TECHNICAL NOTE

# Adding LORAN-C Position Recording to a Satellite-tracked Drifter Buoy

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## ABSTRACT

*A LORAN-C receiver-recording system was designed and embodied in a satellite-tracked drifter buoy. The purpose of the system is to obtain more accurate, uniformly-spaced times series of Lagrangian current measurements. LORAN-C positions, clock counter, receiver status, and other ancillary data are recorded on a data storage module on board the buoy. Depending on battery capacity, minimum deployments of twelve to forty-four days can be expected for sampling rates of ten to sixty minutes.*

## INTRODUCTION

Free-drifting satellite-tracked drifter buoys have provided a wealth of *in situ* data from remote ocean regions. For example, during the First GARP (Global Atmospheric Research Program) Global Experiment (FGGE) more than 300 drifters were deployed in the southern hemisphere (Patterson 1985; Peterson 1985). Other large scale ocean programs followed. These drifting buoy data sets have afforded the opportunity to examine global-scale spatial variations in surface circulation over vast ocean areas.

In the Great Lakes, satellite-tracked drifters have also proven valuable for measuring near-surface currents (Pickett et al. 1983a,b; McCormick et al. 1985; Murthy et al. 1987; Schwab et al. 1989) and ice movements (Campbell et al. 1987). Buoy positions are determined from Doppler-shifted radio signals by means of the ARGOS system aboard TIROS and NOAA satellites. A cost-cutting advantage of using drifters in the Great Lakes is that they are generally recoverable and reusable.

At the latitude of the Great Lakes, an average of seven positions per day is obtained from ARGOS, however, there are two periods each day for intervals of three to eight hours when positions are not available. Position accuracy is about ±0.3 km (Pickett et al. 1983b). The horizontal scales of motion in the Great Lakes are much smaller than in the deep ocean, and coastlines are a constraining influence. ARGOS positioned drifter buoys, suitable for examining lake-wide near-surface circulation, are not as well adapted for measuring smaller scale processes because of the position inaccuracy and limited number of position fixes. Since these drifters are recoverable, it is feasible to record data on board. A low-cost system designed to obtain LORAN-C positions at uniform, frequent time intervals was added to the satellite-tracked drifter buoy.

Buoys designed specifically for a LORAN-C system that transmits data via FM radio have been used successfully in the ocean (Crawford 1988). However, the FM receiver must be within range of the buoy (typically, 100 km over seawater, less over fresh water). This is not a constraint with our present system.

## DESIGN AND TEST RESULTS

The LORAN-C electronics package, designed by Ronald W. Muzzi, one of the authors of this paper, includes a modified Si-Tex EZ97 LORAN-C receiver, Campbell Scientific SM192 data storage module, and an 80C31 microprocessor interface. These components and interfacing cost about $2,000. This package was added to a Polar Research Lab mini-TOD drifter. The LORAN-C receiver is used to obtain positions that are recorded internally to the storage module as timed and controlled by the microprocessor. The ARGOS transmitter is left intact to obtain position comparisons and to locate the drifter for retrieval. The 1.8 m "long" hull of the Polar Research Lab mini-TOD has ample space to house the additional package. The 2.5 m LORAN-C antenna is mounted on an aluminum bracket 0.4 m from the ARGOS antenna (Figure 1). A light is mounted across from the antenna.

The LORAN-C receiver draws 200 mA so it must be cycled to conserve power. The microprocessor turns on the receiver at a selectable sampling interval (ten to sixty minutes) using a quartz crystal as a time reference. The LORAN-C receiver tracks a master station and two secondary stations. When the receiver acquires signal lock, the two LORAN-C time delays (TDs), signal capture time, receiver status, clock counter, and battery voltage are dumped to memory as a data record and the receiver is powered down. If the receiver fails to acquire a lock on the signals within the seven minutes allocated, the data (including whatever TDs are available) are dumped to memory with an appropriate error code and the LORAN-C is powered down. The status code indicates signal-to-noise (S/N) ratio errors and cycle select (C/S) errors for the master and both secondaries, as well as LORAN-C time-out errors. The memory module has a capacity of 192896 bytes or 7144 data records. The system consumes about

23 mAH of power for each position capture (when the receiver is on for seven minutes), and the ARGOS transmitter and microprocessor consume about 0.6 AH of power per day of operation. The alkaline battery stack has a rated capacity of 60 AH. Assuming we obtain 80 percent of that capacity, the buoy will operate for about seventeen days at a fifteen-minute sample rate.

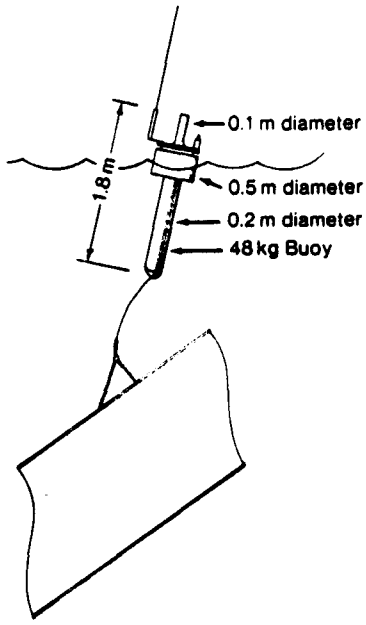


**Figure 1:** *Schematic drawing of the long mini-TOD drifter.*

The unit was field tested for a short period in Lake Michigan during 10 m/s winds and 1.5 m 5 sec waves. Three ARGOS positions were available during the test. ARGOS positions and LORAN-C positions are shown in Figure 2. The time of the ARGOS fixes and the concurrent LORAN-C positions are also shown in Figure 2. LORAN-C positions, taken at fifteen-minute intervals, show a relatively smooth trajectory while the three ARGOS positions are scattered. Distances between the ARGOS and corresponding LORAN-C positions ranged from 0.46 to 0.90 km which is significantly greater than reported by Pickett et al. (1983b) but comparable to the accuracy (96 percent within 0.72 km) during FGGE (National Oceanic and Atmospheric Administration 1981). Battery life is a function of capture time (lock) and the sampling interval. Mean capture time during the limited test was 5.7 minutes. For the fifteen-minute sampling rate, the drifter would have an operational life of about seventeen days, for hourly samples, about forty-four days. Five LORAN-C fixes did not attain a lock condition within the seven minutes allowed, however, with the exception of two lane jumps, the positions did not appear degraded. One lane jump occurred when lock had been achieved but the 10 μs jumps were obvious and correctable during data editing. Additional field testing will determine if a longer minimum locking time for signal capture is necessary.

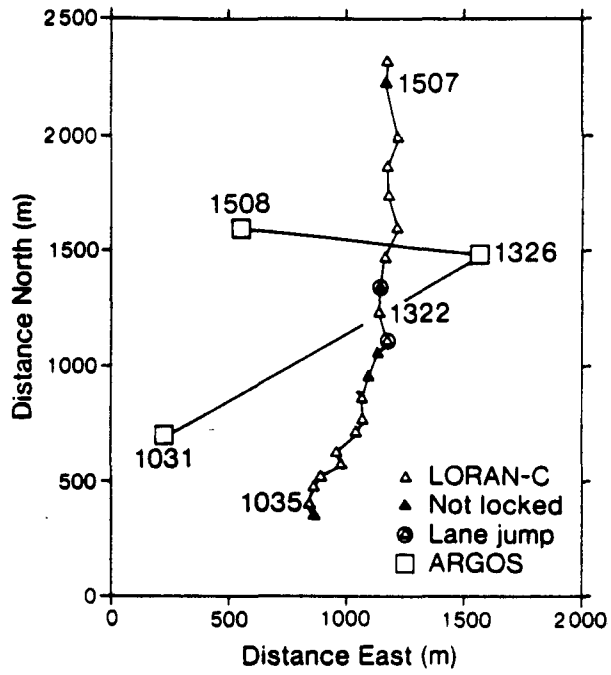


**Figure 2:** *LORAN-C and ARGOS positions during a test in Lake Michigan near 43°N, 86°W, November 22, 1988. Times of ARGOS fixes and concurrent LORAN-C positions are indicated.*

## SUMMARY

A free-drifting satellite-tracked buoy with a LORAN-C on board recording system operated successfully during a short field test in Lake Michigan. Cycling the LORAN-C at preselected intervals from ten to sixty minutes permits the drifter buoys to operate about twelve to forty-four days.

Increased position accuracy and frequency of data provide a nearly uniform time series of Lagrangian current measurements that do not require the extensive averaging and filtering necessary with satellite positions. Measurement of dynamic processes on smaller spatial scales is possible with this system. The disadvantages are the increased battery drain necessitating shorter deployments and the inherent problems of on board recording. The success of this system depends on being able to recover the buoy. A feature will be added that will turn off the LORAN-C system when the battery voltage drops to a critical level. The voltage cutoff will be sufficient to permit the ARGOS positioning to continue, which will facilitate locating and the recovery of the drifter.

## REFERENCES

Campbell, J.E., Clites, A.H., and Greene, G.M. 1987. Measurements of ice motion in Lake Erie using satellite-tracked drifter buoys. NOAA Data Report ERL GLERL-30, 22 pp., Great Lakes Environmental Research Laboratory, Ann Arbor, Michigan.

Crawford, W.R. 1988. The use of LORAN-C drifters to locate eddies on the continental shelf. *J. Atmospheric and Oceanic Tech.*, 5:671-676.

McCormick, M.J., Clites, A.H., and Campbell, J.E. 1985. Water-tracking ability of satellite-tracked drifters in light winds. *MTS Journal*, 19(3)-17.

Murthy, C.R., Miners, K.C., and Sandall, J.E. 1987. Mixing characteristics of the Niagara plume in Lake Ontario. NWRI Contribution #86-82, 34 pp., National Water Research Institute, Burlington, Ontario.

National Oceanic and Atmospheric Administration. 1981. The Global Weather Experiment - Final Report of U.S. Operations. U.S. Dept. of Commerce, Rockville, Md.

Patterson, S.L. 1985. Surface circulation and kinetic energy distributions in the southern hemisphere oceans from FGGE drifting buoys. *J. Phys. Oceanog.*, 15:865-884.

Peterson, R.G. 1985. Drift trajectories through a current meter array at Drake Passage. *J. Geophys. Res.*, 90:4883-4893.

Pickett, R.L., Campbell, J.E., Clites, A.H., and Partridge, R.M. 1983a. Satellite-tracked current drifters in Lake Michigan. *J. Great Lakes Res.*, 9:106-108.

Pickett, R.L., Partridge, R.M., Clites, A.H., and Campbell, J.E. 1983b. Great Lakes satellite-tracked current drifters. *In Proc.*, MTS/NDBC 1983 Symposium on Buoy Technology, 138-143, New Orleans.

Schwab, D.J., Clites, A.H., Murthy, C.R., Sandall, R.E., Meadows, L.A., and Meadows, G.A. 1989. The effect of wind transport and circulation in Lake St. Clair. *J. Geophys. Res.*, (in press).