Development of Methods for Testing Rotational Sensors

JOHN R. EVANS, RAMANATH COWSIK, CHARLES R. HUTT, C.-C. LIU, ROBERT NIGBOR, ULRICH SCHREIBER, FRANK VERNON, AND ERHARD WIELANDT (ALPHABETICAL AFTER FIRST)

ABSTRACT

IEEE Standard 671-1985 gives methods for reporting the performance of point rotational sensors (sensors which directly measure rotation at one point, as distinct from arrays of linear sensors). However, the importance to earthquake applications of the items suggested in this *Specification* is poorly understood; similarly, testing facilities appropriate to the sensitivities and dynamic ranges of seismological rotation sensors (10^{-10} to 10^{-2} rad/s) are needed. It is at least clear that we need verification of sensitivity, linearity, hysteresis, and cross-axis sensitivity (including the sensitivities to both linear and cross-rotational inputs). The authors and others interested will discuss appropriate testing and facilities in a task group at the Workshop and report our findings in plenary session.

The performance of sensitive weak-motion rotational sensors (10–100 prad/s floor) have been verified by the input of Earth's sidereal rotation, a well characterized signal near 73 μrad/s. Comparisons with predicted teleseismic motions also support the sensors' efficacy. As new technologies emerge, weak-motion rotational sensors are being cross-compared, as between co-sited ring lasers and precision torsion balances. While these comparisons are not definitive, they provide confidence where the technologies are distinct. Testing strong-motion rotational sensors (10–100 mrad/s peak) is feasible *via* controlled inputs from high-precision linear and rotational shake tables, however, it is difficult to generate rotational motions of sufficient purity to place more than upper limits on cross-rotation sensitivities. Comparisons between arrays of vertical linear accelerometers (which are not very tilt sensitive) and horizontal-axis rotational sensors co-sited on rigid substrates are being performed and may yield useful confirmation of sensor performance for both active and natural shaking sources. However, this method is hampered by the need for a rigid, unstressed mounting surface as well as the relative transfer functions between the linear vertical accelerometers, which must be known very accurately.

We are using facilities at the Albuquerque Seismological Laboratory, the Geodetic Observatory Wettzell, the Piñon Flat Observatory, several locations in Taiwan (likely to yield quickly events of ≥M6 within 100 km), and various other laboratories, to compare collocated ring laser, torsion balance, fiber optic, and magnetohydrodynamic sensors and to test against natural and shake-table motions. Preliminary tests provide some confidence in the R-1™ magnetohydrodynamic sensor and in the large ring lasers at Wettzell and elsewhere; these tests are being expanded to more sensors and more test locations.

Given rapidly growing interest in the three rotational components of motion in seismology and earthquake engineering, its potential impact on measurement of even linear motions, and some early indications of widely differing results between arrays of linear accelerographs (not mounted on rigid substrates) and point measurements with true rotational sensors, it is very important to verify the performance of point-rotation sensors.