Investigation of RTK initialization times during simulation of the GSM signal lost

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Abstract - **In this paper an analysis of RTK initialization times for GNSS receivers to get fixed solution will be given. Measurements were performed among two different RTK networks (EVN and EPOSA) under similar environment conditions represented by PDOP and Satellites-in-use values. Two different receivers Ashtec Mobile Mapper 100 and Ashtec ProMark 500 were employed to assign an independence of measurement.**

Keywords - **GNSS, RTK, initialization, fixed solution.**

I. INTRODUCTION

Localization accuracy purveyed by Global Navigation Satellite Systems (GNSS) is not sufficient for all applications that it is intended for. Different sources can contribute to the total error in GNSS measurements. [1] In order to achieve an accuracy which suits asked requirements in centimeter level, additional measures are necessary to be taken. Real Time Kinematics (RTK), as the best methods to increase the accuracy of positioning, was therefore introduced. RTK is a technique used especially in a land survey based on the use of carrier phase measurements of the GNSS signals where a single reference station provides the real-time corrections (Fig.1).

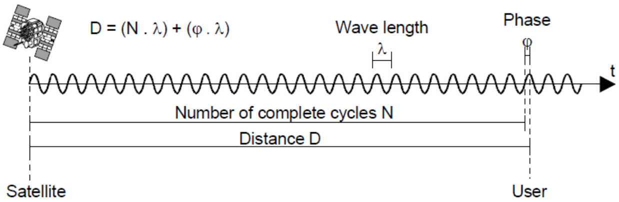


Fig.1 Principle of the phase measurement [2]

By this method an existence of an amount of reference stations where correction data are computed is assumed. Correction values are transmitted to the user side (GNSS receiver) by using a suitable medium, mostly the mobile communication networks (GSM/GPRS) in bands (450), 900 and 1800 MHz according to the RTCM SC 104 standards (Radio Technical Commission for Maritime Services, Special Committee 104), especially:

- RTCM Recommended Standards for Differential Navstar GPS Service, Version 2.0 and 2.1,
- RTCM Recommended Standards for Differential GNSS Service, Version 2.2, 2.3 and version 3,

with respect to the NTRIP (Networked Transport of RTCM via Internet Protocol).

Data differentiations are methods of combining GNSS data (of the same type) measured at different stations allowing GNSS original code observables to be modified as Eq. (1):

$$R_i^k(j) = \rho_k^i - c\delta t_i + c\delta t_k + \delta_{ion}(j) + \delta_{trop} + \varepsilon_c \quad (1)$$

where j (j = 1,2,5) is the index of frequency, subscript i is the index of station number and superscript k is the id number of satellite [3].

Compensation for the determined pseudoranges to correct the calculated position is performed at the user side where an existence of additional hardware (mostly UHF or GSM/GPRS receiver) is assumed. According to the implemented communication standard an access either to the single or to the multiple reference RTK station(s) could be envisaged. Multiple reference RTK stations are considered as a natural extension of single reference station utilization. Although there may be times when a single reference station's solution is better than the network solution, the network solution is generally more likely to accurately represent the errors over the region because of the additional information gained from combining the data from all reference stations [4]. An access to the network of multiple RTK stations is usually restricted only to the specific users authorized by the provider. These stations belong either to the IGS tracking network (International GNSS service), established for providing high quality GNSS products (e.g. precise satellite orbits and clock corrections) and monitoring geodynamic processes on a global scale (e.g. IGS station network) or to operational regional RTK positioning services. In spite of the significant costs growing when integrating RTK, the precise positioning technology with RTK-GNSS is expected to be used for much wider applications increasingly in the future [5].

From the measurement taken in [6] is however obvious that RTK utilization doesn't automatically guarantee an improvement of positioning quality. Various application scenarios exist when additional factors should be considered let the specific localization quality level to be assured [7]. One of these factors is an ability of the receiver to connect to the appropriate RTK network and get the fixed solution - RTK initialization time. In real scenarios very often happens that communication among receiver and RTK network is somehow disturbed or even cancelled. Reconnection and initialization times are therefore very important when the

GNSS system performance with respect to the requirements of designated application is quantified.

In this paper initialization times within the two regional RTK networks (EVN and EPOSA) providing positioning services among Austria were investigated. EVN (Energie-Versorgung Niederösterreich) (Fig.2) is GNSS network operated by the Austrian power supply company Wien-Energie which consists of 12 permanent reference stations placed among the area of Lower Austria even though EPOSA (Echtzeit Positionierung Austria) is Austrian nationwide implemented RTK network (Fig.3).

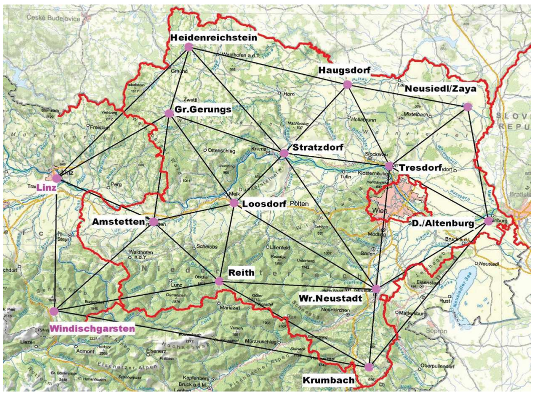


Fig.2 Topography of EVN RTK network among Lower Austria

Fig.3 Topography of EPOSA RTK network among Austria

II. MEASUREMENTS

Measurement was performed by utilization of two different L2 GNSS receivers - Ashtec Mobile Mapper 100 and Ashtec ProMark 500. Measurement scenario was set up on the roof of the building in the centre of Vienna city in Austria above the all possible obstructions that could block a clear sky view (Fig.4). During the measurement was the time necessary for the fixed solution getting for the each receiver and each network separately evaluated. Single interval modes were measured and analyzed with a frequency set to 1Hz. All data were stored in *.rw5 format. When an analysis was performed, all point IDs were read until the fixed solution wasn't reached. Then the connection was cut-off so more than one initialization time could be analyzed within the same environment conditions. HRMS value (Horizontal Root Mean Square) as the statistical measure of the varying quantity size was employed for the time since connected to the network until the first fixed solution was acquired quantifying.

Fig.4 Measurement scenario

The results from the six test measurements taken with the Ashtec ProMark 500 are provided in the figures below (Fig.5 and Fig.6).

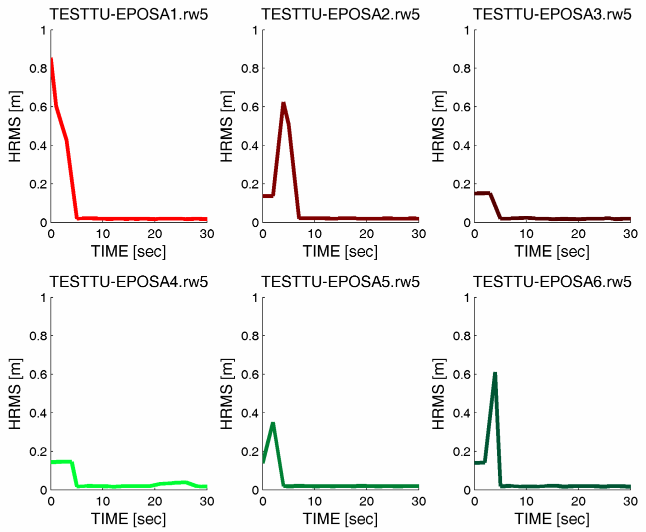


Fig.5 Initiazation of Ashtec ProMark 500 within EPOSA network

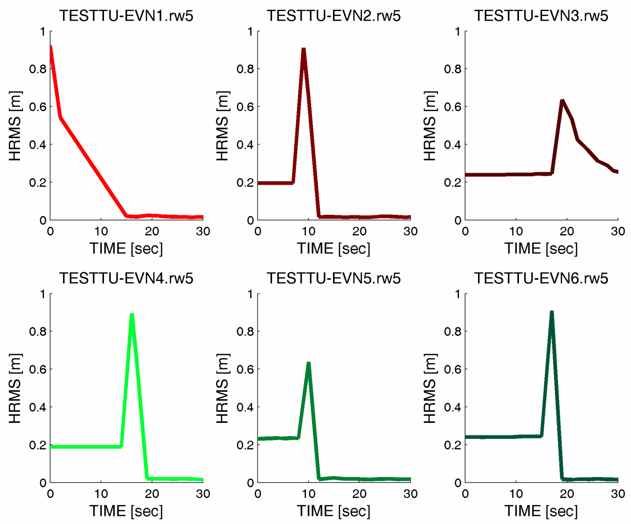


Fig.6 Initiazation of Ashtec ProMark 500 within EVN network

In every scenario, from the first measurement taken both for EPOSA and EVN (red graphs), is obvious that any a priori data were missing. However when comparing with other graphs the time durations since getting connected until getting fixed are similar. Only initial HRMS value became constant to c.a. 20 cm among the next five measurements. So it could be assumed that the latest available RTK data were used as the a priori values in the next measurement after the connection cut-off. Contribution of the a priori data on the initialization times speed-up were not observed.

In the tables below all initialization times containing an accompanying environment conditions (PDOP - Positional Dilution of Precision and SAT - Number of the Satellites in Use) are summarized (TABLE 1 and 2).

TABLE 1

PAGE LAYOUT DESCRIPTION

Test Measurements 27-05-2011, start 10:04 RTK: EPOSA RTCM2-3 TR				
Connected	**Fixed**	**Time [sec]**	**PDOP**	**SAT**
10:04:50	10:04:54	00:04	1.3	13
10:09:50	10:09:57	00:07	1.4	12
10:14:45	10:14:49	00:04	1.4	13
10:19:44	10:19:49	00:05	1.3	13
10:24:46	10:24:50	00:04	1.3	13
10:30:19	10:30:25	00:06	1.3	14
	Mean	**5 sec**	**1.33**	**13**
	Median	**5 sec**		

TABLE 2

PAGE LAYOUT DESCRIPTION

Test Measurements 27-05-2011, start 14:12 RTK: EVN RTCM2-3				
Connected	**Fixed**	**Time [sec]**	**PDOP**	**SAT**
14:12:08	14:12:24	00:16	1.4	14
14:18:45	14:18:57	00:12	1.3	14
14:25:34	14:27:05	**01:31**	1.3	14
14:33:18	14:33:37	00:19	1.0	14
14:40:22	14:40:34	00:12	1.1	14
14:47:03	14:47:22	00:19	1.0	14
	Mean	**28 sec**	**1.88**	**14**
	Median	**18 sec**		

From the Fig. 5 and 6 as well as from the Tables 1 and 2 is obvious that within EVN network it took longer to get the new RTCM message necessary for the solution “fixing” as within EPOSA. It could be assumed that fixed-solution acquiring takes in general a few seconds. Worse circumstances within EVN network could be observed in the Fig. 6 on the Graph 3 when the fixed solution was acquired after up to 90 seconds (grey field marked in TABLE 2, detail is shown in Fig.7).

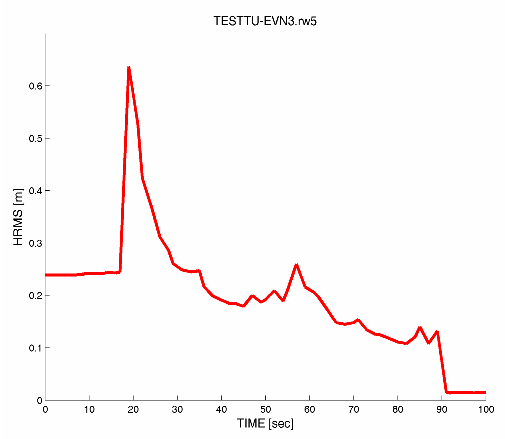


Fig.7 Initiazation of Ashtec ProMark 500 within EVN network - peculiarity

In general it could be assumed that all of the results behave by the same way; they reach fixed solution determined from a priori value with a peak deviation in the state before.

During measuring with Ashtec Mobile Mapper 100 no fixed solutions were reached. Measurement should show the length of initialization times for the EVN and for the EPOSA networks separately. Three measurements for each network were taken; each after 5 minutes broke up since there was no fixed solution reached. HRMS waveforms are shown in the figures bellow (Fig.8).

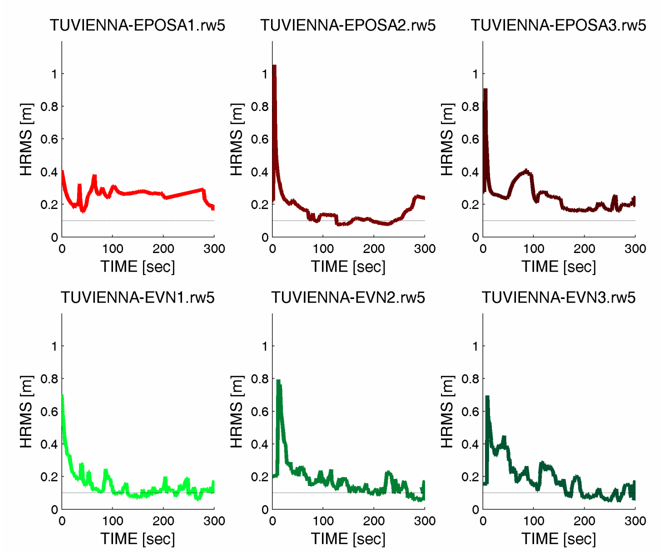
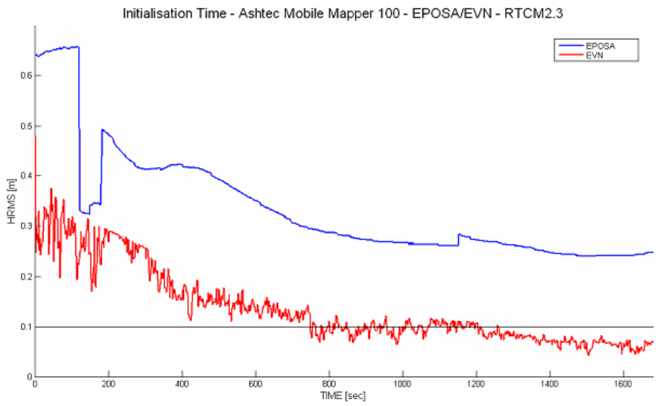


Fig. 8 Initialization of Mobile Mapper 100, within EPOSA and EVN networks – 5min Test

Since after 5 minute test no fixed solution was reached, two longer additional measurements were taken - one with EVN, one with EPOSA correction data.

An aim was to perform the measurement until the fixed solution will be reached. In both cases had to be however the measurement terminated because without fixed solution reach, the HRMS value became after continuous improving constant. After 15 minutes was the reached accuracy in both cases similar (HRMS) <10cm with a little bit better results at the EPOSA side. Measurement conditions were almost similar: PDOPEVN~1.45, PDOPEPOSA~1.31, and number of satellites in use ~14.



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III. CONCLUSION

In this paper an investigation of RTK initialization times during simulation of the GSM signal lost is given. Measurements were performed within two RTK networks implemented regionally in Austria - EVN and EPOSA. Two different L2 GNSS receivers were employed. According to the measured results the classification of GNSS system quality with respect to the length of initialization times among these networks could be made.