Geo++® White Paper
Nr. 2002.01

RTCM Message Type 59−FKP for transmission of FKP

Version 1.0

Gerhard Wübbena, Andreas Bagge

Geo++® Gesellschaft für satellitengestützte geodätische und navigatorische Technologien mbH
D−30827 Garbsen, Germany
http://www.geopp.de

Garbsen, 17. April 2002

1. 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 of this document describes the format of these FKPs in a special RTCM type 59 message.

2. Definitions

2.1 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 (φ,λ) referring to this surface for phase observations of a mobile rover are then used to derive the distance dependent errors with

$$\delta r_0 = 6.37\ \left(N_0\,(\varphi-\varphi_R) + E_0\,(\lambda-\lambda_R)\cos(\varphi_R)\right)$$
$$\delta r_I = 6.37\ H\left(N_I\,(\varphi-\varphi_R) + E_I\,(\lambda-\lambda_R)\cos(\varphi_R)\right)$$

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]

 © 2002 Geo++® GmbH

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 "nar−row lane") in [ppm]
φ_R, λ_R	the geographic coordinates of the reference station in WGS84 datum in [rad]
H	$H = 1 + 16\,(0.53 - E/\pi)^3$
E	the elevation angle of the satellite in [rad]
δr_0	the distance dependent error for the geometric (ionosphere free) signal [m]
δr_I	the distance dependent error for the ionospheric ("narrow lane") signal [m]

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:

δr_1	distance dependent error for L1
δr_2	distance dependent error for L2

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

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

2.2 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".

3. 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 3rd 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.

Data set number

The *data set number* identifies the FKP parameter set. This number (n) is consecutively incre−mented 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 corre−sponding 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. Op−posite 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 consis−tently, 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 ex−treme conditions (scale bits set to 1) the resolution is reduced to 4 mm / 100 km. Thus, the corre−sponding 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 rsp., the parameters *E0,EI* are the corresponding FKPs for the east−west compo−nents.

 © 2002 Geo++® GmbH

Reserve

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

4. 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.rtcm.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 Naviga− tion, November 14.−16., 2001, Tokyo, Japan. 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

Wübbena, G., A. Bagge, M. Schmitz (2001). RTK Networks based on Geo++® GNSMART − Con− cepts, Implementation, Results. Presented at the International Technical Meeting, ION GPS− 01, Salt Lake City, Utah. 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 Geod− esy, 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 Deter− mination. Translation of Wübbena, G. (2001). Zur Modellierung von GNSS−Beobachtungen für die hochgenaue Positionsbestimmung. Wissenschaftliche Arbeiten Fachrichtung Ver− messungswesen 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

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

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 Zentimerter. Vorträge des 1. SAPOS−Symposium der Arbeitsgemeinschaft der Vermessungsverwaltungen der Länder der Bundesrepublik Deutschland (AdV), 11−12. Mai 1998, Hamburg, Germany, 161−172. (Eng− lish 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.

 © 2002 Geo++® GmbH

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

Bits 1–8	Bits 9–16	Bits 17–24	Bits 25–30	
HEADER1	HEADER2	HEADER3	PARITY	Word 3

Bits 1–5	Bit 6	Bits 7–8	Bits 9–24	Bits 25–30	
SUB-ID	R	DS #	SATELLITE ID (UPPER PART) MSB	PARITY	Word 4

Bits 1–16	Bits 17–24	Bits 25–30	
SATELLITE ID (LOWER PART) LSB	IOD	PARITY	Word 5

Bits 1–4	Bit 5	Bit 6	Bits 7–16	Bits 17–24	Bits 25–30	
RESERVE	SL0	SLI	N0 MSB … LSB	NI (Part 1) MSB	PARITY	Word 6, 13, 20, 27

Bits 1–3	Bits 4–13	Bits 14–24	Bits 25–30	
NI (Part 2) LSB	E0 MSB … LSB	EI MSB … LSB	PARITY	Word 7, 14, 21, 28

Table 1 continued on next page...

 © 2002 Geo++® GmbH

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

1–8	9–12	13	14	15–24	25–30	
IOD	RESERVE	SL0	SLI	N0	PARITY	Word 8, 15, 22, 29
				MSB … LSB		

1–11	12–21	22–24	25–30	
NI	E0	EI (Part 1)	PARITY	Word 9, 16, 23, 30
MSB … LSB	MSB … LSB	MSB		

1–8	9–16	17–20	21	22	23–24	25–30	
EI (PART 2)	IOD	RESERVE	SL0	SLI	N0 (P. 1)	PARITY	Word 10, 17, 24, 31
LSB					MSB		

1–8	9–19	20–24	25–30	
N0 (Part 2)	NI	E0 (Part 1)	PARITY	Word 11, 18, 25, 32
LSB	MSB … LSB	MSB		

1–5	6–16	17–24	25–30	
E0 (Part 2)	EI	IOD	PARITY	Word 12, 19, 26, 33
LSB	MSB … LSB			

 © 2002 Geo++® GmbH

Table 2. Contents of a type 59−FKP message

PARAMETER	NO. OF BITS	SCALE FAC−TOR 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 0x05
Reserve	1	−−	0
DATA SET NR	2	1	0−3 derived from the counter n, which is incre−mented 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

 © 2002 Geo++® GmbH