General Architecture Design of Lunar Projection System

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China's lunar exploration program named "chang'e project" has been launched since January 2004, and the Chang'e 1 probe satellite will soon be sent into space in 2007. The first scientific objective of chang'e 1 is to obtain three-dimensional images of the lunar surface. To obtain the object, lunar cartography is absolutely necessarily. Design of lunar projection system and establishment of mathematical base of lunar surface are a basic research for lunar cartography, which is important and urgent.

This paper analyzes basic characteristics of moon, brings forward four design rules of lunar projection system, then designs the general architecture of lunar projection system. The general architecture designed in this paper consists of 3 tiers. The first tier is lunar global projection system, which is used to draw lunar global map which can show whole lunar surface in one map. The second tier is lunar range projection system, which is used to draw lunar range map centering at landing point or lunar space station. The third tier is fixed scale lunar projection system, which is used to draw certain fixed scale lunar maps covering whole lunar surface，such as 1:100,000 lunar relief maps.

Under the guidance of 3 tiers lunar projection system, this paper calculates, analyzes and compares lots of map projection technology, then makes choice of projection technology and related projection parameters suitable to various tier projection systems. For lunar global projection system, Cylindrical Orthomorphic Projection and Pseudocylindrical Projection are appropriate. For lunar range projection system, Azimuthal Projection and Conical Projection are appropriate. For fixed scale lunar projection system, Universal Transverse Mercator Projection (UTM) and Universal Polar Lunar Projection are appropriate.

Subsequently, the paper introduces separately the 6 kinds of projection technology chosen in lunar projection system.

For Cylindrical Orthomorphic Projection, latitudes are a group of parallel lines, and longitudes are another group of parallel lines which are orthogonal to latitudes. Various distortions are only related to latitude and symmetrical to equator. The distortion is 0 along standard parallel, and increase with the distance to standard parallel. If lunar global projection system adopts Cylindrical Orthomorphic Projection, it is proper that two standard parallels are set to ±30°.

For Pseudocylindrical Projection, latitudes are a group of parallel lines, and interval among latitudes is various with the change of latitude. Central meridian is an orthogonal line to latitude, and other longitudes are symmetrical curves to central meridian. Sanson Projection is a typical Pseudocylindrical Projection. If lunar global projection system adopts

Sanson Projection, distance distortion factor is less than 1.0711 in most range of whole lunar surface, most to 2.2969, and angular distortion factor is less than 76°,most to 115°. For Sanson Projection, longitude is sine curve, polar area is a point, and the general appearance of longitude and latitude is globose, solid and integrated.

Azimuthal Projection is a kind of projection technology that supposes a plane is tangent to a point or secant to a circle on moon, then project lunar surface to the plane with perspective or mathematic method. For Azimuthal Projection, directions from central point to other points are not deformed, that is, the direction on map is consistent to the direction on lunar surface. In the range from central point to 30°, distance distortion factor is less than 7.2%, and area distortion factor is less than 15%. In America, A kind of Azimuthal Projection named AMS was ever adopted to draw lunar map.

Conical Projection is a kind of projection technology which takes conical plane as projecting plane, and projects the longitude and latitude to the conical plane, then unwind the conical plane to plane along certain generatrix. For regional lunar cartography, equiangle secant conical projection with 4°zonal span is perfect because of little distortion. Within each zone, if two standard parallels are set at inner side 35′away border latitudes, distance distortion factor can be limited in ±0.3%,and area distortion can be limited in ±0.6%.

Universal Transverse Mercator (UTM) projection is a conformal cylindrical projection using a secant cylinder so it meets conformality and reasonable equidistance for lunar topographic mapping. UTM projection is designed to cover whole moon, excluding the Arctic and Antarctic regions. To keep scale distortions within acceptable limits, 60 narrow, longitudinal zones of six degrees longitude in width are defined and numbered from 1 to 60. Each zone has its own central meridian, and the scale is 0.9996 along each central meridian. In each zone, distance distortion is all less than 1‰.

Universal Polar Lunar Projection is a kind of equiangle orthomorphic azimuthal projection suitable to lunar Arctic and Antarctic regions. For Universal Polar Lunar Projection, angular distortion is 0, area distortion is 2 times of distance distortion, and distance distortion increase with the difference value between object latitude and secant latitude. If the secant latitude is set as N70°, distance distortion is-3% on the Arctic polar, +6.6% on N55°.

In the conclusion, authors bring forward some suggestion on further research about lunar projection system.