The full spectrum of temporal and spatial scales that occur in ocean circulation can be observed only by multiple altimeters [NASA, 1987; Koblinski et al., 1992; Fu et al., 1998]. In general, combining sea surface height (SSH) data from different satellites leads to disappointing results if their orbits have different inclinations or repeat periods [Greenslade et al., 1997]. However, significant benefits can be derived from well-coordinated satellites that work in tandem [Greenslade et al., 1997; Stammer and Dietrich, 1999]. Although TOPEX/Poseidon and Jason-1 may overlap sufficiently to support a limited demonstration of this principle, a mission based on a constellation of altimeter satellites is usually dismissed as too costly. WITTEX belies that assumption; moreover it opens the way to new and previously unobtainable measurements.

WITTEX, named in honor of E. Witte, who in 1878 first discovered the geostrophic current equation, is an acronym for Water Inclination Topography and Technology Experiment. The two-dimensional geostrophic current can be derived if two orthogonal components of the surface height gradient can be observed – hence WITTEX. Normal altimetry can measure only the along-track component. WITTEX would consist of three co-planar small-satellite radar altimeters (Figure 1). The satellites are spaced apart by several hundred kilometers. Their sub-satellite tracks are laterally separated because of the Earth’s rotation. At a given latitude, measurements occur within minutes of each other, so that the cross-track surface gradient can be measured as well as the usual along-track gradient. Track separation may be adjusted during mission operations by selection and maintenance of the inter-satellite spacing. Thus, measurement of the two-dimensional surface gradient can be optimized during a single flight mission. The SSH data are free of off-nadir errors, since all measurements enjoy the accuracy inherent to pulse-limited geometry. The Earth’s equatorial rotation rate of ~450 m/s, combined with a track-repeat tolerance of ~1 km, translates into an along-orbit relative position control requirement of only ~9 km, which can be accomplished easily.

The WITTEX constellation can be tuned to favor dense spatial coverage, relatively tight temporal coverage, or other priorities. A change from one scenario to another would require approximately one day. Using the Geosat 17-day orbit as a reference, consider four possibilities (Figure 2). (Similar scenarios would apply equally well to a TOPEX-class orbit.) SCENARIO I, High spatial resolution (~200 km orbital spacing): Each triplet of sub-satellite orbit tracks would be 24 km wide, and span less than 1 minute. This arrangement would support measurement of both the along-track and the cross-track surface gradients at about the same resolution. SCENARIO II, Uniformly dense spatial coverage (~900 km orbital spacing): Each triplet of sub-satellite orbit tracks would be 24 km wide, and span less than 1 minute. This arrangement would support measurement of both the along-track and the cross-track surface gradients at about the same resolution. SCENARIO III, High temporal resolution (~2600 km orbital spacing): This arrangement would place each succeeding altimeter’s track on top of the spatially adjacent one. This would generate three- and six-day revisit cycles, in addition to the normal 17-day Geosat cycle. An alternative version of this scenario would space the satellites ~5200 km apart, resulting in effective six- and twelve-day repeat cycles within each 17-day base cycle. Frequent revisit is desirable to observe the
evolution of large-scale features, such as El Niño. **Scenario IV, Site-specific coverage:** Given that one of the altimeters would be dedicated to a fixed exact-repeat mission, the others in the constellation could be moved as required upon command. This would allow a user to shift the altimeters’ tracks to pass over an area of particular interest, which would have scientific, military and natural hazard applications. With two roaming satellites, any given site could be covered by both an ascending and a descending pass. This guarantees at least one cross-over at the site of interest. Alternatively, the satellites could be timed to generate four cross-overs that would bracket the site.

One vehicle can launch three satellites efficiently into the same orbit plane, if the satellites are sufficiently small. Fortunately, the delay-Doppler radar altimeter (DDA) [Raney, 1998] leads to a smaller instrument, and therefore a smaller satellite, than is possible with the conventional radar altimeter paradigm. Performance is not sacrificed. Although the DDA technique requires much less transmitted power, it yields more precise measurements than a conventional radar altimeter [Jensen and Raney, 1998]. The notional instrument for WITTEX has two frequencies and an on-board water vapor radiometer, similar to TOPEX. The DDA approach, combined with recent advances in spacecraft technology, leads to substantial miniaturization; the mass of each WITTEX satellite is predicted to be ~65 Kg. This is about one-fifth that of Geosat Follow-On (GFO).

The WITTEX concept is an elegant response to a long-standing need. It offers a flexible, capable, unique, and cost-effective approach that would significantly advance the state-of-the-art of satellite radar altimetry in technical, scientific, and operational arenas.

**References**


