2. GPS SATELLITE ORBITS

G. Beutler, R. Weber, U. Hugentobler, M. Rothacher and A. Verdun
Astronomical Institute, University of Berne, Sidlerstrasse 5, CH - 3012 Berne,
Switzerland

2.1 INTRODUCTION

Nominally the Global Positioning System (GPS) consists of 24 satellites (21 + 3 active spares). The satellites are in almost circular orbits approximately 20 000 km above the surface of the Earth. The sidereal revolution period is almost precisely half a sidereal day (11\textsuperscript{h} 58\textsuperscript{m}). All GPS satellites, therefore, are in deep 2:1 resonance with the rotation of the Earth with respect to inertial space. This particular characteristic gives rise to perturbations to be discussed in section 2.3.3. Thanks to this particular revolution period essentially the same satellite configuration is observed at a given point on the surface of the Earth at the same time of the day on consecutive days (the constellation repeats itself almost perfectly after 23\textsuperscript{h} 56\textsuperscript{m} UT).

The first GPS satellite, PRN 4, was launched on 22 February 1978. PRN 4 was the first in a series of 11 so-called Block I satellites. The orbital planes of the Block I satellites have an inclination of about 63 degrees with respect to the Earth's equator. The test configuration was optimized for the region of North America in the sense that four or more satellites could be observed for a considerable fraction of the day there. The test configuration was not optimal in other parts of the world.

In February 1989 the first of the Block II (or production) satellites was launched. The Block II satellites are arranged in six orbital planes (numbered A, B, C, D, E, and F), separated by about 60 degrees on the equator, and inclined by about 55 degrees with respect to the Earth's equator. Twenty-four Block II satellites are operational today. Figure 2.1 gives an overview of the arrangement of the satellites in the orbital planes, Figure 2.2 contains a drawing of a Block I, a Block II, and a Block IIR satellite (taken from Fliegel et al. [1992]). Figure 2.3 gives an impression of the orbital planes around the Earth in space as seen from a point in 35 degrees latitude, and as seen from the pole (North or South). The philosophy behind the 21+3 active spare satellites may be found in Green et al. [1989].

The present constellation allows for a simultaneous observation of at least four GPS satellites from (almost) every point on the surface of the Earth at (almost) every time of the day. Eight or more satellites may be observed at particular times and places. Figure 2.3 shows that the constellation is problematic in the Arctic.
Figure 2.1. Arrangement of the GPS satellites in the orbital planes A-F.

Figure 2.2. (a) Block I satellite, (b) Block II satellite, (c) Block II R.