Integrity Monitoring of IGS Products

J. Zumberge, H.-P. Plag

The IGS has successfully produced precise GPS and GLONASS transmitter parameters, coordinates of IGS tracking stations, Earth rotation parameters, and atmospheric parameters. In this paper we discuss the concepts of integrity monitoring, system monitoring, and performance assessment, all in the context of IGS products. We report on a recent survey of IGS product users, and propose an integrity strategy for the IGS.

GNSS Integrity Concept

B. Lobert

One main characteristic of the GALILEO system is the provision of an integrity function to the user. This function is based on the so called SISA/IF concept and relies on two components: the signal in space accuracy (SISA), which is a parameter representative of the SISE (Signal In Space Error) estimated during the orbit and timing determination, and the integrity flag (IF) that results from the real time monitoring of the satellites.

This integrity concept differs from the one currently specified for GPS wide area augmentation system (SBAS) such as EGNOS and WAAS. Indeed, such systems provide to the user real time satellite orbit and clock corrections. This allows to assume that the residual error follows a zero mean distribution. This is a primary assumption used in the definition of the protection limit equations (XPL) as it is currently specified in SBAS standard.

In Galileo, corrections are also sent to the user but not in real time. Only the integrity flag is submitted to this constraint. However, the Integrity Flags (IF) guarantees only an upper bound of the residual error. It is unable to guarantee that the satellite residual error distribution is unbiased. This prevents to use the WAAS/ MOPS XPL equation for Galileo without adaptation. This adaptation can either be limited to tuning of the different parameter involved in the XPL equation or can be extended to a modification of the XPL formula.

This presentation aims at describing GALILEO alternatives to the protection limit computation currently specified for SBAS systems such as WAAS and EGNOS.

First the main integrity definitions and requirements are recalled, next the assumptions behind the WAAS/ MOPS XPL equation are thoroughly reviewed and confronted to current Galileo integrity concept.

Finally we detail an adapted solution for GALILEO that allows to directly highlight the link between the check performed at Ground segment level to generate the Integrity Flag and the algorithm performed at user level for integrity determination.

Products Produced Under the Direction of the AC Coordinator: Processes, Accuracies and Quality Control

G. Gendt

The IGS generates a series of products; namely: (i) satellites ephemerides, (ii) satellite/station clock offsets, (iii) earth rotation parameters (ERP), (iv) station coordinates/velocities, (v) ionospheric and tropospheric delays. The first four are generally referred to as IGS core products. To fulfill the specific requirements for the various applications IGS offers three lines, which are named after the delay of their generation with Final, Rapid and Ultra Rapid.

The first three products for all lines are computed under the direction of the Analysis Center (AC) coordinator during the Orbit-ERP-Clock Combination. For the Finals the third and forth products are generated within the Reference Frame Working Group (RFWG) by combining the AC SINEX solutions. All this products are available to support a number of scientific activities. Many agencies contribute to the various IGS components (station network, data centers, ACs), which are necessary to get finally the listed products.

Of crucial importance is the quality and integrity of the IGS products. During the combination several checks are performed to ensure the product generation at all (by "meaningful inputs"), and to ensure a reasonable high quality and consistency (by "validation of AC submissions"). Additionally, many off-line checks are performed to ensure the long-term product stability. For the last step the products from the SINEX combination by the RFWG are of special importance.

The paper gives an overview of the Orbit-ERP-Clock Combination for all the parallel lines and summarizes the quality obtained for the individual products. The consistency and integrity will be discussed in some details, and changes to fulfill the increasing requirements are proposed.

The Use and Integrity Monitoring of IGS Products at Geoscience Australia

R. Govind, J. Dawson, J. Manning

Geoscience Australia (GA) routinely uses the International GPS Service (IGS) data and analysis products for a wide range of services and applications. At GA, IGS data and analysis products have become critical and are routinely used for high precision GPS processing applications for spatial data infrastructure, regional tectonics, ITRF densification, satellite altimeter calibration, sea level monitoring, ITRF to Geocentric Datum of Australia (GDA) coordinate transformations and the GA online positioning application (AUSPOS). The use of the IGS product suite reduces the need for intense global data processing for satellite orbits and Earth orientation and their quality allows use for science applications. To demonstrate the importance of the IGS product suite the impact of these applications is reviewed. For example the AUSPOS service provides geodetic GPS users with access to high precision GPS processing software, established October 2000 the AUSPOS service has processed over 25,000 user RINEX files observed in Australia and around the world and is widely regarded as a critical component of the Australian spatial data infrastructure. In this paper the use of the IGS product suite and our experiences with these products and their integrity monitoring are reviewed.

Modelling of GPS Satellite Clocks and Comparisons of IGU Clock Products

V. Bröderbauer, R. Weber

Since November 2000 the IGS (International GPS Service) provides so-called Ultra-Rapid products comprising precise GPS satellite orbits and satellite clocks. This solution, issued twice daily, contains both an observed and a predicted part. The predicted part covers a period of 24 hours. While the orbits are output to an integration of the well-known force field the clocks have to be extrapolated by means of an experienced prediction model.

In a first step we present statistics of all Ultra Rapid clock corrections submitted by the various IGS Analysis Centres in comparison to the IGS Rapid solutions. After a linear fit using a least squares adjustment the clock- rms is calculated both for the observed (about 0.1 –0.4 ns) and the predicted part. Resulting diagrams are available on a weekly basis at the homepage of the Department of Advanced Geodesy at the TU Vienna (http://mars.hg.tuwien.ac.at/).

Secondly the available observed part of the IGS Ultra Rapids of the past 48 hours are used as input to a least squares adjustment to determine the clock polynomials of second order. Depending on type and behaviour (caesium or rubidium) we add cyclic terms to predict the satellite clock values over the upcoming 12 hours. Our predictions are compared to the IGS Rapid clock offsets and to the solutions of the individual IGS Analysis Centres. The quality of our clock predictions is usually at the sub-nanosecond level over the upcoming 6 hours and at the 3 ns level over a 12 hours period, which is quite comparable to most of the IGS Analysis Centre-models. Model parameters and comparisons are presented at the poster.

Routine GPS Data Quality Check at GFZ-Potsdam

M. Ramatschi, R. Galas

The GFZ Potsdam performs routinely quality checks on every available hourly GPS data file e. g. using UNAVCO's TEQC. In addition several parameters such as delay and multipath are visualized and statistically treated. The output is then made available through a graphical web interface (http://www.gfz-potsdam.de/pb1/igs/igs_stat/Global_IGS_100.htm). Currently 162 global station are monitored.

With an online archive of about 2 years of historical quality check data trends and changes in the quality of the GPS data could be determined and warnings can be generated.

Zero Difference Residuals for Multipath Maps and ZTD Quality Indication

B. Gundlich, H. van der Marel

Zero difference residuals for a number of IGS stations have been analysed. The zero difference residuals have been computed from double difference residuals, computed with the Bernese GPS software. The zero difference residuals are used to study the properties of different sites, antennas and receivers by making maps of the site-multipath and plotting the rms of the residuals as function of elevation. The quality of estimated parameters such as the estimated Zenith Total Delay has been evaluated using variance component estimation. Finally, we discuss briefly the use of residuals for slant delay estimation.