

# RTCM Message Type 59-FKP for transmission of FKP

## Version 1.1

Gerhard Wübbena, Andreas Bagge

*Geo++<sup>®</sup> Gesellschaft für satellitengestützte geodätische und  
navigatorische Technologien mbH*  
D-30827 Garbsen, Germany  
<http://www.geopp.com>

Garbsen, 2006-03-01

## Introduction

For GNSS applications the RTK performance can be increased by using area correction parameters (in German: Flächen-Korrektur-Parameter FKP) information from reference station networks. The FKPs provide information about the distance dependent error components. For example, the German AdV organization, responsible for the operation of the SAPOS reference station networks, introduced FKPs as its standard technique to provide network information to any RTK rover.

For the use within SAPOS the AdV has defined and published linear FKPs and the corresponding algorithm. The parameters given in the RTCM message 59-FKP described in this document are conforming to that definition, which is also summarized in chapter 2.1.

Chapter 2.2 describes the format of these FKPs in a special RTCM type 59 message.

## Definitions

### FKP

For the representation of the position dependent errors a linear area polynomial is used. It refers to a surface which is defined to be parallel to the WGS-84 ellipsoid in the height of the reference station. The coordinates  $(\varphi, \lambda)$  referring to this surface for phase observations of a mobile rover are then used to derive the distance dependent errors with

$$\begin{aligned}\delta r_0 &= 6.37 (N_0 (\varphi - \varphi_R) + E_0 (\lambda - \lambda_R) \cos(\varphi_R)) \\ \delta r_I &= 6.37 H (N_I (\varphi - \varphi_R) + E_I (\lambda - \lambda_R) \cos(\varphi_R))\end{aligned}$$

with:

- $N_0$  the FKP in north-south ( $N_0$ ) direction for the geometric (ionosphere free) signal in [ppm]
- $E_0$  the FKP in east-west ( $E_0$ ) direction for the geometric (ionosphere free) signal in [ppm]
- $N_I$  the FKP in north-south ( $N_I$ ) direction for the ionospheric signal (influence on the "narrow lane") in [ppm]

$E_I$  the FKP in east-west ( $E_I$ ) direction for the ionospheric signal (influence on the "narrow lane") in [ppm]

$\varphi_R, \lambda_R$  the geographic coordinates of the reference station in WGS84 datum in [rad]

$H = 1 + 16 (0.53 - E/\pi)^3$

$E$  the elevation angle of the satellite in [rad]

$\delta r_0$  the distance dependent error for the geometric (ionosphere free) signal [m]

$\delta r_I$  the distance dependent error for the ionospheric ("narrow lane") signal [m].

For GLONASS the same reference frequency (GPS "narrow lane") is used as for GPS.

The distance dependent errors for the L1 and L2 signals can be computed in [m] from

$$\delta r_1 = \delta r_0 + (120/154) \delta r_I,$$

$$\delta r_2 = \delta r_0 + (154/120) \delta r_I.$$

with:

$\delta r_1$  distance dependent error for L1

$\delta r_2$  distance dependent error for L2

From a pseudo range  $R$  of a mobile rover derived from a carrier phase measurement a pseudo range  $R_k$  corrected for position dependent errors can be computed with

$$R_k = R - \delta r.$$

## RTCM

Since current RTCM version 2.3 does not support information from networked reference stations, the FKPs must be transmitted through the message type 59.

The representation of the parameters in message type defined herein corresponds to the RTCM conventions. I.e. the bit sequence of the parameters is always "MSB first" and the representation of negative values is in the so called "2's complement".

## Message Structure

Table 1 shows the structure of the message. The first two words of any RTCM messages are not described here. They can be taken from the RTCM documentation. Table 2 summarizes the content of the message.

The following parameters are transmitted in the type 59-FKP message.

### Institution ID

In order to achieve a unique differentiation of different, manufacturer dependent type 59 messages, a constant institution ID in form of the character string 'Adv' is transmitted in the 3<sup>rd</sup> word.

### SUB-ID

In order to keep the possibility to define further messages with the same institution ID, a Sub-ID is transmitted. For the linear FKPs of GPS satellites the Sub-ID 5 is used. For the linear FKPs of GLONASS satellites the Sub-ID 6 is used.

## Data set number

The *data set number* identifies the FKP parameter set. This number (n) is consecutively incremented for each new data set and transmitted as "n modulo 4" ( $n\%4$ ).

## SAT ID

The satellites are not identified by their PRN number as generally usual in RTCM, but by a corresponding bit in the SAT ID (satellite identification) word. The SAT ID is an integer value with a length of 4 bytes ("32 bit unsigned long"). For the satellite with the PRN number (p) the bit (p-1) is set, with bit 0 as the LSB, bit 31 as the MSB.

This type of representation is possible for GPS, since GPS can handle no more than 32 PRNs. Opposite to the usual representation with 5 bits per satellite this method is more economical for 7 or more satellites.

If FKP for more than 12 satellites have to be transmitted, further FKPs can be send in a second message with the same Z-count and the same data set number.

## FKP data block per satellite

After the satellite identification the *FKP data blocks* per satellite are following. The FKP data blocks are ordered with increasing PRN number, i.e. satellite with the lowest PRN first. FKP data blocks are transmitted only for those satellites, whose bits are set in the satellite identification. There are no gaps between the blocks for the individual satellites.

## IOD

The parameter *IOD* corresponds to its definition in the type 1 message (IODE). The FKPs depend on the broadcast orbit used for the calculation. At the rover the FKP must be processed consistently, i.e. using the same "broadcast data" that was used during the creation of the FKP.

## SL0, SLI

Two different scales and ranges are provided. The scale bits *SL0,SLI* are used to identify scale and range. They allow a different handling of the non-dispersive and the dispersive FKPs. *SL0* is the scale parameter for the non-dispersive part (L0), *SLI* for the dispersive part (LI).

With the standard scale (scale bits set to 0) a resolution of 1 mm / 100 km is achieved. Under extreme conditions (scale bits set to 1) the resolution is reduced to 4 mm / 100 km. Thus, the corresponding maximum error is +/- 2 mm at a distance of 100 km from the reference station.

For the very unlikely case of even higher values, the corresponding satellites have to be deleted from the FKP message.

## FKPs N0, NI, E0, EI

The parameters *N0, NI* are the north-south components of the FKPs for the non-dispersive and for the dispersive part resp., the parameters *E0,EI* are the corresponding FKPs for the east-west components.

## Reserve

All *reserve* bits must always be set to 0.

## References

- RTCM Radio Technical Commission for Marine Services (2001). RTCM Recommended Standards for Differential GNSS (Global Navigation Satellite Systems) Service, Version. 2.3.  
<http://www.rtcn.org>
- AdV - Arbeitsgemeinschaft der Länder der Vermessungsverwaltungen der Bundesrepublik Deutschland, see <http://www.adv-online.de>
- SAPOS Satellitenpositionierungsdienst der deutschen Landesvermessung, see <http://www.sapos.de>
- Wübbena, G., A. Bagge, M. Schmitz (2001). Network-Based Techniques for RTK Applications. Presented at the GPS Symposium, GPS JIN 2001, GPS Society, Japan Institute of Navigation, November 14.-16., 2001, Tokyo, Japan. [http://www.geopp.de/download/gpsjin01\\_p.pdf](http://www.geopp.de/download/gpsjin01_p.pdf)
- Euler, H.-J., C.R. Keenan, B.E. Zebhauser, G. Wübbena (2001). Study of a Simplified Approach Utilizing Information from Permanent Station Arrays. Draft submitted to RTCM-Meeting, Salt Lake City, Utah. [http://www.geopp.de/download/ion2001-rtcm\\_extended\\_p.pdf](http://www.geopp.de/download/ion2001-rtcm_extended_p.pdf)
- Wübbena, G., A. Bagge, M. Schmitz (2001). RTK Networks based on Geo++<sup>®</sup> GNSMART - Concepts, Implementation, Results. Presented at the International Technical Meeting, ION GPS-01, Salt Lake City, Utah. [http://www.geopp.de/download/ion2001-gnsmart\\_p.pdf](http://www.geopp.de/download/ion2001-gnsmart_p.pdf)
- Wübbena, G., S. Willgalis (2001). State Space Approach for Precise Real Time Positioning in GPS Reference Networks. Presented at International Symposium on Kinematic Systems in Geodesy, Geomatics and Navigation, KIS-01, Banff, June 5-8, Canada.  
<http://www.geopp.de/download/kis2001.pdf>
- Wübbena, G. (2001). On the Modelling of GNSS Observations for High-Precision Position Determination. Translation of Wübbena, G. (2001). Zur Modellierung von GNSS-Beobachtungen für die hochgenaue Positionsbestimmung. Wissenschaftliche Arbeiten Fachrichtung Vermessungswesen an der Universität Hannover, Festschrift Prof. G. Seeber zum 60. Geburtstag, Nr. 239, Hannover, 143-155. [http://www.geopp.de/download/seeb60\\_wuebbena\\_e.pdf](http://www.geopp.de/download/seeb60_wuebbena_e.pdf)
- Wübbena, G., A. Bagge, M. Schmitz (2000). GPS-Referenznetze und internationale Standards. Vorträge des 3. SAPOS-Symposium der Arbeitsgemeinschaft der Vermessungsverwaltungen der Länder der Bundesrepublik Deutschland (AdV), 23.-24. Mai 2000, München, Germany, 14-23.  
[http://www.sapos.de/pdf/3symposium/SAPOS\\_V03.pdf](http://www.sapos.de/pdf/3symposium/SAPOS_V03.pdf)
- Wübbena, G. (1999). GNSMART RTK Lösungen bei starker Sonnenaktivität. AdV, Vortrag zum 2. SAPOS-Symposium, 10-11. Mai 1999, Berlin. <http://www.geopp.de/download/sapos99.pdf>
- Wübbena, G. (1998). GNSS-SMART: Echtzeit-GPS genauer als 1 Zentimeter. Vorträge des 1. SAPOS-Symposium der Arbeitsgemeinschaft der Vermessungsverwaltungen der Länder der Bundesrepublik Deutschland (AdV), 11-12. Mai 1998, Hamburg, Germany, 161-172. (English version: <http://www.geopp.de/download/sapos98en.pdf>)

Wübbena, G., A. Bagge (1997). Neuere Entwicklungen zu GNSS-RTK für optimierte Genauigkeit, Zuverlässigkeit und Verfügbarkeit: Referenzstationsnetze und Multistations-RTK-Lösungen. DVW-Seminar GPS-Praxis und Trends '97, 30.9.-1.10.1997, Frankfurt/M., DVW Schriftenreihe 35/1999, Verlag Konrad Wittwer, 73-92. <http://www.geopp.de/download/dvw97.pdf>

Wübbena, G., A. Bagge, G. Seeber, V. Böder, P. Hankemeier (1996). Reducing Distance Dependent Errors for Real-Time Precise DGPS Applications by Establishing Reference Station Networks. Proceedings of the International Technical Meeting, ION GPS-96, Kansas City, Missouri, 1845-1852. <http://www.geopp.de/download/kansas96.pdf>

An example data set of RTCM data with embedded type 59-FKP messages according to this definition and its decoded values can be found at <http://www.geopp.de/download/fkp59adv.zip>.

**Table 1. Message type 59-FKP - FKP network parameters**

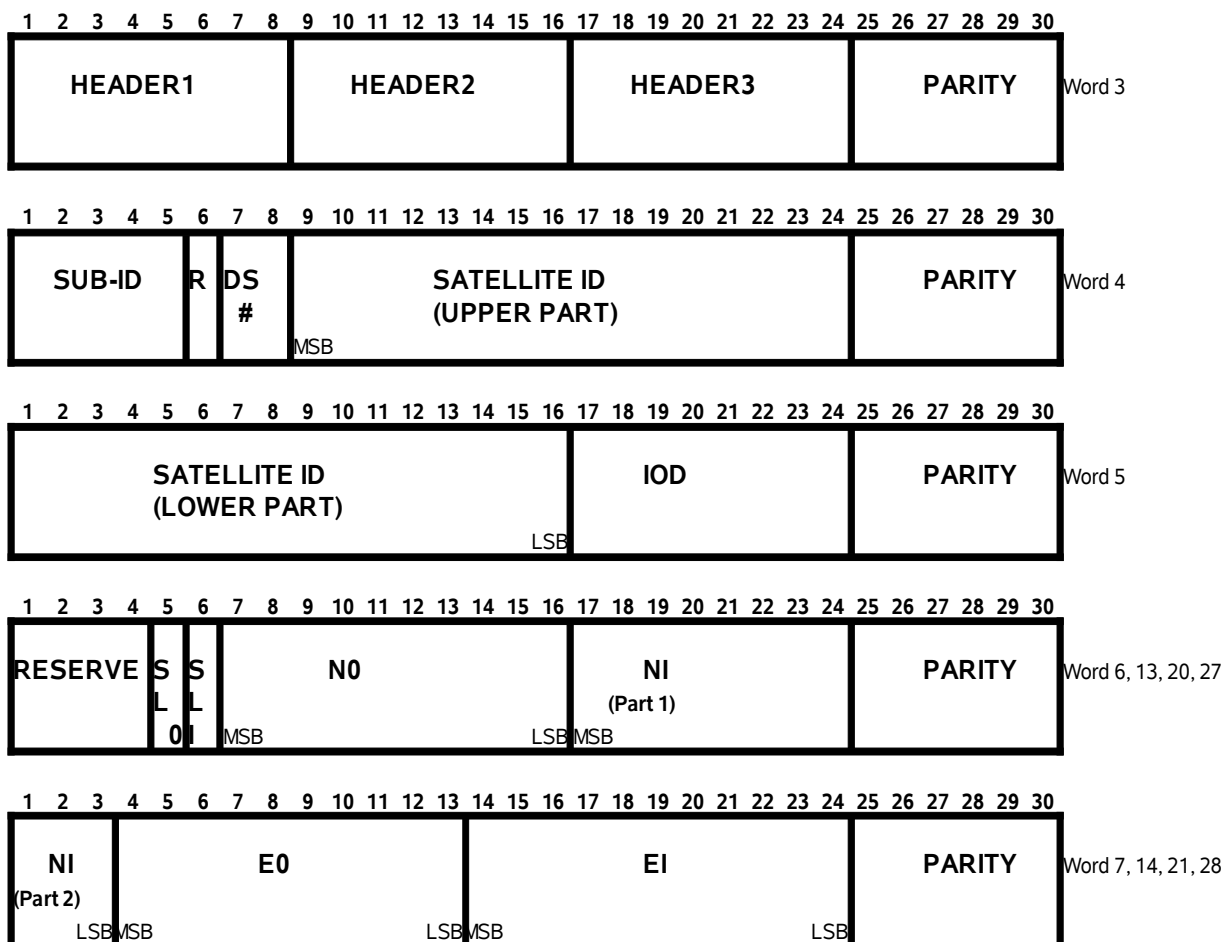


Table 1 continued on next page...

**Table 1. Message type 59-FKP - FKP network parameters (continued)**

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30																																		
IOD								RESERVE				S	S	NO												PARITY						Word 8, 15, 22, 29		
												L	L	MSB												LSB								
												0	I																					
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30																																		
NI												E0												EI				PARITY						Word 9, 16, 23, 30
MSB												LSB												MSB				LSB						
																								(Part 1)										
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30																																		
EI (PART 2)								IOD								RESERVE				S	S	NO				PARITY						Word 10, 17, 24, 31		
LSB																				L	L	(P. 1)												
																				0	I	MSB												
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30																																		
NO (Part 2)								NI												E0				PARITY						Word 11, 18, 25, 32				
LSB								MSB												LSB				MSB										
																				(Part 1)														
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30																																		
E0 (Part 2)				EI												IOD								PARITY						Word 12, 19, 26, 33				
LSB				MSB												LSB																		

**Table 2. Contents of a type 59-FKP message**

PARAMETER	NO. OF BITS	SCALE FACTOR AND UNITS	RANGE
institution ID 1	8	--	'A' 0x41
institution ID 2	8	--	'd' 0x64
institution ID 3	8	--	'V' 0x56
SUB-ID	5	1	5-6, 0x05 for GPS, 0x06 for GLONASS
Reserve	1	--	0
DATA SET NR	2	1	0-3 derived from the counter n, which is incremented for each new set of FKP parameters: DATA SET NR = (n%4)
SAT-ID	32	--	0-31 bits are set for each satellite with FKP, bit 0 represents the satellite with PRN 1, bit 1 the satellite PRN 2, and so on
IOD	8	1	0-255 (according to message type 1)
Reserve	4	1	0
SL0	1	--	0: SL0=0.01 ppm, 1: SL0 =0.04 ppm
SLI	1	--	0: SLI=0.01 ppm, 1: SLI =0.04 ppm
N0	10	SL0 (0.01 or 0.04) ppm	+/- 5.11 or +/- 20.47
NI	11	SLI (0.01 or 0.04) ppm	+/- 10.23 or +/- 40.95
E0	10	SL0 (0.01 or 0.04) ppm	+/- 5.11 or +/- 20.47
EI	11	SL0 (0.01 or 0.04) ppm	+/- 10.23 or +/- 40.95

## **Document History**

2002-04-17 Version 1.0: Document created

2006-03-01 Version 1.1: Specification extensions for GLONASS