Real-Time GNSS Data Transmission Standard RTCM 3.0

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Outline

- RTCM Overview
- RTCM SC104 DGNSS Standards
- RTCM 3.0 Standard
  - General Structure
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- Other Issues
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Radio Technical Commission for Maritime Services

www.rtcm.org

Slides borrowed from:

RTCM SC-104: Enabling Standards that Support Emerging Positioning and Related Technologies

Rudy Kalfus (SC-104 Chairman)
Bob Markle (RTCM President)

Streaming GNSS Data Via Internet-Symposium
Frankfurt, 6 February 2006

RTCM founded in 1947 as U.S. State Department Advisory Committee

Now an independent membership organization

RTCM Standards Work

RTCM Standards

RTCM supports development of standards and regulations of –

- International Maritime Organization (IMO)
- International Telecommunications Union (ITU)
- International Electrotechnical Commission (IEC)
- International Organization for Standardization (ISO)

RTCM Liaisons

European Telecommunications Standards Institute (ETSI)

Comité International Radio-Maritime (CIRM)

Cospas-Sarsat

International Association of Aids to Navigation and Lighthouse Authorities (IALA)

International Hydrographic Bureau (IHB)

National Marine Electronics Association (NMEA)

RTCM Members

22 Government Agencies from 7 nations

56 Manufacturers from 14 nations

41 Others:

- Associations
- Designers
- Trainers
- Service Providers
- Vessel Owners/Operators

RTCM Standards used internationally

SC104: Differential Global Navigation Satellite Systems (DGNSS)

SC109: Electronic Charts

RTCM regional Standards used in USA

SC101: Digital Selective Calling marine radios
SC110: Emergency Beacons
SC112: Radar
SC117: Electromagnetic Interference Resistance for marine radios
SC119: Maritime Survivor Locating Devices

RTCM SC-104 Differential GNSS Standards

- Originally set up in 1983 to develop standards for DGPS to achieve 5 meter accuracy navigation & positioning
- Version 1 was replaced by Version 2, when implmentation problems turned up (1990)
- Version 2.1 added Real-Time Kinematic (RTK) messages to provide decimeter accuracy of short ranges (1994)
- Version 2.2 expanded diffrential operation to GLONASS, provided ancillary RTK messages (1998)
- Version 2.3 added several new messages to improve RTK, radiobeacon broadcasts, use of Loran-C (2001)

RTCM SC-104 Differential GNSS Standards

- Inefficiency of Version 2 messages led to the development of an improved format – more efficient, higher integrity, and simplicity of development – Version 3.0 (2004)
- Version 3 primariliy aimed at improving RTK, supporting networked RTK
- Current Working Groups: Network RTK, Internet Protocol, Coordinate Transformations, Reference Station Integrity Monitoring, GLONASS, Galileo
- New Proposed Working Group: Encryption

RTCM SC-104 Differential GNSS Standards

- While the Commission was originally set up to address maritime standards, DGNSS standards are applied world-wide to land and maritime positioning systems
- One strength of the SC-104 Committee is that paritcipating companies benefit from world-wide standards, thus are motivated to develop them
- Participants include vendors, service providers and government agencies from around the world
- Standards are subjected to performance and interoperability testing prior to adoption and publication

RTCM 3.0 General Structure

- Scope: OSI standard reference model
  - Application Layer (brief discussion)
  - **Presentation Layer (Data Field and Message Definition)**
  - **Transport Layer (Message Framing, CRC)**
  - Data Link Layer (no specifications, up to service providers)
    - **RTCM-NTRIP**
  - Physical Layer (no specifications, up to service providers)
- Version 3 Database Architecture
  - Definition of **Data Fields (DF)** (fixed length, variable length text)
    - Data Fields not on Byte Boundaries for Maximum Compression
  - Definition of **Message Types (MT)** composed of Data Fields
- Format designed for Broadcast Transmission

RTCM3.0: DF Examples

DF #	DF Name	DF Range	DF Resolution	Data Type	Data Field Notes
DF003	Reference Station ID	0-4095		uint12	The Reference Station ID is determined by the service provider. Its primary purpose is to support multiple reference stations within a single data link transmission. It is also useful in distinguishing between desired and undesired data in cases where more than one service may be using the same data link frequency.
DF009	L1 Pseudo-range	0-299792.46 m	0.02m	uint24	The GPS L1 Pseudorange field provides the raw L1 pseudorange measurement at the reference station in meters, modulo one lightmillisecond (299,792.458 meters). The GPS L1 pseudorange measurement is reconstructed by the user receiver from the L1 pseudorange field by: (GPS L1 pseudorange measurement) = (GPS L1 pseudorange field) modulo (299,792.458 m) + integer as determined from the user receiver's estimate of the reference station range, or as provided by the extended data set. If DF012 is set to 80000h, this field does not represent a valid L1 pseudorange, and is used only in the calculation of L2 measurements.

RTCM3.0: MT Example

DATA FIELD	DF #	DATA TYPE	NO. OF BITS	NOTES
Satellite ID	DF007	uint6	6	
P(Y)/CA Code Indicator	DF008	bit(1)	1	
Reserved	DF001	bit(1)	1	
L1 Pseudorange	DF009	uint24	24	
L1 PhaseRange – L1 Pseudorange	DF010	int20	20	
L1 Lock time Indicator	DF011	bit(3)	3	
Reserved	DF001	bit(1)	1	
Integer L1 Pseudorange Modulus Ambiguity (8 MSB's of Pseudorange)	DF012	uint8	8	
L1 CNR	DF013	uint8	8	
TOTAL			***72***	

Table 3.5-3: Contents of the Satellite-Specific Portion of a Type 1002 Message, Each Satellite – GPS Extended RTK, L1 Only

RTCM 3.0 Message Groups, Message Types (MT)

- Observations
  - GPS L1 MT: 1001, 1002
  - GPS L1/L2 MT: 1003, 1004
  - GLONASS L1 MT: 1009, 1010
  - GLONASS L1/L2 MT: 1011, 1012
- Station Coordinates MT: 1005,1006
- Antenna Description MT: 1007,1008
- Auxiliary Operation Information MT: 1013
- Supplement # 1: (to be decided in May 2006)
  - GPS Ephemeris MT: 1019
  - GLONASS Ephemeris MT: 1020
  - Network RTK (MAC) MT: 1014-1017
  - Proprietary Messages MT: 4088-4095

RTCM 3.0 Raw Data Messages

- Observables (GPS, SBAS and GLONASS):
  - Pseudorange (C/A,P1(Y),P2(Y),P2(Y) cross correlated,Correlated P/Y)
  - PhaseRange (L1,L2)
  - Carrier to Noise Ratio (L1,L2) [dB-Hz]
- Observable Related Parameters
  - Pseudorange Smoothing Parameters (Smoothing Interval 0…unlimited)
  - Loss of Lock: Lock Time Indicator
  - GLONASS Frequency Number
- Compression Method
  - L1 Pseudorange Modulo 1ms (2ms GLONASS) or Full L1 Pseudorange
  - L2 Pseudorange – L1 Pseudorange (+/- 163.82 m)
  - L1 PhaseRange – L1 Pseudorange (+/- 262.143 m + Overflow)
  - L2 PhaseRange – L2 Pseudorange (+/- 262.143 m + Overflow)

RTCM 3.0 Raw Data Messages

- Observables
  - MT 1001,1002,1009,1010 L1 Only
  - **MT 1003,1004,1011,1012 L1+L2**
  - MT 1001,1003,1009,1011 – PR Modulo 1ms, no CNO
    - Requires Receiver (or Software) **Clock Steering** (+/- 100 ns)
  - **MT 1002,1004,1010,1012 – Full PR,2 Codes, 2 Carriers, 2CNO**
    - **Clock Steering** required, although not necessary (atomic clocks?)
  - Transmission of **3 or more signals** (Code,Carrier,CNO) possible through **combination of messages** (1004,1002), but currently not allowed
  - Pseudoranges may be smoothed or unsmoothed
    - No simultaneous transmission of both
- **Bandwidth Requirement (10 SVs, MT 1004)**
  - 1368 Bits (171 Bytes) per Epoch
- **Maximum Data Rate: 1000 Hz**

RTCM 3.0: Antenna Description Message

- Reference Station ID (DF003)
- Antenna Descriptor (DF030)
  - IGS Naming Convention for Antenna Type
- Antenna Setup ID (DF031)
  - To be changed every time a change occurs at the station that could affect the antenna phase center variations (PCV)
- Antenna Serial Number (DF033)
  - Alphanumeric Characters, allows unique identification of individual antennas in conjunction with „Antenna Descriptor“

RTCM 3.0: Reference Station Coordinates

- Reference Station ID (DF003)
- Antenna Reference Point (ARP) Coordinates
  - ECEF-X (DF025)
  - ECEF-Y (DF026)
  - ECEF-Z (DF027)
- Antenna Height (ARP) above Marker (DF028)

RTCM 3.0 Transport Layer

- 8 Bits Preamble
- 6 Bits reserved
- 10 Bits Message Length
- 0-1023 Bytes of Data
  - (the Messages Defined in Presentation Layer)
- 24 Bits CRC
  - QualComm CRC-24Q
  - Probability of undetected errors < 2^{-24} for channel bit error probabilities < 0.5

Real Time Format Features/Requirements

	RTCM	IGS
• Observables for all Signals	Yes/No	x
• Observables	Resolution	
– Code (Pseudorange)	2 cm	?
– Phase (Phaserange)	0.5 mm	?
– Doppler	-	?
– Loss Of Lock Indicator (Lock Time)	LockTime	?
– Carrier to Noise Ratio (Standardized ?)	0.25 dbHz	?
– Channel Number	-	?
– Wavelength Factor	-	?
• Time Tag Resolution	1 ms	?
• Data Rate	<1000 Hz	1Hz min.
• Compression	Yes	?

Format Comparison

	RTCM 3.0	SOC	BINEX 0x7f-00	RINEX 2.2
Pseudorange	C/A + P2(Y) or P1(Y) + P2(Y)	C/A + P1 + P2	C/A + P1 + P2	C/A + P1 +P2
PR Resolution	0.02 m	0.001 m	0.001 m	0.001 m
Carrier Phase	LA + L2 or L1 + L2	L1 + L2	L1 + L2 + LA	L1 + L2 + LA
Carrier Phase Resoultion	0.5 mm	0.02 mm	0.0001 Cycles = 0.02 mm	0.001 cyles = 0.2 mm
Wavelength Factor	-	-	-	+
Doppler	-	-	0x7f-02	+
CNO	L1+L2	C/A + L1 + L2	+	S1,S2,SA
CNO Resolution	0.25 db-Hz	1	1,0.25 Rx Dep.	0.001 Rx Dep.
Loss of Lock	Lock Time	-		Slip Flag
Time Tag Resolution	1 ms	1 ms		100 ns
NavTime	Clock Steering (100 ns)	10 m		1 ns

Other Issues – Currently not Supported by RTCM3

- Is there need for a Standardized Receiver Control Protocol ?
  - Rx Setup: (Elevation, Data Rate,…)
  - Reset
  - Data Retrieval, …
- Is there need for Data Encryption ?
- Kinematic and Stop and Go Support
- More Meta-Data
  - Receiver Type / Serial Number / FW Versions, …
- Support for Standardized Meteorological Data/Sensors
- Support for Products
  - State Space Parameters (Orbits, Clocks, Biases, Iono, Tropo…)

Summary

- RTCM3.0 provides GNSS Raw Data in a Compressed Format
- RTCM is the major GNSS Standard for Real Time Data exchange
  - Directly supported by most Geodetic Receivers
  - Supported by Service Providers
- Flexible Structure, easily extendable
- RTCM3.0 is a good choice for a Standardized Raw Data Format
  - IGS requirements not fulfilled yet, may be considered by SC104
  - **IGS** should become a **member of RTCM**
- Next RTCM SC104 Meeting: May 11-12, 2006
  - 3 Meetings per Year

Thank you for your attention