THE POSSIBILITY OF SAILING ACROSS OCEANS BY STAR CHARTS IN EARLY 15TH CENTURY

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ABSTRACT：The purpose of the study is to introduce the application of star charts, 365.25 units of angle measurement, and celestial sphere with a globe at its center and how they were able to assist astronomical navigation in early Ming Dynasty or early 15th Century.

1. INTRODUCTION

Menzies（2002）proposed the Chinese had completed global cruising by ships in Ming Dynasty. There are both positive and negative opinions on his website（1421 Team 2002）. It is known that mathematics and navigation tools, such as star catalogues, Sun Table, observing tools, are needed for astronomical navigation. However, spherical trigonometry, navigation methods, and optical instruments appeared in modern practical astronomy were not ready yet in time of Ming Dynasty. According to ancient Chinese history of science and technology, the author collects concepts from ancient Chinese astronomy and explains how astronomical navigation was possible at sea in early 15th Century.

2. EARLY CONCEPTS FOR NAVIGATION

Longitude, latitude, and true north determination on earth surface in land are contents in Field Astronomy, or Practical Astronomy(Hosmer & Robbins 1972). However, ancient navigator did sailing at sea by simple tools and knowledge of star observations. Teresi (2002) wrote Chinese emperors established observatories to study changes of movement of celestial bodies for astrological reason to support their regime. Ancient Chinese oracle bone writings have shown that Chinese adopted tropical year of the sun as 365.25 solar days some 3500 years ago. General Tsao in his translation of Needham (1975a) denoted that the Chinese history is a history of Chinese calendar. Each Dynasty had its own calendar for counting days and years. Calendars not only record dates for emperors' regime but also provide stars' position at events.

Since modern star catalogues are star tables in terms of celestial coordinate system. The integration of Chinese ancient star charts and modern coordinate system can be used as star catalogues(Combined Service Forces 2002) as in modern ephemerides and almanacs (USNO 2006, H.M. Nautical Almanac Office 1993). They provide variations of star position subject to the consecutive change of vernal equinox. Star catalogues in ephemeris and almanac used to be important for precise positioning in astro-geodetic control surveying before the use of Global Navigation Satellite Systems (GNSS).

Needham(1975a, 1975b) introduced many early science and technology of astronomical observation in China. The author proposes three concepts from it for the explanation and procedure of star charts navigation.

Concept I : Early Chinese star charts displayed the distribution of stars for complete celestial sphere which is useful everywhere on earth when star observation is possible at night (Combined Service Forces 2002, Needham 1975a).

Concept II : The 365.25 graduation system for circumference has long been used in ancient China for the discovery of tropical year, which is 365.2422 Solar days (Liu 2010, Needham 1975a, Teresi 2002) .This is why stars appeared 4 minutes(3^m56^s to be exactly when 24hr divided by 365.2422 days) earlier every day. This also relates the leap year of 366 solar days for every 4 calendar years today.

Concept III : Needham (1975b)described armillary sphere constructed in the 3rd century in China had a small solid sphere at its center. The knowledge behind this small solid sphere implied that both east and west

have considered that earth is a sphere long time ago(Liu 2010).

3. LONGITUDE DETERMINATION BY STAR CHARTS

Chao (2006) indicated longitude determination is more difficult than latitude and true north determination due to timekeeping device was not accurate enough in early 15th century. The possible way sailing at sea could be made on larger ships with reliable hourglass, as larger ships can reduce wave motion and help better timekeeping. Star charts do not provide coordinates as star catalogues do, but they are good for identification purpose. Because the earth rotates on its axis and revolves around the sun at the same time, stars appear slightly different every night by 3^m56^s as shown in Figure 1.

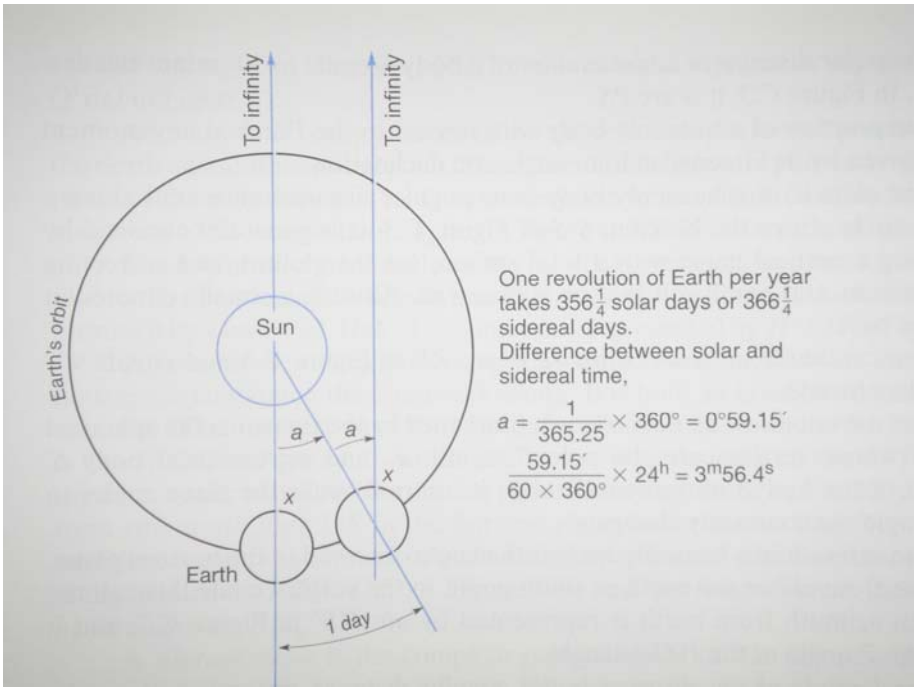

Figure 1 Comparison of Sidereal and Solar Time (Ghilani &Wolf 2008)
(Note that the number 356.25 in the figure should be 365.25.)

The theory for ancient ships sailing across oceans is the combination of the three concepts in Section 2. It is not a complex idea if one knew the earth is round, stars appeared 3^m56^s earlier every day. By using a star chart and setting a transit star westward one graduation a day can keep track of the sky of departure port. The difference of longitude between two stations can be determined by comparing transit stars of departure port with stars of waypoints. Since timekeeping accuracy by hourglass is poor for longitude determination, early maps appeared to be distorted great. The statement in Menzies (2002) of 23 early observatories, found along the coast from Asia to east Africa during Cheng Ho's voyages, could be a design of zero setting for longitude errors.

4. CONCLUSIONS

The approaches of longitude determination described in Section 3 is feasible though errors are expected high due to the lack of precise timekeeping and pointing device. It is possible to sail globally for reasons below.

1. Ancient Chinese authority is responsible for astronomical observation for calendar and astrology purpose with reliable stars and charts.

2. Star charts, armillary sphere with earth inside, and 365.25 graduations of circumference are listed in both Chinese and western publications. These concepts provide basic consideration for longitude determination.

3. Longitude determined in Section 3 can be explained theoretically and applied practically. If transit stars at departure port can be tracked continuously.

REFERENCES

1421 Team, 2002. www.1421.tv

Chao, H.M., 2006. The Possibility of Sailing Global by Star Charts in Early 15th Century. Proceedings of the 25th Conference on Surveying and Geomatics, Taiwan. p.p.1295-1298.

Combined Service Forces, 2002. Military Abridged Ephemeris. Taiwan.

Ghilani, C.D., Wolf, P.R., 2008. Elementary Surveying – An Introduction to Geomatics. 12th Edition, Appendix C p.892. Pearson Education.

Hosmer, G.L., Robbins, J.M., 1972. Practical Astronomy. 4th Edition. John Wiley, New York.

H.M. Nautical Almanac Office, 1993. The Star Almanac for Land Surveyors for the year 1993. London HMSO.

Liu, G., 2010. Ancient Map Code. Chinese Edition, Linking Publishing , Taiwan.

Menzies, G., 2002. 1421 The Year China Discovered America. HarperCollins Publishers.

Needham, J., 1975a. Science and Civilization in China. Chapter 20, Vol.3. Chinese Translation published by The Commercial Press, Ltd. Taiwan.

Needham, J., 1975b. Science and Civilization in China. Chapter 29, Vol.4. Chinese Translation published by The Commercial Press, Ltd. Taiwan.

Teresi, D., 2002. Lost Discoveries. Simon &Schuster.

U.S. Naval Observatory, 2006. The Astronomical Almanac for the year 2008. U.S. Government printing Office, Washington D.C.