Development of an autonomous seafloor positioning system on a buoy

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GPS has revolutionized observation of crustal movement on land. The GEONET operated by the Geographical Survey Institute of Japan is one of the most successful examples; it has monitored tectonic deformation of the Japanese Islands as well as crustal movements associate with earthquakes and slow earthquakes. However, GPS is not directly accessible to the subduction zones, where most of large earthquakes occur under the veil of the ocean. A GPS-Acoustic (GPS-A) positioning technique has been recognized as the most probable for in situ observation of a seafloor crustal movement since Spiess et al. (1998) presented important results of seafloor geodesy.

Compared with land-based GPS observation, however, the seafloor observation has critical problems against on-line, continuous and long-term observations. The GPS-A technique is only available as repeated observations, and each observation requires a cruise of a survey vessel. The interval of the observations is several months to a few years. Long-term observation is crucial for geodetic monitoring, because precision of GPS-A seafloor positioning is much the same as the expected crustal movement in a year. However, observation for more than several years is difficult for seafloor instruments because of the problem of power supply.

A cabled seafloor observatory is the most probable solution to cope with these problems in the geophysical observations such as earthquakes and tsunamis. JAMSTEC is developing a cabled observatory system off Kii Peninsula in preparation for the coming Tonankai earthquake with a fund from the MEXT, Japan (DONET Program). However, the GPS-A positioning observation has another problem; it requires a sea surface unit as well as a seafloor unit. The sea surface unit needs to remain above the seafloor array.

The research group in Tohoku University has used a towed buoy for GPS/A observation keeping it above the center of an acoustic transponder array on the ocean bottom. The system can basically be compatible with a moored buoy system in a short period of observation. In order to realize continuous GPS-A observation on a moored buoy, the group is now trying to modify the system on a towed buoy into an autonomous seafloor positioning system, and to reduce the power consumption under the DONET Project.

A low-power GPS receiver will take the place of four GPS receivers, and the acoustic ranging system will be replaced with a battery-driven compact system. The system can be controlled with a wireless LAN. If the system is connected to an ocean bottom cable in the future, a land-based station can supply power, clock signals, control signals, and receive the observed GPS and acoustic data.