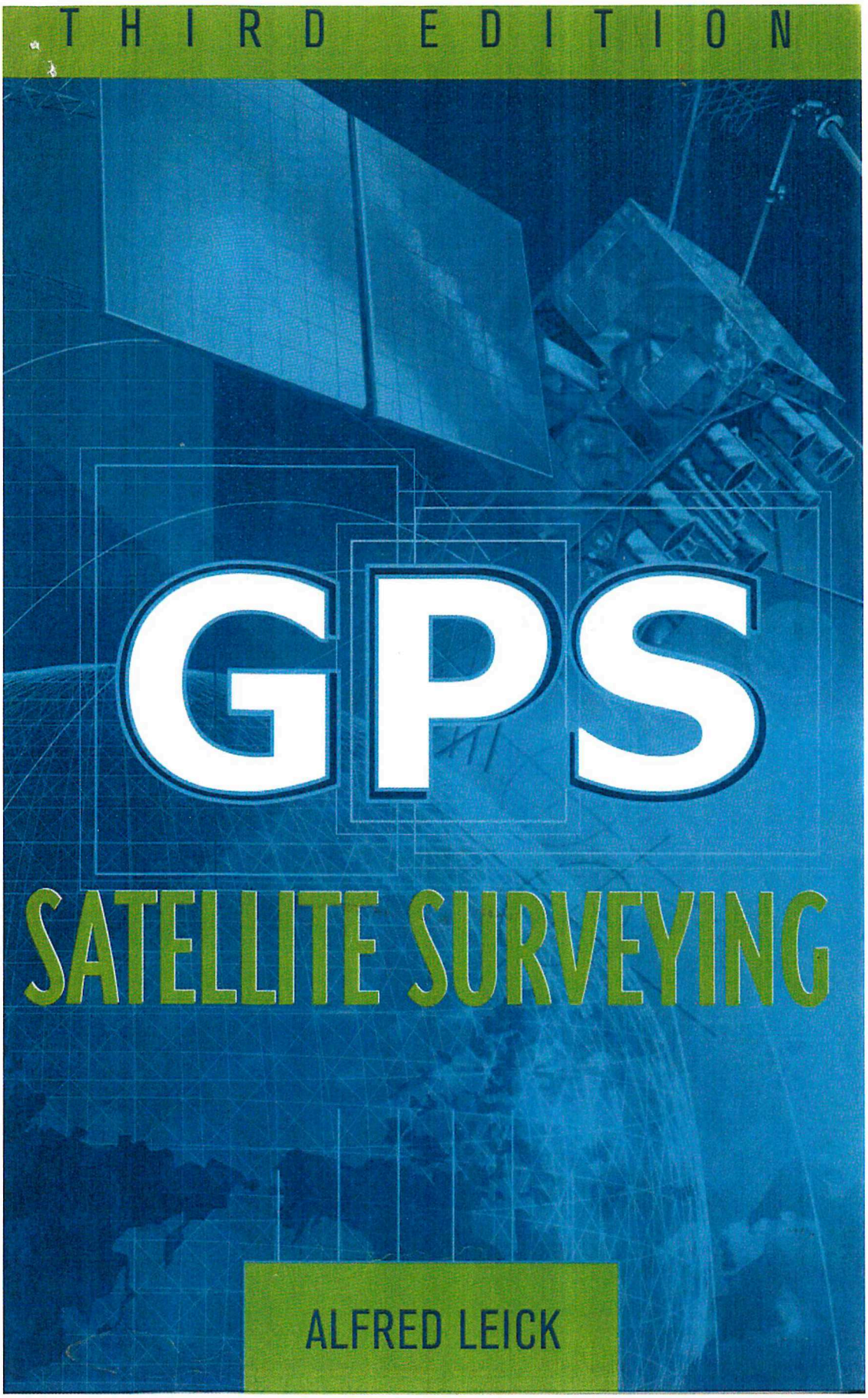
THIRD EDITION



GPS

SATELLITE SURVEYING

ALFRED LEICK

CHAPTER 5

PSEUDORANGE AND CARRIER PHASE OBSERVABLES

Pseudoranges and carrier phases are the most important GPS observations (observables) used for positioning. Solutions are available that use pseudoranges only, carrier phases only, or both types of observations. The early solutions for navigation relied on pseudoranges. More recently, even point positioning often includes the carrier phase observable. Carrier phases are always required for accurate surveying at the centimeter level. Processing algorithms exist that use the (undifferenced) observations directly. However, one often uses certain linear combinations. Popular examples are the double differences and the triple differences.

Measuring pseudoranges and carrier phases involves advanced techniques in electronics and digital signal processing. This chapter deals with the equations that directly apply to the pseudoranges and carrier phases as downloaded from the receiver. The goal is to determine geocentric positions (point positioning) or relative positions between co-observing stations (differential or relative positioning). These equations are also the basis for estimating ionospheric and tropospheric parameters with GPS, or the transfer of time.

In addition to deriving and discussing the basic pseudorange and carrier phase equations and the double- and triple-difference functions, we address frequently asked questions of novice GPS users. Examples include simultaneity of observations, singularities, and a priori knowledge of initial station and ephemeris. The implications of relativity for GPS observables have widely been addressed in the literature, e.g., Grafarend (1992), Hatch (1992), Ashby (1993), and Schwarze et al. (1993). In this chapter, remarks on relativity are limited to Section 5.3.1, where a clock correction term is given to account for satellite orbital eccentricity. The correction and the adjustment to the fundamental frequency of 10.23 MHz mentioned in Section 3.2.2 are the only references to the applicability of relativity to GPS in this book. In relative positioning, most of the relativistic effects cancel or become negligible.