PRECISION OF SATELLITE POSITIONING
IMPACT OF SATELLITE GEOMETRY

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Abstract

Precision of Global Navigation Satellite Systems (GNSS) is affected by two separated factors: the precision of pseudo-distance measurements between receivers and satellites and the satellite sky distribution (satellite geometry). The main object of our study is the second factor which depends on the considered system. So, the conclusions that we draw for the American Global Positioning System allow us to consider potential benefit of the future European system, Galileo, but also the interoperability between different GNSS.

In the case of absolute and relative positioning, the quality of satellite geometry can be evaluated by means of indicators: DOP (*Dilution of Precision*) and RDOP (*Relative Dilution of Precision*) respectively.

The first part of our study concerns the spatiotemporal variability of the quality of satellite geometry, evaluated by the DOP value, in the case of absolute positioning. We identified a series of elements affecting spatiotemporal variability of quality of satellite geometry. Currently, the spatiotemporal coverage of GPS constellation is excellent but some critical situations with very high DOP values can be punctually observed in time and space. These events find their origin in singular states of normal matrix, whose elements are related to satellite geometry. We demonstrate that a specific form of satellite geometry could involve a singular state of normal matrix, in particular a conical satellite geometry. This satellite geometry is encountered when the satellite sky distribution adopt a conical form whose the apex would be the receiver. Using a method consisting of the least squares adjustment of a cone on a real satellite sky distribution, we explained the origin of critical events observed.

In the case of high-precision applications, scientists generally exploit relative positioning techniques. Mostly, only the DOP value is made available by receivers whatever the technique used. The second part of our study is based on the correlation between DOP and RDOP. The objective is to evaluate the predictability of RDOP, knowing only the DOP value. We established that the correlation between DOP and RDOP is even stronger than the baseline is short. As in the case of absolute positioning, the critical events encountered are caused by singular states of the normal matrix. As before, we proved that the conical form of satellite geometry is responsible for the singularity of the normal matrix in the case of relative positioning. Moreover, our study allows us to explain some problematic results of GNSS applications. So, we demonstrated that some important ionospheric errors observed in the results of SoDIPE-RTK of Royal Meteorological Institute (RMI) could be justified by a conical aspect of the satellite geometry.

Keywords

Global navigation satellite system (GNSS) – satellite positioning – satellite sky distribution – geometry – precision – DOP – singularity – absolute positioning – relative positioning