

Chapter Two: Time and Position

What Time is it and Where are We?

Anon

Humankind has been asking itself these questions for all of recorded history. In England, Stonehenge had, as a minimum, been used as a calendar in ~4000 BCE. The Babylonians introduced the base 60 numbering convention used in both time and position at about the same time. These calendars were accurate to about one day per year. The ancient Egyptians used sun dials and water clocks accurate to about one hour per day. The Greeks, Romans and Chinese developed water and mechanical clocks with accuracies of better than one hour per day. In the 1400s, Galileo Galilee discovered that a ~ one meter pendulum had a 2 second period.

As far back as 330 BCE, the Greek philosopher/scientist Aristotle (384-322BCE) observed that the earth was round. Another Greek, Eratosthenes (ca. 276-196 BCE) in Alexandria, Egypt, later estimated the earth's circumference to be approximately forty six thousand kilometers (vs. 40,008 Km today). The Greek Hipparchus (ca. 190-120 BCE) divided the globe into 360 degrees. The Greek, Ptolemy of Alexandria (90-168 CE), further divided it into 60 minutes and 60 seconds of arc. The great library of Alexandria was sacked and burned in 391 CE by Christian mobs and much of this knowledge was lost to the western world. Fortunately Ptolemy's two books on mathematics, science and geography, *The Almagest* and *Geography*, (*written in Greek*) survived in Arabic and were later translated into Latin a thousand years later to be hand copied and later printed for re-discovery and use in the Renaissance.

In 1214 CE the Mongol Genghis Khan captured Beijing, China and opened commerce with the western world. The trade routes were made famous by the writings of Marco Polo (1254-1324 CE). When the Mongol Empire collapsed in 1368, with the establishment of the Ming dynasty, the trade routes between east and west declined. The flow ceased altogether when the Turks captured Constantinople in 1453. This gave rise to the need for ocean trade routes between the east and the west. Astronomers had known for over a thousand years how to measure Latitude by measuring the angle of the horizon to the sun, moon and the stars as a function to time-of-year. Longitude was much more difficult, however, and needed an accurate measure of time to safely transit large oceans. It was known that the earth rotates at a rate of ~15 deg./hour. So knowing time at ones position relative to the time at a fixed and commonly agreed upon datum is a direct measure of Longitude distance.

Time Line

1693 John Harrison born 24 March
1707 loss of 4 British War Ships by Sir Clowdisley's navigation error
1717 British Parliament Longitude Act set prize
1721 Isaac Newton states Longitude cannot be measured with a mechanical clock
1735-37 First clock H-1 to sea
1741 Second clock H-2 delivered but not sea tested due to design flaws discovered
1757 Third clock H-3 delivered not tested at sea
1759 H-4 delivered for sea trials that wins Longitude prize (5 in dia 3 lbs)
1761-64 H-4 sea trials
1765-75 Nevil Maskelyne Astronomer Royal contests prize to Harrison
1773 Harrison awarded partial prize for H-5 with help of King George III
1776 John Harrison dies 24 March at 83
1815 ~5,000 marine chronometers in existence
1935 Bradford Parkinson born Feb 16 Madison Wis
1941-45 LORAN radio navigation developed during WW II
1949 first atomic clock at Nat. Bu Stand USA (now NIST)
1955 NPL UK improved design
1957 Parkinson graduates USNA takes commission in USAF
1959 TRANSIT sat based nav for naval use
1961 Parkinson MS at MIT
1963 Aerospace Corp GPS idea of Ivan Getting named system 621B
1966 Parkinson PhD at Stanford Univ
1971 ballon and psudolite testing at White Sands
1973 DSARC approval and Parkinson named PM
1974 1st sat launch
1977 18 July, 11:41 pm Rockwell engineers receive first GPS message
1978 -85 Blk I sat launched
1978 Parkinson retires from USAF
1983 May, DARPA begins miniature GPS receiver program named the Virginia Slims
1983 KAL 007 shot down by N Korea, Pres Reagan offers GPS to Aviation
1984 Parkinson Prof emer at Stanford
1987 USCG assumes DoT authority for civil use
1989 Blk II sat launched
1989 December, Virginia slims receiver demonstrated
1990 Trimble begins civil receiver mfg
1993 GPS IOC
1994 FAA starts WAAS for international civil aviation
1995 President Clinton offers free service to the world with joint DoD and DoT oversight
1997? ICAO meeting in Rio de Janero rejects free GPS service for international air navigation standard
2000 FAA WAAS system declares IOC **check date???**
2003 Parkinson shares Draper Prize with Ivan Getting

Discussion Questions

1. Compare and contrast the relationship between science and engineering in the 18th and 20th centuries.
2. Compare and contrast the educational background of Harrison and Parkinson.
3. Discuss the use of base 60 for time and position vs. base 10. Should we change? If so, why? If not, why?
4. Compare the engineering development and testing time cycle between Harrison's clock and the GPS system
5. Discuss the engineering teaming relationships between the two developments.
6. Discuss the tension between the science of astronomy and mathematics and the engineering approach of a mechanical design by Harrison.
7. Compare and Contrast the tension between Air Force, Navy and Army views on position measurement.
8. Discuss the possibility of obtaining civilian GPS applications without the national security and military development program.

Bibliography

Longitude, Dava Sobel and William J. H. Andrewes, 1995,1998, Walker & Company NY, ISBN: 0-8027-7593-4

The Global Positioning System: Assessing National Policies, Scott Pace, et.al., 1995, RAND, Santa Monica, Cal., ISBN:0-8330-2349-7

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Personal Communication with Dr. Bradford Parkinson, November 2011.