

4.2.9 GNSS Position, Velocity and Time Blocks

PVTCartesian	Number: 4006
	"OnChange" interval: default PVT output rate (see 4.1.8)

This block contains the GNSS-based position, velocity and time (PVT) solution at the time specified in the `TOW` and `WNc` fields. The time of applicability is specified in the receiver time frame.

The computed position (x , y , z) and velocity (v_x , v_y , v_z) are reported in a Cartesian coordinate system using the datum indicated in the `Datum` field. The position is that of the marker. The ARP-to-marker offset is set through the command **setAntennaOffset**.

The PVT solution is also available in ellipsoidal form in the `PVTGeodetic` block.

The variance-covariance information associated with the reported PVT solution can be found in the `PosCovCartesian` and `VelCovCartesian` blocks.

If no PVT solution is available, the `Error` field indicates the cause of the unavailability and all fields after the `Error` field are set to their respective Do-Not-Use values.

Parameter	Type	Units	Do-Not-Use	Description
Sync1	c1			Block Header, see 4.1.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 4.1.3
WNc	u2	1 week	65535	
Mode	u1			<p>Bit field indicating the GNSS PVT mode, as follows:</p> <p>Bits 0-3: type of PVT solution:</p> <ul style="list-style-type: none"> 0: No GNSS PVT available (the <code>Error</code> field indicates the cause of the absence of the PVT solution) 1: Stand-Alone PVT 2: Differential PVT 3: Fixed location 4: RTK with fixed ambiguities 5: RTK with float ambiguities 6: SBAS aided PVT 7: moving-base RTK with fixed ambiguities 8: moving-base RTK with float ambiguities 10: Precise Point Positioning (PPP) 12: Reserved <p>Bits 4-5: Reserved</p> <p>Bit 6: Set if the user has entered the command <code>setPVTMode, Static, auto</code> and the receiver is still in the process of determining its fixed position.</p> <p>Bit 7: 2D/3D flag: set in 2D mode (height assumed constant and not computed).</p>
Error	u1			<p>PVT error code. The following values are defined:</p> <ul style="list-style-type: none"> 0: No Error 1: Not enough measurements 2: Not enough ephemerides available 3: DOP too large (larger than 15) 4: Sum of squared residuals too large 5: No convergence 6: Not enough measurements after outlier rejection 7: Position output prohibited due to export laws 8: Not enough differential corrections available 9: Base station coordinates unavailable 10: Ambiguities not fixed and user requested to only output RTK-fixed positions
X	f8	1 m	$-2 \cdot 10^{10}$	X coordinate in coordinate frame specified by <code>Datum</code>
Y	f8	1 m	$-2 \cdot 10^{10}$	Y coordinate in coordinate frame specified by <code>Datum</code>
Z	f8	1 m	$-2 \cdot 10^{10}$	Z coordinate in coordinate frame specified by <code>Datum</code>
Undulation	f4	1 m	$-2 \cdot 10^{10}$	Geoid undulation. See the <code>setGeoidUndulation</code> command.
Vx	f4	1 m / s	$-2 \cdot 10^{10}$	Velocity in the X direction
Vy	f4	1 m / s	$-2 \cdot 10^{10}$	Velocity in the Y direction
Vz	f4	1 m / s	$-2 \cdot 10^{10}$	Velocity in the Z direction

COG	f4	1 degree	$-2 \cdot 10^{10}$	Course over ground: this is defined as the angle of the vehicle with respect to the local level North, ranging from 0 to 360, and increasing towards east. Set to the Do-Not-Use value when the speed is lower than 0.1m/s.
RxClkBias	f8	1 ms	$-2 \cdot 10^{10}$	Receiver clock bias relative to the GNSS system time reported in the <code>TimeSystem</code> field. Positive when the receiver time is ahead of the system time. To transfer the receiver time to the system time, use: $t_{GPS/GST} = t_{rx} - RxClkBias$
RxClkDrift	f4	1 ppm	$-2 \cdot 10^{10}$	Receiver clock drift relative to the GNSS system time (relative frequency error). Positive when the receiver clock runs faster than the system time.
TimeSystem	u1		255	Time system of which the offset is provided in this sub-block: 0: GPS time 1: Galileo time 3: GLONASS time 4: BeiDou time 5: QZSS time
Datum	u1		255	This field defines in which datum the coordinates are expressed: 0: WGS84/ITRS 19: Datum equal to that used by the DGNSS/RTK base station 30: ETRS89 (ETRF2000 realization) 31: NAD83(2011), North American Datum (2011) 32: NAD83(PA11), North American Datum, Pacific plate (2011) 33: NAD83(MA11), North American Datum, Marianas plate (2011) 34: GDA94(2010), Geocentric Datum of Australia (2010) 35: GDA2020, Geocentric Datum of Australia 2020 250: First user-defined datum 251: Second user-defined datum
NrSV	u1		255	Total number of satellites used in the PVT computation.
WACorrInfo	u1		0	Bit field providing information about which wide area corrections have been applied: Bit 0: set if orbit and satellite clock correction information is used Bit 1: set if range correction information is used Bit 2: set if ionospheric information is used Bit 3: set if orbit accuracy information is used (UERE/SISA) Bit 4: set if DO229 Precision Approach mode is active Bits 5-7: Reserved
ReferenceID	u2		65535	This field indicates the reference ID of the differential information used. In case of DGPS or RTK operation, this field is to be interpreted as the base station identifier. In SBAS operation, this field is to be interpreted as the PRN of the geostationary satellite used (from 120 to 158). If multiple base stations or multiple geostationary satellites are used the value is set to 65534.
MeanCorrAge	u2	0.01 s	65535	In case of DGPS or RTK, this field is the mean age of the differential corrections. In case of SBAS operation, this field is the mean age of the 'fast corrections' provided by the SBAS satellites.
SignalInfo	u4		0	Bit field indicating the type of GNSS signals having been used in the PVT computations. If a bit i is set, the signal type having index i has been used. The signal numbers are listed in section 4.1.10. Bit 0 (GPS-C/A) is the LSB of <code>SignalInfo</code> .

Rev 1

AlertFlag	u1		0	<p>Bit field indicating integrity related information:</p> <p>Bits 0-1: RAIM integrity flag: 0: RAIM not active (integrity not monitored) 1: RAIM integrity test successful 2: RAIM integrity test failed 3: Reserved</p> <p>Bit 2: set if integrity has failed as per Galileo HPCA (HMI Probability Computation Algorithm)</p> <p>Bit 3: set if Galileo ionospheric storm flag is active</p> <p>Bit 4: Reserved</p> <p>Bits 5-7: Reserved</p>
NrBases	u1		0	Number of base stations used in the PVT computation.
PPPInfo	u2	1 s	0	<p>Bit field containing PPP-related information:</p> <p>Bits 0-11: Age of the last seed, in seconds. The age is clipped to 4091s. This field must be ignored when the seed type is 0 (see bits 13-15 below).</p> <p>Bit 12: Reserved</p> <p>Bits 13-15: Type of last seed: 0: Not seeded or not in PPP positioning mode 1: Manual seed 2: Seeded from DGPS 3: Seeded from RTKFixed</p>
Latency	u2	0.0001 s	65535	Time elapsed between the time of applicability of the position fix and the generation of this SBF block by the receiver. This time includes the receiver processing time, but not the communication latency.
HAccuracy	u2	0.01 m	65535	2DRMS horizontal accuracy: twice the root-mean-square of the horizontal distance error. The horizontal distance between the true position and the computed position is expected to be lower than <code>HAccuracy</code> with a probability of at least 95%. The value is clipped to 65534 = 655.34m
VAccuracy	u2	0.01 m	65535	2-sigma vertical accuracy. The vertical distance between the true position and the computed position is expected to be lower than <code>VAccuracy</code> with a probability of at least 95%. The value is clipped to 65534 = 655.34m.
Misc	u1			<p>Bit field containing miscellaneous flags:</p> <p>Bit 0: In DGNSS or RTK mode, set if the baseline points to the base station ARP. Unset if it points to the antenna phase center, or if unknown.</p> <p>Bit 1: Set if the phase center offset is compensated for at the rover, unset if not or unknown.</p> <p>Bit 2: Proprietary.</p> <p>Bit 3: Proprietary.</p> <p>Bits 4-5: Proprietary.</p> <p>Bits 6-7: Flag indicating whether the marker position reported in this block is also the ARP position (i.e. whether the ARP-to-marker offset provided with the <code>setAntennaOffset</code> command is zero or not) 0: Unknown 1: The ARP-to-marker offset is zero 2: The ARP-to-marker offset is not zero</p>
Padding	u1[.]			Padding bytes, see 4.1.5

Rev 2

PVTGeodetic	Number: 4007
	"OnChange" interval: default PVT output rate (see 4.1.8)

This block contains the GNSS-based position, velocity and time (PVT) solution at the time specified in the `TOW` and `WNc` fields. The time of applicability is specified in the receiver time frame.

The computed position (ϕ, λ, h) and velocity (v_n, v_e, v_u) are reported in an ellipsoidal coordinate system using the datum indicated in the `Datum` field. The velocity vector is expressed relative to the local-level Cartesian coordinate frame with north-, east-, up-unit vectors. The position is that of the marker. The ARP-to-marker offset is set through the command **setAntennaOffset**.

The PVT solution is also available in Cartesian form in the `PVTCartesian` block.

The variance-covariance information associated with the reported PVT solution can be found in the `PosCovGeodetic` and `VelCovGeodetic` blocks.

If no PVT solution is available, the `Error` field indicates the cause of the unavailability and all fields after the `Error` field are set to their respective Do-Not-Use values.

Parameter	Type	Units	Do-Not-Use	Description
Sync1	c1			Block Header, see 4.1.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 4.1.3
WNc	u2	1 week	65535	
Mode	u1			<p>Bit field indicating the GNSS PVT mode, as follows:</p> <p>Bits 0-3: type of PVT solution:</p> <ul style="list-style-type: none"> 0: No GNSS PVT available (the <code>Error</code> field indicates the cause of the absence of the PVT solution) 1: Stand-Alone PVT 2: Differential PVT 3: Fixed location 4: RTK with fixed ambiguities 5: RTK with float ambiguities 6: SBAS aided PVT 7: moving-base RTK with fixed ambiguities 8: moving-base RTK with float ambiguities 10: Precise Point Positioning (PPP) 12: Reserved <p>Bits 4-5: Reserved</p> <p>Bit 6: Set if the user has entered the command <code>setPVTMode, Static, auto</code> and the receiver is still in the process of determining its fixed position.</p> <p>Bit 7: 2D/3D flag: set in 2D mode (height assumed constant and not computed).</p>
Error	u1			<p>PVT error code. The following values are defined:</p> <ul style="list-style-type: none"> 0: No Error 1: Not enough measurements 2: Not enough ephemerides available 3: DOP too large (larger than 15) 4: Sum of squared residuals too large 5: No convergence 6: Not enough measurements after outlier rejection 7: Position output prohibited due to export laws 8: Not enough differential corrections available 9: Base station coordinates unavailable 10: Ambiguities not fixed and user requested to only output RTK-fixed positions
Latitude	f8	1 rad	$-2 \cdot 10^{10}$	Latitude, from $-\pi/2$ to $+\pi/2$, positive North of Equator
Longitude	f8	1 rad	$-2 \cdot 10^{10}$	Longitude, from $-\pi$ to $+\pi$, positive East of Greenwich
Height	f8	1 m	$-2 \cdot 10^{10}$	Ellipsoidal height (with respect to the ellipsoid specified by <code>Datum</code>)
Undulation	f4	1 m	$-2 \cdot 10^{10}$	Geoid undulation. See the <code>setGeoidUndulation</code> command.
Vn	f4	1 m / s	$-2 \cdot 10^{10}$	Velocity in the North direction
Ve	f4	1 m / s	$-2 \cdot 10^{10}$	Velocity in the East direction
Vu	f4	1 m / s	$-2 \cdot 10^{10}$	Velocity in the 'Up' direction

COG	f4	1 degree	$-2 \cdot 10^{10}$	Course over ground: this is defined as the angle of the vehicle with respect to the local level North, ranging from 0 to 360, and increasing towards east. Set to the Do-Not-Use value when the speed is lower than 0.1m/s.
RxClkBias	f8	1 ms	$-2 \cdot 10^{10}$	Receiver clock bias relative to the GNSS system time reported in the <code>TimeSystem</code> field. Positive when the receiver time is ahead of the system time. To transfer the receiver time to the system time, use: $t_{GPS/GST} = t_{rx} - RxClkBias$
RxClkDrift	f4	1 ppm	$-2 \cdot 10^{10}$	Receiver clock drift relative to the GNSS system time (relative frequency error). Positive when the receiver clock runs faster than the system time.
TimeSystem	u1		255	Time system of which the offset is provided in this sub-block: 0: GPS time 1: Galileo time 3: GLONASS time 4: BeiDou time 5: QZSS time
Datum	u1		255	This field defines in which datum the coordinates are expressed: 0: WGS84/ITRS 19: Datum equal to that used by the DGNSS/RTK base station 30: ETRS89 (ETRF2000 realization) 31: NAD83(2011), North American Datum (2011) 32: NAD83(PA11), North American Datum, Pacific plate (2011) 33: NAD83(MA11), North American Datum, Marianas plate (2011) 34: GDA94(2010), Geocentric Datum of Australia (2010) 35: GDA2020, Geocentric Datum of Australia 2020 250: First user-defined datum 251: Second user-defined datum
NrSV	u1		255	Total number of satellites used in the PVT computation.
WACorrInfo	u1		0	Bit field providing information about which wide area corrections have been applied: Bit 0: set if orbit and satellite clock correction information is used Bit 1: set if range correction information is used Bit 2: set if ionospheric information is used Bit 3: set if orbit accuracy information is used (UERE/SISA) Bit 4: set if DO229 Precision Approach mode is active Bits 5-7: Reserved
ReferenceID	u2		65535	This field indicates the reference ID of the differential information used. In case of DGPS or RTK operation, this field is to be interpreted as the base station identifier. In SBAS operation, this field is to be interpreted as the PRN of the geostationary satellite used (from 120 to 158). If multiple base stations or multiple geostationary satellites are used the value is set to 65534.
MeanCorrAge	u2	0.01 s	65535	In case of DGPS or RTK, this field is the mean age of the differential corrections. In case of SBAS operation, this field is the mean age of the 'fast corrections' provided by the SBAS satellites.
SignalInfo	u4		0	Bit field indicating the type of GNSS signals having been used in the PVT computations. If a bit i is set, the signal type having index i has been used. The signal numbers are listed in section 4.1.10. Bit 0 (GPS-C/A) is the LSB of <code>SignalInfo</code> .

Rev 1

AlertFlag	u1		0	<p>Bit field indicating integrity related information:</p> <p>Bits 0-1: RAIM integrity flag: 0: RAIM not active (integrity not monitored) 1: RAIM integrity test successful 2: RAIM integrity test failed 3: Reserved</p> <p>Bit 2: set if integrity has failed as per Galileo HPCA (HMI Probability Computation Algorithm)</p> <p>Bit 3: set if Galileo ionospheric storm flag is active</p> <p>Bit 4: Reserved</p> <p>Bits 5-7: Reserved</p>
NrBases	u1		0	Number of base stations used in the PVT computation.
PPPInfo	u2	1 s	0	<p>Bit field containing PPP-related information:</p> <p>Bits 0-11: Age of the last seed, in seconds. The age is clipped to 4091s. This field must be ignored when the seed type is 0 (see bits 13-15 below).</p> <p>Bit 12: Reserved</p> <p>Bits 13-15: Type of last seed: 0: Not seeded or not in PPP positioning mode 1: Manual seed 2: Seeded from DGPS 3: Seeded from RTKFixed</p>
Latency	u2	0.0001 s	65535	Time elapsed between the time of applicability of the position fix and the generation of this SBF block by the receiver. This time includes the receiver processing time, but not the communication latency.
HAccuracy	u2	0.01 m	65535	2DRMS horizontal accuracy: twice the root-mean-square of the horizontal distance error. The horizontal distance between the true position and the computed position is expected to be lower than HAccuracy with a probability of at least 95%. The value is clipped to 65534 = 655.34m
VAccuracy	u2	0.01 m	65535	2-sigma vertical accuracy. The vertical distance between the true position and the computed position is expected to be lower than VAccuracy with a probability of at least 95%. The value is clipped to 65534 = 655.34m.
Misc	u1			<p>Bit field containing miscellaneous flags:</p> <p>Bit 0: In DGNSS or RTK mode, set if the baseline points to the base station ARP. Unset if it points to the antenna phase center, or if unknown.</p> <p>Bit 1: Set if the phase center offset is compensated for at the rover, unset if not or unknown.</p> <p>Bit 2: Proprietary.</p> <p>Bit 3: Proprietary.</p> <p>Bits 4-5: Proprietary.</p> <p>Bits 6-7: Flag indicating whether the marker position reported in this block is also the ARP position (i.e. whether the ARP-to-marker offset provided with the setAntennaOffset command is zero or not) 0: Unknown 1: The ARP-to-marker offset is zero 2: The ARP-to-marker offset is not zero</p>
Padding	u1[.]			Padding bytes, see 4.1.5

Rev 2

PosCovCartesian	Number: 5905
	"OnChange" interval: default PVT output rate (see 4.1.8)

This block contains the elements of the symmetric variance-covariance matrix of the position expressed relative to the Cartesian axes of the coordinate system datum requested by the user:

$$\begin{pmatrix} \sigma_x^2 & \sigma_{xy} & \sigma_{xz} & \sigma_{xb} \\ \sigma_{yx} & \sigma_y^2 & \sigma_{yz} & \sigma_{yb} \\ \sigma_{zx} & \sigma_{zy} & \sigma_z^2 & \sigma_{zb} \\ \sigma_{bx} & \sigma_{by} & \sigma_{bz} & \sigma_b^2 \end{pmatrix}$$

This variance-covariance matrix contains an indication of the accuracy of the estimated parameters (see diagonal elements) and the correlation between these estimates (see off-diagonal elements). Note that the variances and covariances are estimated: they are not necessarily indicative of the actual scatter of the position estimates at a given site.

The position variance results from the propagation of all pseudorange variances using the observation geometry. The receiver implements a stochastic error model for individual measurements, based on parameters such as the C/N_0 , the satellite elevation, the pseudorange type, the URA of the broadcast ephemeris and the ionospheric model.

If the ellipsoidal height is not estimated (2D-mode), all components of the variance-covariance matrix are undefined and set to their Do-Not-Use value.

Parameter	Type	Units	Do-Not-Use	Description
Sync1	c1			Block Header, see 4.1.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 4.1.3
WNc	u2	1 week	65535	
Mode	u1			<p>Bit field indicating the GNSS PVT mode, as follows:</p> <p>Bits 0-3: type of PVT solution:</p> <ul style="list-style-type: none"> 0: No GNSS PVT available (the <code>Error</code> field indicates the cause of the absence of the PVT solution) 1: Stand-Alone PVT 2: Differential PVT 3: Fixed location 4: RTK with fixed ambiguities 5: RTK with float ambiguities 6: SBAS aided PVT 7: moving-base RTK with fixed ambiguities 8: moving-base RTK with float ambiguities 10: Precise Point Positioning (PPP) 12: Reserved <p>Bits 4-5: Reserved</p> <p>Bit 6: Set if the user has entered the command <code>setPVTMode,Static,auto</code> and the receiver is still in the process of determining its fixed position.</p> <p>Bit 7: 2D/3D flag: set in 2D mode (height assumed constant and not computed).</p>
Error	u1			<p>PVT error code. The following values are defined:</p> <ul style="list-style-type: none"> 0: No Error 1: Not enough measurements 2: Not enough ephemerides available 3: DOP too large (larger than 15) 4: Sum of squared residuals too large 5: No convergence 6: Not enough measurements after outlier rejection 7: Position output prohibited due to export laws 8: Not enough differential corrections available 9: Base station coordinates unavailable 10: Ambiguities not fixed and user requested to only output RTK-fixed positions
Cov_xx	f4	1 m ²	$-2 \cdot 10^{10}$	Variance of the x estimate
Cov_yy	f4	1 m ²	$-2 \cdot 10^{10}$	Variance of the y estimate
Cov_zz	f4	1 m ²	$-2 \cdot 10^{10}$	Variance of the z estimate
Cov_bb	f4	1 m ²	$-2 \cdot 10^{10}$	Variance of the clock bias estimate
Cov_xy	f4	1 m ²	$-2 \cdot 10^{10}$	Covariance between the x and y estimates
Cov_xz	f4	1 m ²	$-2 \cdot 10^{10}$	Covariance between the x and z estimates
Cov_xb	f4	1 m ²	$-2 \cdot 10^{10}$	Covariance between the x and clock bias estimates
Cov_yz	f4	1 m ²	$-2 \cdot 10^{10}$	Covariance between the y and z estimates
Cov_yb	f4	1 m ²	$-2 \cdot 10^{10}$	Covariance between the y and clock bias estimates

Cov_zb	f4	1 m ²	$-2 \cdot 10^{10}$	Covariance between the z and clock bias estimates
Padding	u1[.]			Padding bytes, see 4.1.5

PosCovGeodetic	Number: 5906
	"OnChange" interval: default PVT output rate (see 4.1.8)

This block contains the elements of the symmetric variance-covariance matrix of the position expressed in the geodetic coordinates in the datum requested by the user:

$$\begin{pmatrix} \sigma_{\phi}^2 & \sigma_{\phi\lambda} & \sigma_{\phi h} & \sigma_{\phi b} \\ \sigma_{\lambda\phi} & \sigma_{\lambda}^2 & \sigma_{\lambda h} & \sigma_{\lambda b} \\ \sigma_{h\phi} & \sigma_{h\lambda} & \sigma_h^2 & \sigma_{hb} \\ \sigma_{b\phi} & \sigma_{b\lambda} & \sigma_{bh} & \sigma_b^2 \end{pmatrix}$$

Please refer to the PosCovCartesian block description for a general explanation of the contents.

Note that the units of measure for all the variances and covariances, for height as well as for latitude and longitude, are m² for ease of interpretation.

If the ellipsoidal height is not estimated (2D-mode), all height related components of the variance-covariance matrix are undefined and set to their Do-Not-Use value.

Parameter	Type	Units	Do-Not-Use	Description
Sync1	c1			Block Header, see 4.1.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 4.1.3
WNc	u2	1 week	65535	
Mode	u1			<p>Bit field indicating the GNSS PVT mode, as follows:</p> <p>Bits 0-3: type of PVT solution:</p> <ul style="list-style-type: none"> 0: No GNSS PVT available (the <code>Error</code> field indicates the cause of the absence of the PVT solution) 1: Stand-Alone PVT 2: Differential PVT 3: Fixed location 4: RTK with fixed ambiguities 5: RTK with float ambiguities 6: SBAS aided PVT 7: moving-base RTK with fixed ambiguities 8: moving-base RTK with float ambiguities 10: Precise Point Positioning (PPP) 12: Reserved <p>Bits 4-5: Reserved</p> <p>Bit 6: Set if the user has entered the command <code>setPVTMode,Static,auto</code> and the receiver is still in the process of determining its fixed position.</p> <p>Bit 7: 2D/3D flag: set in 2D mode (height assumed constant and not computed).</p>
Error	u1			<p>PVT error code. The following values are defined:</p> <ul style="list-style-type: none"> 0: No Error 1: Not enough measurements 2: Not enough ephemerides available 3: DOP too large (larger than 15) 4: Sum of squared residuals too large 5: No convergence 6: Not enough measurements after outlier rejection 7: Position output prohibited due to export laws 8: Not enough differential corrections available 9: Base station coordinates unavailable 10: Ambiguities not fixed and user requested to only output RTK-fixed positions
Cov_latlat	f4	1 m ²	$-2 \cdot 10^{10}$	Variance of the latitude estimate
Cov_lonlon	f4	1 m ²	$-2 \cdot 10^{10}$	Variance of the longitude estimate
Cov_hghgt	f4	1 m ²	$-2 \cdot 10^{10}$	Variance of the height estimate
Cov_bb	f4	1 m ²	$-2 \cdot 10^{10}$	Variance of the clock-bias estimate
Cov_latlon	f4	1 m ²	$-2 \cdot 10^{10}$	Covariance between the latitude and longitude estimates
Cov_lathgt	f4	1 m ²	$-2 \cdot 10^{10}$	Covariance between the latitude and height estimates
Cov_latb	f4	1 m ²	$-2 \cdot 10^{10}$	Covariance between the latitude and clock-bias estimates
Cov_lonhgt	f4	1 m ²	$-2 \cdot 10^{10}$	Covariance between the longitude and height estimates

Cov_lonb	f4	1 m ²	$-2 \cdot 10^{10}$	Covariance between the longitude and clock-bias estimates
Cov_hb	f4	1 m ²	$-2 \cdot 10^{10}$	Covariance between the height and clock-bias estimates
Padding	u1[.]			Padding bytes, see 4.1.5

VelCovCartesian	Number: 5907
	"OnChange" interval: default PVT output rate (see 4.1.8)

This block contains the elements of the symmetric variance-covariance matrix of the velocity expressed in the Cartesian coordinates of the coordinate system datum requested by the user:

$$\begin{pmatrix} \sigma_{v_x}^2 & \sigma_{v_x v_y} & \sigma_{v_x v_z} & \sigma_{v_x d} \\ \sigma_{v_y v_x} & \sigma_{v_y}^2 & \sigma_{v_y v_z} & \sigma_{v_y d} \\ \sigma_{v_z v_x} & \sigma_{v_z v_y} & \sigma_{v_z}^2 & \sigma_{v_z d} \\ \sigma_{dv_x} & \sigma_{dv_y} & \sigma_{dv_z} & \sigma_d^2 \end{pmatrix}$$

Please refer to the `PosCovCartesian` block description for a general explanation of the contents.

If the up-velocity is not estimated (2D-mode), all components of the variance-covariance matrix are undefined and set to their Do-Not-Use value.

Parameter	Type	Units	Do-Not-Use	Description
Sync1	c1			Block Header, see 4.1.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 4.1.3
WNc	u2	1 week	65535	
Mode	u1			<p>Bit field indicating the GNSS PVT mode, as follows:</p> <p>Bits 0-3: type of PVT solution:</p> <ul style="list-style-type: none"> 0: No GNSS PVT available (the <code>Error</code> field indicates the cause of the absence of the PVT solution) 1: Stand-Alone PVT 2: Differential PVT 3: Fixed location 4: RTK with fixed ambiguities 5: RTK with float ambiguities 6: SBAS aided PVT 7: moving-base RTK with fixed ambiguities 8: moving-base RTK with float ambiguities 10: Precise Point Positioning (PPP) 12: Reserved <p>Bits 4-5: Reserved</p> <p>Bit 6: Set if the user has entered the command <code>setPVTMode,Static,auto</code> and the receiver is still in the process of determining its fixed position.</p> <p>Bit 7: 2D/3D flag: set in 2D mode (height assumed constant and not computed).</p>
Error	u1			<p>PVT error code. The following values are defined:</p> <ul style="list-style-type: none"> 0: No Error 1: Not enough measurements 2: Not enough ephemerides available 3: DOP too large (larger than 15) 4: Sum of squared residuals too large 5: No convergence 6: Not enough measurements after outlier rejection 7: Position output prohibited due to export laws 8: Not enough differential corrections available 9: Base station coordinates unavailable 10: Ambiguities not fixed and user requested to only output RTK-fixed positions
Cov_VxVx	f4	$1 \text{ m}^2 / \text{s}^2$	$-2 \cdot 10^{10}$	Variance of the x-velocity estimate
Cov_VyVy	f4	$1 \text{ m}^2 / \text{s}^2$	$-2 \cdot 10^{10}$	Variance of the y-velocity estimate
Cov_VzVz	f4	$1 \text{ m}^2 / \text{s}^2$	$-2 \cdot 10^{10}$	Variance of the z-velocity estimate
Cov_DtDt	f4	$1 \text{ m}^2 / \text{s}^2$	$-2 \cdot 10^{10}$	Variance of the clock drift estimate
Cov_VxVy	f4	$1 \text{ m}^2 / \text{s}^2$	$-2 \cdot 10^{10}$	Covariance between the x- and y-velocity estimates
Cov_VxVz	f4	$1 \text{ m}^2 / \text{s}^2$	$-2 \cdot 10^{10}$	Covariance between the x- and z-velocity estimates
Cov_VxDt	f4	$1 \text{ m}^2 / \text{s}^2$	$-2 \cdot 10^{10}$	Covariance between the x-velocity and the clock drift estimates
Cov_VyVz	f4	$1 \text{ m}^2 / \text{s}^2$	$-2 \cdot 10^{10}$	Covariance between the y- and z-velocity estimates

Cov_VyDt	f4	$1 \text{ m}^2 / \text{s}^2$	$-2 \cdot 10^{10}$	Covariance between the y-velocity and the clock drift estimates
Cov_VzDt	f4	$1 \text{ m}^2 / \text{s}^2$	$-2 \cdot 10^{10}$	Covariance between the z-velocity and the clock drift estimates
Padding	u1[.]			Padding bytes, see 4.1.5

VelCovGeodetic	Number: 5908
	"OnChange" interval: default PVT output rate (see 4.1.8)

This block contains the elements of the symmetric variance-covariance matrix of the velocity expressed in the geodetic coordinates in the datum requested by the user:

$$\begin{pmatrix} \sigma_{v_N}^2 & \sigma_{v_N v_E} & \sigma_{v_N v_U} & \sigma_{v_N d} \\ \sigma_{v_E v_N} & \sigma_{v_E}^2 & \sigma_{v_E v_U} & \sigma_{v_E d} \\ \sigma_{v_U v_N} & \sigma_{v_U v_E} & \sigma_{v_U}^2 & \sigma_{v_U d} \\ \sigma_{d v_N} & \sigma_{d v_E} & \sigma_{d v_U} & \sigma_d^2 \end{pmatrix}$$

Please refer to the PosCovCartesian block description for a general explanation of the contents.

If the up-velocity is not estimated (2D-mode), all up-velocity related components of the variance-covariance matrix are undefined and set to their Do-Not-Use value.

Parameter	Type	Units	Do-Not-Use	Description
Sync1	c1			Block Header, see 4.1.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 4.1.3
WNc	u2	1 week	65535	
Mode	u1			<p>Bit field indicating the GNSS PVT mode, as follows:</p> <p>Bits 0-3: type of PVT solution:</p> <ul style="list-style-type: none"> 0: No GNSS PVT available (the <code>Error</code> field indicates the cause of the absence of the PVT solution) 1: Stand-Alone PVT 2: Differential PVT 3: Fixed location 4: RTK with fixed ambiguities 5: RTK with float ambiguities 6: SBAS aided PVT 7: moving-base RTK with fixed ambiguities 8: moving-base RTK with float ambiguities 10: Precise Point Positioning (PPP) 12: Reserved <p>Bits 4-5: Reserved</p> <p>Bit 6: Set if the user has entered the command <code>setPVTMode,Static,auto</code> and the receiver is still in the process of determining its fixed position.</p> <p>Bit 7: 2D/3D flag: set in 2D mode (height assumed constant and not computed).</p>
Error	u1			<p>PVT error code. The following values are defined:</p> <ul style="list-style-type: none"> 0: No Error 1: Not enough measurements 2: Not enough ephemerides available 3: DOP too large (larger than 15) 4: Sum of squared residuals too large 5: No convergence 6: Not enough measurements after outlier rejection 7: Position output prohibited due to export laws 8: Not enough differential corrections available 9: Base station coordinates unavailable 10: Ambiguities not fixed and user requested to only output RTK-fixed positions
Cov_VnVn	f4	$1 \text{ m}^2 / \text{s}^2$	$-2 \cdot 10^{10}$	Variance of the north-velocity estimate
Cov_VeVe	f4	$1 \text{ m}^2 / \text{s}^2$	$-2 \cdot 10^{10}$	Variance of the east-velocity estimate
Cov_VuVu	f4	$1 \text{ m}^2 / \text{s}^2$	$-2 \cdot 10^{10}$	Variance of the up-velocity estimate
Cov_DtDt	f4	$1 \text{ m}^2 / \text{s}^2$	$-2 \cdot 10^{10}$	Variance of the clock drift estimate
Cov_VnVe	f4	$1 \text{ m}^2 / \text{s}^2$	$-2 \cdot 10^{10}$	Covariance between the north- and east-velocity estimates
Cov_VnVu	f4	$1 \text{ m}^2 / \text{s}^2$	$-2 \cdot 10^{10}$	Covariance between the north- and up-velocity estimates
Cov_VnDt	f4	$1 \text{ m}^2 / \text{s}^2$	$-2 \cdot 10^{10}$	Covariance between the north-velocity and clock drift estimates
Cov_VeVu	f4	$1 \text{ m}^2 / \text{s}^2$	$-2 \cdot 10^{10}$	Covariance between the east- and up-velocity estimates

Cov_VeDt	f4	$1 \text{ m}^2 / \text{s}^2$	$-2 \cdot 10^{10}$	Covariance between the east-velocity and clock drift estimates
Cov_VuDt	f4	$1 \text{ m}^2 / \text{s}^2$	$-2 \cdot 10^{10}$	Covariance between the up-velocity and clock drift estimates
Padding	u1[.]			Padding bytes, see 4.1.5

DOP	Number: 4001
	"OnChange" interval: default PVT output rate (see 4.1.8)

This block contains both Dilution of Precision (DOP) values and SBAS protection levels. The DOP values result from a trace of the unit position variance-covariance matrices:

$$\text{Position Dilution of Precision: } PDOP = \sqrt{\mathbf{Q}_{xx} + \mathbf{Q}_{yy} + \mathbf{Q}_{zz}}$$

$$\text{Time Dilution of Precision: } TDOP = \sqrt{\mathbf{Q}_{bb}}$$

$$\text{Horizontal Dilution of Precision: } HDOP = \sqrt{\mathbf{Q}_{\lambda\lambda} + \mathbf{Q}_{\phi\phi}}$$

$$\text{Vertical Dilution of Precision: } VDOP = \sqrt{\mathbf{Q}_{hh}}$$

In these equations, the matrix \mathbf{Q} is the inverse of the unweighted normal matrix used for the computation of the position. The normal matrix equals the product of the geometry matrix \mathbf{A} with its transpose ($\mathbf{A}^t\mathbf{A}$). The term "unweighted" implies that the DOP factor only addresses the effect of the geometric factors on the quality of the position.

The DOP values can be used to interpret the current constellation geometry. This is an important parameter for the quality of the position fix: the DOP parameter is the propagation factor of the pseudorange variance. For example, if an error of 5 m is present in the pseudorange, it will propagate into the horizontal plane with a factor expressed by the HDOP. Hence a low DOP value indicates that the satellites used for the position fix result in a low multiplication of the systematic ranging errors. A value of six (6) for the PDOP is generally considered as the maximum value allowed for an acceptable position computation.

The horizontal and vertical protection levels (HPL and VPL) indicate the integrity of the computed horizontal and vertical position components as per the DO 229 specification. In SBAS-aided PVT mode (see the `Mode` field of the `PVTCartesian` SBF block), HPL and VPL are based upon the error estimates provided by SBAS. Otherwise they are based upon internal position-mode dependent error estimates.

Parameter	Type	Units	Do-Not-Use	Description
Sync1	c1			Block Header, see 4.1.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 4.1.3
WNc	u2	1 week	65535	
NrSV	u1		0	Total number of satellites used in the DOP computation, or 0 if the DOP information is not available (in that case, the <code>xDOP</code> fields are all set to 0)
Reserved	u1			Reserved for future use, to be ignored by decoding software
PDOP	u2	0.01	0	If 0, PDOP not available, otherwise divide by 100 to obtain PDOP.
TDOP	u2	0.01	0	If 0, TDOP not available, otherwise divide by 100 to obtain TDOP.
HDOP	u2	0.01	0	If 0, HDOP not available, otherwise divide by 100 to obtain HDOP.
VDOP	u2	0.01	0	If 0, VDOP not available, otherwise divide by 100 to obtain VDOP.
HPL	f4	1 m	$-2 \cdot 10^{10}$	Horizontal Protection Level (see the DO 229 standard).
VPL	f4	1 m	$-2 \cdot 10^{10}$	Vertical Protection Level (see the DO 229 standard).
Padding	u1[.]			Padding bytes, see 4.1.5

PosCart	Number: 4044
	"OnChange" interval: default PVT output rate (see 4.1.8)

This block contains the absolute and relative (relative to the nearest base station) position at the time specified in the `TOW` and `WNc` fields. The time of applicability is specified in the receiver time frame.

The absolute position (X , Y , Z) is reported in a Cartesian coordinate system using the datum indicated in the `Datum` field. The position is that of the marker. The ARP-to-marker offset is set through the command **setAntennaOffset**.

For highest accuracy, the receiver tries to compute the baseline (`Base2RoverX`, `Base2RoverY`, `Base2RoverZ`) from rover ARP to base ARP. See the description of the `BaseVectorCart` block for details.

Accurate ARP-to-ARP baseline is guaranteed only if both bits 0 and 1 of the `Misc` field are set. Otherwise, centimeter-level offsets may arise because the receiver cannot make the distinction between phase center and ARP positions. See section 2.5 for a discussion on the phase center and ARP positions.

This block also contains the variance-covariance information and DOP factors associated with the position.

Parameter	Type	Units	Do-Not-Use	Description
Sync1	c1			Block Header, see 4.1.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 4.1.3
WNc	u2	1 week	65535	
Mode	u1			<p>Bit field indicating the GNSS PVT mode, as follows:</p> <p>Bits 0-3: type of PVT solution:</p> <ul style="list-style-type: none"> 0: No GNSS PVT available (the <code>Error</code> field indicates the cause of the absence of the PVT solution) 1: Stand-Alone PVT 2: Differential PVT 3: Fixed location 4: RTK with fixed ambiguities 5: RTK with float ambiguities 6: SBAS aided PVT 7: moving-base RTK with fixed ambiguities 8: moving-base RTK with float ambiguities 10: Precise Point Positioning (PPP) 12: Reserved <p>Bits 4-5: Reserved</p> <p>Bit 6: Set if the user has entered the command <code>setPVTMode,Static,auto</code> and the receiver is still in the process of determining its fixed position.</p> <p>Bit 7: 2D/3D flag: set in 2D mode (height assumed constant and not computed).</p>
Error	u1			<p>PVT error code. The following values are defined:</p> <ul style="list-style-type: none"> 0: No Error 1: Not enough measurements 2: Not enough ephemerides available 3: DOP too large (larger than 15) 4: Sum of squared residuals too large 5: No convergence 6: Not enough measurements after outlier rejection 7: Position output prohibited due to export laws 8: Not enough differential corrections available 9: Base station coordinates unavailable 10: Ambiguities not fixed and user requested to only output RTK-fixed positions
X	f8	1 m	$-2 \cdot 10^{10}$	X coordinate in coordinate frame specified by <code>Datum</code>
Y	f8	1 m	$-2 \cdot 10^{10}$	Y coordinate in coordinate frame specified by <code>Datum</code>
Z	f8	1 m	$-2 \cdot 10^{10}$	Z coordinate in coordinate frame specified by <code>Datum</code>
Base2RoverX	f8	1 m	$-2 \cdot 10^{10}$	X baseline component (from base to rover)
Base2RoverY	f8	1 m	$-2 \cdot 10^{10}$	Y baseline component (from base to rover)
Base2RoverZ	f8	1 m	$-2 \cdot 10^{10}$	Z baseline component (from base to rover)
Cov_xx	f4	1 m ²	$-2 \cdot 10^{10}$	Variance of the x estimate
Cov_yy	f4	1 m ²	$-2 \cdot 10^{10}$	Variance of the y estimate

Cov_zz	f4	1 m ²	$-2 \cdot 10^{10}$	Variance of the z estimate
Cov_xy	f4	1 m ²	$-2 \cdot 10^{10}$	Covariance between the x and y estimates
Cov_xz	f4	1 m ²	$-2 \cdot 10^{10}$	Covariance between the x and z estimates
Cov_yz	f4	1 m ²	$-2 \cdot 10^{10}$	Covariance between the y and z estimates
PDOP	u2	0.01	0	If 0, PDOP not available, otherwise divide by 100 to obtain PDOP.
HDOP	u2	0.01	0	If 0, HDOP not available, otherwise divide by 100 to obtain HDOP.
VDOP	u2	0.01	0	If 0, VDOP not available, otherwise divide by 100 to obtain VDOP.
Misc	u1			<p>Bit field containing miscellaneous flags:</p> <p>Bit 0: In DGNSS or RTK mode, set if the baseline points to the base station ARP. Unset if it points to the antenna phase center, or if unknown.</p> <p>Bit 1: Set if the phase center offset is compensated for at the rover, unset if not or unknown.</p> <p>Bit 2: Proprietary.</p> <p>Bit 3: Proprietary.</p> <p>Bits 4-5: Proprietary.</p> <p>Bits 6-7: Flag indicating whether the marker position reported in this block is also the ARP position (i.e. whether the ARP-to-marker offset provided with the setAntennaOffset command is zero or not)</p> <p>0: Unknown</p> <p>1: The ARP-to-marker offset is zero</p> <p>2: The ARP-to-marker offset is not zero</p>
Reserved	u1			Reserved for future use.
AlertFlag	u1		0	<p>Bit field indicating integrity related information:</p> <p>Bits 0-1: RAIM integrity flag:</p> <p>0: RAIM not active (integrity not monitored)</p> <p>1: RAIM integrity test successful</p> <p>2: RAIM integrity test failed</p> <p>3: Reserved</p> <p>Bit 2: set if integrity has failed as per Galileo HPCA (HMI Probability Computation Algorithm)</p> <p>Bit 3: set if Galileo ionospheric storm flag is active</p> <p>Bit 4: Reserved</p> <p>Bits 5-7: Reserved</p>
Datum	u1		255	<p>This field defines in which datum the coordinates are expressed:</p> <p>0: WGS84/ITRS</p> <p>19: Datum equal to that used by the DGNSS/RTK base station</p> <p>30: ETRS89 (ETRF2000 realization)</p> <p>31: NAD83(2011), North American Datum (2011)</p> <p>32: NAD83(PA11), North American Datum, Pacific plate (2011)</p> <p>33: NAD83(MA11), North American Datum, Marianas plate (2011)</p> <p>34: GDA94(2010), Geocentric Datum of Australia (2010)</p> <p>35: GDA2020, Geocentric Datum of Australia 2020</p> <p>250: First user-defined datum</p> <p>251: Second user-defined datum</p>
NrSV	u1		255	Total number of satellites used in the PVT computation.

WACorrInfo	u1		0	<p>Bit field providing information about which wide area corrections have been applied:</p> <p>Bit 0: set if orbit and satellite clock correction information is used</p> <p>Bit 1: set if range correction information is used</p> <p>Bit 2: set if ionospheric information is used</p> <p>Bit 3: set if orbit accuracy information is used (UERE/SISA)</p> <p>Bit 4: set if DO229 Precision Approach mode is active</p> <p>Bits 5-7: Reserved</p>
ReferenceId	u2		65535	<p>This field indicates the reference ID of the differential information used. In case of DGPS or RTK operation, this field is to be interpreted as the base station identifier. In SBAS operation, this field is to be interpreted as the PRN of the geostationary satellite used (from 120 to 158). If multiple base stations or multiple geostationary satellites are used the value is set to 65534.</p>
MeanCorrAge	u2	0.01 s	65535	<p>In case of DGPS or RTK, this field is the mean age of the differential corrections.</p> <p>In case of SBAS operation, this field is the mean age of the 'fast corrections' provided by the SBAS satellites.</p>
SignalInfo	u4		0	<p>Bit field indicating the type of GNSS signals having been used in the PVT computations. If a bit i is set, the signal type having index i has been used. The signal numbers are listed in section 4.1.10. Bit 0 (GPS-C/A) is the LSB of <code>SignalInfo</code>.</p>
Padding	u1[.]			Padding bytes, see 4.1.5

PosLocal	Number: 4052
	"OnChange" interval: default PVT output rate (see 4.1.8)

This block contains the position at the time specified in the `TOW` and `WNc` fields. The time of applicability is specified in the receiver time frame.

The position (Lat, Lon, Alt) relates to the local datum identified with the `Datum` field. The coordinate transformation to the local datum is done using parameters transmitted by the RTK service provider in RTCM message types MT1021 to MT1023.

The position is that of the marker. The ARP-to-marker offset is set through the command **setAntennaOffset**.

If no position is available, the `Error` field indicates the cause of the unavailability and all fields after the `Error` field are set to their respective Do-Not-Use values.

To be able to output a position in the `PosLocal` block, the receiver needs to have received the relevant RTCM transformation messages (at least either MT1021 or MT1022 is required). If they have not been received yet, the local position is not available and the `Error` field is set to value 17. See also section 2.4.6.

The corresponding `RTCMDatum` block provides information on the local datum name and transformation quality indicators. The corresponding `RTCMDatum` block is the one of which the `Datum` field matches the `Datum` field in the `PosLocal` block.

Parameter	Type	Units	Do-Not-Use	Description
Sync1	c1			Block Header, see 4.1.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 4.1.3
WNc	u2	1 week	65535	
Mode	u1			Bit field indicating the GNSS PVT mode, as follows: Bits 0-3: type of PVT solution: 0: No GNSS PVT available (the <code>Error</code> field indicates the cause of the absence of the PVT solution) 1: Stand-Alone PVT 2: Differential PVT 3: Fixed location 4: RTK with fixed ambiguities 5: RTK with float ambiguities 6: SBAS aided PVT 7: moving-base RTK with fixed ambiguities 8: moving-base RTK with float ambiguities 10: Precise Point Positioning (PPP) 12: Reserved Bits 4-5: Reserved Bit 6: Set if the user has entered the command setPVTMode,Static,auto and the receiver is still in the process of determining its fixed position. Bit 7: 2D/3D flag: set in 2D mode (height assumed constant and not computed).

Error	u1			<p>PVT error code. The following values are defined:</p> <ul style="list-style-type: none"> 0: No Error 1: Not enough measurements 2: Not enough ephemerides available 3: DOP too large (larger than 15) 4: Sum of squared residuals too large 5: No convergence 6: Not enough measurements after outlier rejection 7: Position output prohibited due to export laws 8: Not enough differential corrections available 9: Base station coordinates unavailable 10: Ambiguities not fixed and user requested to only output RTK-fixed positions 17: Datum transformation parameters unknown
Lat	f8	1 rad	$-2 \cdot 10^{10}$	Latitude, from $-\pi/2$ to $+\pi/2$, positive North of Equator
Lon	f8	1 rad	$-2 \cdot 10^{10}$	Longitude, from $-\pi$ to $+\pi$, positive East of Greenwich
Alt	f8	1 m	$-2 \cdot 10^{10}$	Height. See the <code>HeightType</code> field of the corresponding <code>RTCMDatum</code> block for the interpretation of the height.
Datum	u1			<p>Reference frame to which the position relate. If the value is in the 20 to 24 range, the corresponding datum parameters can be found in the <code>RTCMDatum</code> block having a matching <code>Datum</code> field.</p> <p>Value 25 corresponds to the local coordinate reference system selected with the <code>setLocalCoordOperation</code> command.</p>
Padding	u1[.]			Padding bytes, see 4.1.5

PosProjected	Number: 4094
	"OnChange" interval: default PVT output rate (see 4.1.8)

This block contains the projected coordinates at the time specified in the `TOW` and `WNc` fields. The time of applicability is specified in the receiver time frame.

The coordinates (Northing, Easting, Alt) relate to the local datum identified with the `Datum` field. The coordinate transformation and projection is done using parameters transmitted by the RTK service provider in RTCM message types MT1021 to MT1027.

The position is that of the marker. The ARP-to-marker offset is set through the command **setAntennaOffset**.

If no position is available, the `Error` field indicates the cause of the unavailability and all fields after the `Error` field are set to their respective Do-Not-Use values.

To be able to output a position in the `PosProjected` block, the receiver needs to have received at least one RTCM message in the MT1025 to MT1027 range. If none of these messages is sent out by the service provider, or if they have not been received yet, the projected position is not available and the `Error` field is set to value 17. See also section 2.4.6.

The corresponding `RTCMDatum` block provides information on the local datum name and transformation/projection quality indicators. The corresponding `RTCMDatum` block is the one of which the `Datum` field matches the `Datum` field in the `PosProjected` block.

Parameter	Type	Units	Do-Not-Use	Description
Sync1	c1			Block Header, see 4.1.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 4.1.3
WNc	u2	1 week	65535	
Mode	u1			<p>Bit field indicating the GNSS PVT mode, as follows:</p> <p>Bits 0-3: type of PVT solution:</p> <ul style="list-style-type: none"> 0: No GNSS PVT available (the <code>Error</code> field indicates the cause of the absence of the PVT solution) 1: Stand-Alone PVT 2: Differential PVT 3: Fixed location 4: RTK with fixed ambiguities 5: RTK with float ambiguities 6: SBAS aided PVT 7: moving-base RTK with fixed ambiguities 8: moving-base RTK with float ambiguities 10: Precise Point Positioning (PPP) 12: Reserved <p>Bits 4-5: Reserved</p> <p>Bit 6: Set if the user has entered the command <code>setPVTMode,Static,auto</code> and the receiver is still in the process of determining its fixed position.</p> <p>Bit 7: 2D/3D flag: set in 2D mode (height assumed constant and not computed).</p>
Error	u1			<p>PVT error code. The following values are defined:</p> <ul style="list-style-type: none"> 0: No Error 1: Not enough measurements 2: Not enough ephemerides available 3: DOP too large (larger than 15) 4: Sum of squared residuals too large 5: No convergence 6: Not enough measurements after outlier rejection 7: Position output prohibited due to export laws 8: Not enough differential corrections available 9: Base station coordinates unavailable 10: Ambiguities not fixed and user requested to only output RTK-fixed positions 17: Datum transformation parameters unknown
Northing	f8	1 m	$-2 \cdot 10^{10}$	Northing coordinate in the plane grid representation.
Easting	f8	1 m	$-2 \cdot 10^{10}$	Easting coordinate in the plane grid representation.
Alt	f8	1 m	$-2 \cdot 10^{10}$	Height. If the <code>Datum</code> field is in the 20 to 24 range, see the <code>HeightType</code> field of the corresponding <code>RTCMDatum</code> block for the interpretation of the height.
Datum	u1			<p>Reference frame to which the position relate. If the value is in the 20 to 24 range, the corresponding datum parameters can be found in the <code>RTCMDatum</code> block having a matching <code>Datum</code> field.</p> <p>Value 25 corresponds to the local coordinate reference system selected with the <code>setLocalCoordOperation</code> command.</p>
Padding	u1[.]			Padding bytes, see 4.1.5

BaseVectorCart	Number: 4043
	"OnChange" interval: default PVT output rate (see 4.1.8)

The `BaseVectorCart` block contains the relative position and orientation of one or more base stations, as seen from the rover (i.e. this receiver). The relative position is expressed in the Cartesian X, Y, Z directions.

For highest accuracy, the receiver tries to compute the baseline from rover antenna reference point (ARP) to base ARP. This requires to compensate for the phase center offset at both the base and the rover antennas. This is possible if two conditions are met:

- the base station must transmit its antenna parameters in RTCM2 message types 23 and 24 or in RTCM3 message types 1005/1006 and 1007/1008. Older RTCM2 messages and CMR do not allow phase center offset compensation.
- the base and rover antenna types must belong to the list returned by the command **1stAntennaInfo, overview**. (see the description of the commands **setAntennaOffset** and **1stAntennaInfo** for details).

Accurate ARP-to-ARP baseline is guaranteed only if both bits 0 and 1 of the `Misc` field are set. Otherwise, centimeter-level offsets may arise because the receiver cannot make the distinction between phase center and ARP positions. See section 2.5 for a discussion on the phase center and ARP positions.

The block supports multi-base operation. It contains as many sub-blocks as available base stations, each sub-block containing the baseline relative to a single base station identified by the `ReferenceID` field.

Parameter	Type	Units	Do-Not-Use	Description
Sync1	c1			Block Header, see 4.1.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 4.1.3
WNc	u2	1 week	65535	
N	u1			Number of baselines for which relative position, velocity and direction are provided in this SBF block, i.e. number of <code>VectorInfoCart</code> sub-blocks. If <code>N</code> is 0, there are no baseline available for this epoch.
SBLength	u1	1 byte		Length of one sub-block
<i>VectorInfoCart</i>		<i>A succession of N VectorInfoCart sub-blocks, see definition below</i>
Padding	u1[.]			Padding bytes, see 4.1.5

VectorInfoCart sub-block definition:

Parameter	Type	Units	Do-Not-Use	Description
nrSV	u1			Number of satellites for which corrections are available from the base station identified by the <code>ReferenceID</code> field.
Error	u1			PVT error code. The following values are defined: 0: No Error 1: Not enough measurements 2: Not enough ephemerides available 3: DOP too large (larger than 15) 4: Sum of squared residuals too large 5: No convergence 6: Not enough measurements after outlier rejection 7: Position output prohibited due to export laws 8: Not enough differential corrections available 9: Base station coordinates unavailable 10: Ambiguities not fixed and user requested to only output RTK-fixed positions
Mode	u1			Bit field indicating the GNSS PVT mode, as follows: Bits 0-3: type of PVT solution: 0: No GNSS PVT available (the <code>Error</code> field indicates the cause of the absence of the PVT solution) 1: Stand-Alone PVT 2: Differential PVT 3: Fixed location 4: RTK with fixed ambiguities 5: RTK with float ambiguities 6: SBAS aided PVT 7: moving-base RTK with fixed ambiguities 8: moving-base RTK with float ambiguities 10: Precise Point Positioning (PPP) 12: Reserved Bits 4-5: Reserved Bit 6: Set if the user has entered the command <code>setPVTMode,Static,auto</code> and the receiver is still in the process of determining its fixed position. Bit 7: 2D/3D flag: set in 2D mode (height assumed constant and not computed).
Misc	u1			Bit field containing miscellaneous flags: Bit 0: Set if the baseline points to the base station ARP. Unset if it points to the antenna phase center, or if unknown. Bit 1: Set if the phase center offset is compensated for at the rover (i.e. the baseline starts from the antenna ARP), unset if not or unknown. Bit 2: Proprietary. Bit 3: Proprietary. Bits 4-5: Proprietary. Bits 6-7: Reserved
DeltaX	f8	1 m	$-2 \cdot 10^{10}$	X baseline component (from rover to base)
DeltaY	f8	1 m	$-2 \cdot 10^{10}$	Y baseline component (from rover to base)
DeltaZ	f8	1 m	$-2 \cdot 10^{10}$	Z baseline component (from rover to base)

DeltaVx	f4	1 m / s	$-2 \cdot 10^{10}$	X velocity of base with respect to rover
DeltaVy	f4	1 m / s	$-2 \cdot 10^{10}$	Y velocity of base with respect to rover
DeltaVz	f4	1 m / s	$-2 \cdot 10^{10}$	Z velocity of base with respect to rover
Azimuth	u2	0.01 degrees	65535	Azimuth of the base station (from 0 to 360°, increasing towards east)
Elevation	i2	0.01 degrees	-32768	Elevation of the base station (from -90° to 90°)
ReferenceID	u2			Base station ID
CorrAge	u2	0.01 s	65535	Age of the oldest differential correction used for this baseline computation.
SignalInfo	u4		0	Bit field indicating the GNSS signals for which differential corrections are available from the base station identified by <code>ReferenceID</code> . If bit <i>i</i> is set, corrections for the signal type having index <i>i</i> are available. The signal numbers are listed in section 4.1.10. Bit 0 (GPS-C/A) is the LSB of <code>SignalInfo</code> .
Padding	u1[.]			Padding bytes, see 4.1.5

BaseVectorGeod	Number: 4028
	"OnChange" interval: default PVT output rate (see 4.1.8)

The `BaseVectorGeod` block contains the relative position and orientation of one or more base stations, as seen from the rover (i.e. this receiver). The relative position is expressed in the East-North-Up directions.

For highest accuracy, the receiver tries to compute the baseline from rover antenna reference point (ARP) to base ARP. See the description of the `BaseVectorCart` block for details.

Accurate ARP-to-ARP baseline is guaranteed only if both bits 0 and 1 of the `Misc` field are set. Otherwise, centimeter-level offsets may arise because the receiver cannot make the distinction between phase center and ARP positions. See section 2.5 for a discussion on the phase center and ARP positions.

The block supports multi-base operation. It contains as many sub-blocks as available base stations, each sub-block containing the baseline coordinates relative to a single base station identified by the `ReferenceID` field.

Parameter	Type	Units	Do-Not-Use	Description
Sync1	c1			Block Header, see 4.1.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 4.1.3
WNc	u2	1 week	65535	
N	u1			Number of baselines for which relative position, velocity and direction are provided in this SBF block, i.e. number of <code>VectorInfoGeod</code> sub-blocks. If <code>N</code> is 0, there are no baseline available for this epoch.
SBLength	u1	1 byte		Length of one sub-block
<i>VectorInfoGeod</i>		<i>A succession of <code>N</code> <code>VectorInfoGeod</code> sub-blocks, see definition below</i>
Padding	u1[.]			Padding bytes, see 4.1.5

VectorInfoGeod sub-block definition:

Parameter	Type	Units	Do-Not-Use	Description
NrSV	u1			Number of satellites for which corrections are available from the base station identified by the <code>ReferenceID</code> field.
Error	u1			PVT error code. The following values are defined: 0: No Error 1: Not enough measurements 2: Not enough ephemerides available 3: DOP too large (larger than 15) 4: Sum of squared residuals too large 5: No convergence 6: Not enough measurements after outlier rejection 7: Position output prohibited due to export laws 8: Not enough differential corrections available 9: Base station coordinates unavailable 10: Ambiguities not fixed and user requested to only output RTK-fixed positions
Mode	u1			Bit field indicating the GNSS PVT mode, as follows: Bits 0-3: type of PVT solution: 0: No GNSS PVT available (the <code>Error</code> field indicates the cause of the absence of the PVT solution) 1: Stand-Alone PVT 2: Differential PVT 3: Fixed location 4: RTK with fixed ambiguities 5: RTK with float ambiguities 6: SBAS aided PVT 7: moving-base RTK with fixed ambiguities 8: moving-base RTK with float ambiguities 10: Precise Point Positioning (PPP) 12: Reserved Bits 4-5: Reserved Bit 6: Set if the user has entered the command <code>setPVTMode,Static,auto</code> and the receiver is still in the process of determining its fixed position. Bit 7: 2D/3D flag: set in 2D mode (height assumed constant and not computed).
Misc	u1			Bit field containing miscellaneous flags: Bit 0: Set if the baseline points to the base station ARP. Unset if it points to the antenna phase center, or if unknown. Bit 1: Set if the phase center offset is compensated for at the rover (i.e. the baseline starts from the antenna ARP), unset if not or unknown. Bit 2: Proprietary. Bit 3: Proprietary. Bits 4-5: Proprietary. Bits 6-7: Reserved
DeltaEast	f8	1 m	$-2 \cdot 10^{10}$	East baseline component (from rover to base)
DeltaNorth	f8	1 m	$-2 \cdot 10^{10}$	North baseline component (from rover to base)
DeltaUp	f8	1 m	$-2 \cdot 10^{10}$	Up baseline component (from rover to base)

DeltaVe	f4	1 m / s	$-2 \cdot 10^{10}$	East velocity of base with respect to rover
DeltaVn	f4	1 m / s	$-2 \cdot 10^{10}$	North velocity of base with respect to rover
DeltaVu	f4	1 m / s	$-2 \cdot 10^{10}$	Up velocity of base with respect to rover
Azimuth	u2	0.01 degrees	65535	Azimuth of the base station (from 0 to 360°, increasing towards east)
Elevation	i2	0.01 degrees	-32768	Elevation of the base station (from -90° to 90°)
ReferenceID	u2			Base station ID
CorrAge	u2	0.01 s	65535	Age of the oldest differential correction used for this baseline computation.
SignalInfo	u4		0	Bit field indicating the GNSS signals for which differential corrections are available from the base station identified by <code>ReferenceID</code> . If bit <i>i</i> is set, corrections for the signal type having index <i>i</i> are available. The signal numbers are listed in section 4.1.10. Bit 0 (GPS-C/A) is the LSB of <code>SignalInfo</code> .
Padding	u1[.]			Padding bytes, see 4.1.5

PVTSupport	Number: 4076
	"OnChange" interval: default PVT output rate (see 4.1.8)

This block contains various internal parameters that can be used for maintenance and support.

The detailed definition of this block is not available in this document.

PVTSupportA	Number: 4079 "OnChange" interval: default PVT output rate (see 4.1.8)
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This block contains various internal parameters that can be used for maintenance and support.

The detailed definition of this block is not available in this document.

EndOfPVT	Number: 5921 "OnChange" interval: default PVT output rate (see 4.1.8)
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This block marks the end of transmission of all PVT related blocks belonging to the same epoch.

Parameter	Type	Units	Do-Not-Use	Description
Sync1	c1			Block Header, see 4.1.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 4.1.3
WNc	u2	1 week	65535	
Padding	u1[.]			Padding bytes, see 4.1.5

4.2.10 GNSS Attitude Blocks

AttEuler	Number: 5938
	"OnChange" interval: default PVT output rate (see 4.1.8)

The `AttEuler` block contains the Euler angles (pitch, roll and heading) at the time specified in the `TOW` and `WNc` fields (in the receiver time frame).

Parameter	Type	Units	Do-Not-Use	Description
Sync1	c1			Block Header, see 4.1.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 4.1.3
WNc	u2	1 week	65535	
NrSV	u1		255	The average over all antennas of the number of satellites currently included in the attitude calculations.
Error	u1			<p>Bit field providing error information. For each antenna baseline, two bits are used to provide error information:</p> <p>Bits 0-1: Error code for Main-Aux1 baseline: 0: No error 1: Not enough measurements 2: Reserved 3: Reserved</p> <p>Bits 2-3: Error code for Main-Aux2 baseline, same definition as bit 0-1. Bits 4-6: Reserved Bit 7: Set when GNSS-based attitude not requested by user. In that case, the other bits are all zero.</p>
Mode	u2			<p>Attitude mode code:</p> <p>0: No attitude 1: Heading, pitch (roll = 0), aux antenna positions obtained with float ambiguities 2: Heading, pitch (roll = 0), aux antenna positions obtained with fixed ambiguities 3: Heading, pitch, roll, aux antenna positions obtained with float ambiguities 4: Heading, pitch, roll, aux antenna positions obtained with fixed ambiguities</p>
Reserved	u2			Reserved for future use, to be ignored by decoding software
Heading	f4	1 degree	$-2 \cdot 10^{10}$	Heading
Pitch	f4	1 degree	$-2 \cdot 10^{10}$	Pitch
Roll	f4	1 degree	$-2 \cdot 10^{10}$	Roll
PitchDot	f4	1 degree / s	$-2 \cdot 10^{10}$	Rate of change of the pitch angle
RollDot	f4	1 degree / s	$-2 \cdot 10^{10}$	Rate of change of the roll angle
HeadingDot	f4	1 degree / s	$-2 \cdot 10^{10}$	Rate of change of the heading angle
Padding	u1[.]			Padding bytes, see 4.1.5

AttCovEuler	Number: 5939
	"OnChange" interval: default PVT output rate (see 4.1.8)

This block contains the elements of the symmetric variance-covariance matrix of the attitude angles reported in the `AttEuler` block

$$\begin{pmatrix} \sigma_{\phi}^2 & \sigma_{\phi\theta} & \sigma_{\phi\psi} \\ \sigma_{\theta\phi} & \sigma_{\theta}^2 & \sigma_{\theta\psi} \\ \sigma_{\psi\phi} & \sigma_{\psi\theta} & \sigma_{\psi}^2 \end{pmatrix}$$

This variance-covariance matrix contains an indication of the accuracy of the estimated parameters (see diagonal elements) and the correlation between these estimates (see off-diagonal elements).

In case the receiver is in heading and pitch mode only, only the heading and pitch variance values will be valid. All other components of the variance-covariance matrix are set to their Do-Not-Use value.

Parameter	Type	Units	Do-Not-Use	Description
Sync1	c1			Block Header, see 4.1.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 4.1.3
WNc	u2	1 week	65535	
Reserved	u1			Reserved for future use, to be ignored by decoding software
Error	u1			<p>Bit field providing error information. For each antenna baseline, two bits are used to provide error information:</p> <p>Bits 0-1: Error code for Main-Aux1 baseline:</p> <ul style="list-style-type: none"> 0: No error 1: Not enough measurements 2: Reserved 3: Reserved <p>Bits 2-3: Error code for Main-Aux2 baseline, same definition as bit 0-1.</p> <p>Bits 4-6: Reserved</p> <p>Bit 7: Set when GNSS-based attitude not requested by user. In that case, the other bits are all zero.</p>
Cov_HeadHead	f4	1 degree ²	$-2 \cdot 10^{10}$	Variance of the heading estimate
Cov_PitchPitch	f4	1 degree ²	$-2 \cdot 10^{10}$	Variance of the pitch estimate
Cov_RollRoll	f4	1 degree ²	$-2 \cdot 10^{10}$	Variance of the roll estimate
Cov_HeadPitch	f4	1 degree ²	$-2 \cdot 10^{10}$	Covariance between Euler angle estimates. Future functionality. The values are currently set to their Do-Not-Use values.
Cov_HeadRoll	f4	1 degree ²	$-2 \cdot 10^{10}$	Covariance between Euler angle estimates. Future functionality. The values are currently set to their Do-Not-Use values.
Cov_PitchRoll	f4	1 degree ²	$-2 \cdot 10^{10}$	Covariance between Euler angle estimates. Future functionality. The values are currently set to their Do-Not-Use values.
Padding	u1[.]			Padding bytes, see 4.1.5

AuxAntPositions	Number:	5942
	"OnChange" interval:	default PVT output rate (see 4.1.8)

The `AuxAntPositions` block contains the relative position and velocity of the different antennas in a multi-antenna receiver. The coordinates are expressed in the local-level ENU reference frame.

When the antenna positions cannot be estimated, the baseline vectors are set to their Do-Not-Use value.

Parameter	Type	Units	Do-Not-Use	Description
Sync1	c1			Block Header, see 4.1.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 4.1.3
WNc	u2	1 week	65535	
N	u1			Number of <code>AuxAntPositionSub</code> sub-blocks in this <code>AuxAntPositions</code> block
SBLength	u1	1 byte		Length of one sub-block in bytes
<i>AuxAntPosition</i>		<i>A succession of N <code>AuxAntPositionSub</code> sub-blocks, see definition below</i>
Padding	u1[.]			Padding bytes, see 4.1.5

`AuxAntPositionSub` sub-block definition:

Parameter	Type	Units	Do-Not-Use	Description
NrSV	u1		255	Total number of satellites tracked by the antenna identified by the <code>AuxAntID</code> field and used in the attitude computation.
Error	u1			Aux antenna position error code: 0: No error 1: Not enough measurements 2: Reserved 3: Reserved If <code>error</code> is not 0, the coordinates reported later in this block are all set to their Do-Not-Use value.
AmbiguityType	u1		255	Aux antenna positions obtained with 0: Fixed ambiguities 1: Float ambiguities
AuxAntID	u1			Auxiliary antenna ID: 1 for the first auxiliary antenna, 2 for the second, etc...
DeltaEast	f8	1 m	$-2 \cdot 10^{10}$	Position in East direction (relative to main antenna)
DeltaNorth	f8	1 m	$-2 \cdot 10^{10}$	Position in North direction (relative to main antenna)
DeltaUp	f8	1 m	$-2 \cdot 10^{10}$	Position in Up direction (relative to main antenna)
EastVel	f8	1 m / s	$-2 \cdot 10^{10}$	Velocity in East direction (relative to main antenna)
NorthVel	f8	1 m / s	$-2 \cdot 10^{10}$	Velocity in North direction (relative to main antenna)
UpVel	f8	1 m / s	$-2 \cdot 10^{10}$	Velocity in Up direction (relative to main antenna)
Padding	u1[.]			Padding bytes, see 4.1.5

EndOfAtt	Number: 5943
	"OnChange" interval: default PVT output rate (see 4.1.8)

This block marks the end of transmission of all GNSS-attitude related blocks belonging to the same epoch.

Parameter	Type	Units	Do-Not-Use	Description
Sync1	c1			Block Header, see 4.1.1
Sync2	c1			
CRC	u2			
ID	u2			
Length	u2	1 byte		
TOW	u4	0.001 s	4294967295	Receiver time stamp, see 4.1.3
WNc	u2	1 week	65535	
Padding	u1[.]			Padding bytes, see 4.1.5