ESTIMATION OF HORIZONTAL AND VERTICAL COMPONENTS FOR POSITIONING STANDARD DEVIATION IN ABSOLUTE GPS POSITIONING

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1. RESEARCH BACKGROUND

Precise Point Positioning (PPP) greatly improves the precision of absolute GPS positioning by using the international GPS services (IGSs) orbit and satellite clock error products with positioning precision reaching the 1cm level [1-3]. At present, this technique has been widely applied in many engineering fields, such as mining engineering, high precise navy engineering surveying, lane surveying and cadastration[4-8]. Since the requirements for horizontal and vertical components of positioning standard deviations vary enormously in different applications，it is necessary to estimate the horizontal and vertical components of positioning standard deviation.

2. POSITIONING PRECISION OF SPECIFIC DIRECTIONS IN WGS-84

The geometric dilution of precision (GDOP) factor, which is defined as the square root of the trace of the inverse measurement matrix or the inverse of each eigenvalue in the original measurement matrix, respectively, reflects dilutions of precision in *X*, *Y*, *Z* directions in WGS-84 coordinate system [8-10], rather than the dilutions of precision in vertical direction and horizontal plane, as shown in Fig.1.

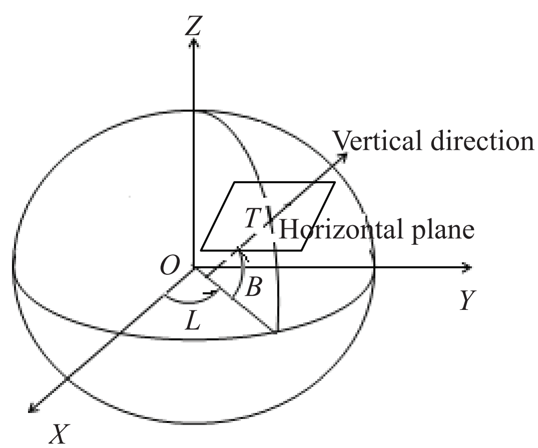

Fig. 1 Coordinate systems of WGS-84 and vertical direction

In general, *Z* axis direction in WGS-84 is referred to as “vertical direction” and *XOY* plane as “horizontal plane”. Obviously, that is not true.

3. DERIVATION OF HORIZONTAL AND VERTICAL COMPONENTS FOR POSITIONING STANDARD DEVIATION

As is well known, the horizontal plane strictly refers to the plane parallel with the Geoid, while vertical direction refers to the normal direction of the Geoid. However, the Geoid is too complicated to be rigorously expressed by means of any mathematical models due to the exception of the Earth's gravity. That is to say, it is actually impossible to denote the horizontal plane or vertical direction with analytical formulae. As a result, it is reasonable and feasible to approximately supersede the Geoid with the surface of the WGS-84 ellipsoid, hence plane which is tangent with the WGS-84 ellipsoid at a point is approximately referred as to horizontal plane and the corresponding normal as vertical direction. Now, let us establish a horizontal coordinate system of GPS station center *xyz* (as shown in Fig.2) with the GPS station T as the origin, the normal of WGS-84 ellipsoid as z axis, the north direction of meridian as x axis and parallel circle (east direction) as y axis. It is obvious that the xTy plane is the horizontal plane, and the z axis direction is the vertical direction. There is a conversion relationship between the horizontal coordinates of station center $[x, y, z]^T$ and the WGS-84 coordinates differences $[\Delta X, \Delta Y, \Delta Z]^T$ [10][11]. According to the variance-covariance propagation law[12], the dilutions of precision for x, y, z directions can be easily arrived. Furthermore, we may derive the horizontal and vertical dilutions of precision as well as the corresponding horizontal and vertical components of positioning standard deviation.

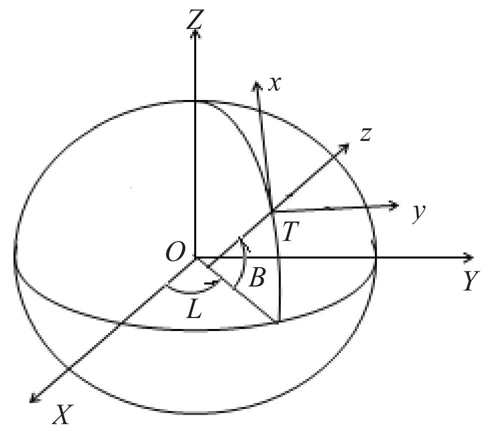

Fig.2 Coordinate systems of WGS-84 and horizontal station center

4. CONCLUSIONS

(1) The Z axis direction in WGS-84 coordinate system is intrinsically different from the vertical direction; similarly, the XOY plane of WGS-84 coordinate system differs substantially from the horizontal plane;

(2) It is impossible to precisely denote horizontal plane or vertical direction by analytical formula. Under the assumption of approximately superseding the Geoid with the surface of WGS-84 ellipsoid, the estimate formulae for horizontal and vertical components of positioning standard deviation are derived, which are of theoretical significance and application value in practical engineering.

5. REFERENCES

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