japan, and it will accomplish in the near future.

The plan of the WEOS wan a prize at the First Small Satellite Design Contest in Japan in 1993, and this is the first realization of the proposal appeared at the Contest as a piggyback launch by H2A vehicle

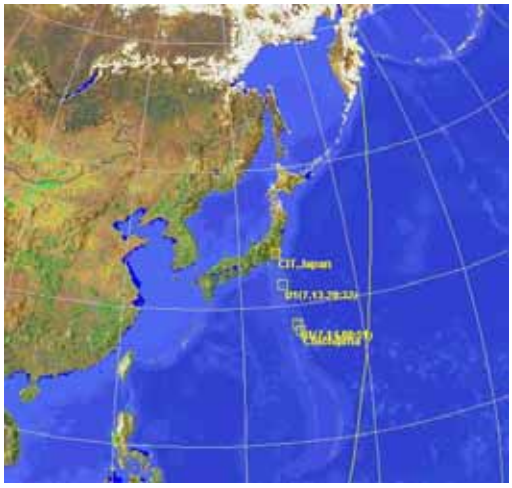

Fig. 4 Course of the ship obtained by the WEOS