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Fred Gloeckler

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U.S. Army Topographic Engineering Center
ATTN: CETEC-LO
Fort Belvoir, VA 22060-5546

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The Radio Technical Commission for Maritime Services (RTCM) Recommended standard for Differential NAVSTAR/GPS Service have been widely adopted for code based differential GPS applications. With the present and expected future state of development of carrier phase technology, it is time to revise the RTCM standards to accommodate differential carrier phase GPS applications. A working group has been established to develop changes to the standards for carrier phase data. This is a status report of the first meeting and future plans of the Carrier Phase Communication Working Group.

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STATUS REPORT
RTCM SPECIAL COMMITTEE No. 104, CARRIER PHASE WORKING GROUP

Fred Gloeckler
U.S. Army Topographic Engineering Center

BIOGRAPHY

Fred Gloeckler received a B.S. degree in Electrical Engineering from Lehigh University in 1966. Since that time he has worked for the U.S. Army Corps of Engineers. He has participated in the development of several inertial and satellite and airborne radio frequency systems for military and civil positioning. He chairs the RTCM SC-104 GPS Carrier Phase Communication Working Group.

ABSTRACT

The Radio Technical Commission for Maritime Services (RTCM) Recommended Standards for Differential NAVSTAR/GPS Service have been widely adopted for code based differential GPS applications. With the present and expected future state of development of carrier phase technology, it is time to revise the RTCM standards to accommodate differential carrier phase GPS applications. A working group has been established to develop changes to the standards for carrier phase data. This is a status report of the first meeting and future plans of the Carrier Phase Communication Working Group.

INTRODUCTION

The RTCM Recommended Standards for Differential NAVSTAR/GPS Service have been adopted by many GPS manufacturers and system integrators for code based differential (DGPS) applications.[1] These standards were developed by RTCM Special Committee 104 (SC-104) which had the foresight to allow for modification and growth of the standards as new requirements become known.

GPS carrier phase measurements routinely are used for determination of precise positions using static, kinematic and pseudo-kinematic differential survey techniques. Recent developments indicate the feasibility of initializing kinematic surveys "on-the-fly" without requiring the roving receiver to occupy known or fixed positions.[2][3] Many users desire precise differential positioning in real time.

The RTCM standards contain a tentative Surveying Parameters message which incorporates carrier phase data. With present knowledge, it's felt the Surveying Parameters message is inadequate to support real-time, carrier phase applications. As far as we know,

the Surveying Parameters message has not been implemented in practice.

Based on the perceived need, it was decided to establish a GPS Carrier Phase Communication Working Group, under RTCM SC 104, to recommend changes to the standards. The first working group meeting was held on December 4-5, 1991, at the U.S. Department of Transportation Headquarters, Washington, D.C. The meeting was attended by an international group of recognized GPS experts. This status report summarizes that meeting and future plans for the working group.

TERMS OF REFERENCE

The major tasks in the terms of reference adopted by the GPS Carrier Phase Communications Working Group are:

(a) Review the RTCM Recommended Standards For Differential NAVSTAR/GPS Service, Version 2.0, January 1, 1990, for suitability in communicating GPS carrier phase information in near real time.

(b) Where warranted, propose changes or additions to the messages defined in the Version 2.0 Recommended Standards to support carrier phase applications. Proposed changes or additions shall comply with the basic message formats defined in the Recommended Standards, Version 2.0.

(c) Consider all potential applications requiring communication of GPS carrier phase information. Known applications include static and precise kinematic surveys. It is desired that the number of messages supporting communication of carrier phase data be minimized. However, it is recognized that different applications may require different messages for efficient communication of the needed information.

(d) Provide recommended changes for consideration by RTCM Special Committee No. 104 by 1 July 1992.[4]

APPLICATIONS

At the meeting, Steve DeLoach described some of the potential, real-time, differential, carrier phase applications within the construction, dredging and maintenance civil works programs of the U.S. Army Corps of Engineers. Ben Remondi classified applications by their use of real-time data (e.g., real-time precise positioning, data distribution for post processing, on-site processing for quality control, etc.).

Potential applications include: construction, dredging, hydrographic survey, land survey, tidal datum determination, aircraft landing approach control, navigation of aircraft on the ground, deformation monitoring, photogrammetric survey control, reference benchmark for land surveys, robotic guidance and control, range control, and calibration of other sensors.

DATA FORMATS

Günter Hein presented message formats, developed by members of the German ION, for transmission of raw carrier phase, pseudorange and doppler data. Three message formats were proposed for L1 only, L1 and code L2, and L1 and codeless L2. Provisions were made to

include reference station coordinates in the messages, if needed.

Ron Hatch proposed transmission of carrier phase differential corrections in lieu of raw data. The carrier phase correction is the calculated satellite to reference station range (in carrier cycles) minus the measured carrier phase at the time of measurement. To avoid large biases in the corrections, the whole cycle value of the initial phase measurement is set to the code range. Alternatively, the whole cycle value of the initial correction can be set to zero. When the corrections are applied at the remote receiver, any errors in the reference station integer ambiguities are absorbed in the remote station ambiguities. Advantages claimed for this approach were: data transmission rate is reduced, time sensitivity of the data is reduced, data transmission rate is flexible, and the remote receiver's computational load is reduced.

DATA ELEMENTS

Most of the meeting discussion involved deciding which data elements were needed and their range, resolution and accuracy requirements. It was agreed that raw measurements may be more suitable for some applications and carrier phase corrections for others.

Draft "strawman" formats for three messages were developed for carrier phase corrections, uncorrected carrier phase measurements, and uncorrected pseudorange measurements.[5][6][7] Because the data formats are "work in progress," all the details won't be presented here. The draft formats conform to the basic RTCM message structure.

The three "strawman" messages share a higher resolution time tag which augments the modified Z-Count in the RTCM header. The time tag and a L1/L2 indicator flag are common to all measurements within a message.

Measurement or correction data is provided for each satellite being observed. The Issues of Data for the ephemerides used to compute corrections are given in the Carrier Phase Correction Message. Flags are provided for full or half-cycle L2 carrier phase and C/A-code or P-code measurements, where appropriate. There is a cumulative loss-of-continuity indicator for the phase messages.

Representation of data quality in a meaningful manner was discussed, but not resolved. Space was included in the message formats for data quality, however, definition was left for future meetings.

Also deferred for consideration were transmission of reference station information not included in the type 3 message and transmission of ionospheric and tropospheric correction information.

PLANS

The next working group meeting is scheduled to follow the closing luncheon of the ION National Technical Meeting. Topics to be discussed include: representation of data quality, review of the "strawman" message formats, the need for further reference station information, and transmission of ionospheric and tropospheric correction data.

SUMMARY

In its first meeting, the GPS Carrier Phase Communication Working Group has made considerable progress in drafting three message formats for transmission of carrier phase corrections and raw carrier phase and pseudorange data. Additional effort will be devoted to defining data quality indicators and considering the needs for transmission of reference station, ionospheric correction and tropospheric correction information, as well as refining the "strawman" formats.

ACKNOWLEDGEMENT

Development of standards is a group effort. Many individuals contributed to the discussions which resulted in the progress made in the first meeting. Their participation makes the chairman's job easy and is gratefully acknowledged.

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