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M3 .ALL Data Format

Document revisions

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About this document

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Document history

Version 1.0 First release.

1 FORMAT INFORMATION

1.1 Introduction

.All data format is the output data format of Kongsberg EM series. M3 software can output this data format to be compatible with third party post processing software packages to process M3 profiling data.

1.2 Supported .ALL datagrams

The M3 software V2.0 has implemented the following datagrams:

- Installation parameters (I or i)
- Runtime parameters (R)
- Multibeam data XYZ 88 (X)
- Multibeam data Raw range and angle 78 (N)
- External Sensor – Attitude (A)
- External Sensor – Clock (C)
- External Sensor – Position (P)
- Surface sound speed (G)

The descriptions for these formats in this document are based on Kongsberg EM Series multibeam echo sounder – EM datagram format document (document number 850-160692/U), but provide more details particularly for the M3 system.

1.3 Binary Data Type

In EM datagram format documentation, the binary fields are described by the number of bytes plus “U” for unsigned and “S” for signed data. In this documentation, we follow the data type conventions in the KML.

Data Type	Description
Byte	8 bit unsigned integer
unsigned int16	16-bit unsigned integer
unsigned int32	32-bit unsigned integer
__int8	8-bit signed integer
__int16	16-bit signed integer

__int32	32-bit signed integer
Float	32-bit floating point
Double	64-bit floating point

1.4 ASCII Presentation Format

The ASCII presentation format is the same as the one in the EM datagram format document. The format description is according to the NMEA 0183 standard, Approved Parametric Sentence Structure, with the ASCII character(s) given as follows:

- “x.x” defines a variable length numerical field, with optionally included decimal point and sign.
- “c-c” defines a variable length field of printable characters.
- “x-x” defines a variable length field of numeric characters.
- “a_ _” defines a fixed length field of alphabetical characters (e.g. “aa” = two character long field.
- “x_ _” defines a fixed length field of numeric characters.

2 DATAGRAM STRUCTURE

The data packets are packed with packet header and packet footer for data integrity purpose.

Header

Body

Footer

Note:

1. Invalid data are always identified by the highest positive number allowed in a field unless otherwise noted.
2. The dual head support will be added in the future release. Current system produces one .ALL stream for each head. If the customer needs to run two M3 heads, they will need to run two M3 software and export two .ALL streams to their acquisition software.
3. In the datagrams for M3, both valid and invalid beams are included (The beam index then became redundant information and is therefore removed). This is done to be able to store seabed image data also for beams missing a valid detection.

2.1 Datagram Header

Field	Item size (bytes)	Data type	Description
dwNumBytes	4	unsigned int32	Total length of the datagram, excluding this 4-byte field. The length field is only included when logging to tape and/or disk, but not for datagrams logged to a remote location. The length can then be derived from the network software. Systems logging data remotely should add this length at the start of each datagram. This length is required if the data are to be used with Kongsberg Maritime post-processing systems.
bySTX	1	Byte	Start identifier, always 02h

byTypeDatagram	1	Byte	Type of Datagram. Installation (I or i) or r (Remote information): Start = 049h Stop = 069h Remote info = 070h Runtime (R): 052h Raw range and beam angle 78 (N): 04eh XYZ88 (X): 058h, or 88d Clock (C): 043h Attitude (A): 041h Position (P): 050h Surface sound speed (G): 047h
wEMModeNum	2	unsigned int16	EM model number. For M3, use 30. For M3 dual head, use 30D
dwDate	4	unsigned int32	Date (in binary format) = year*10000+Month*100+day (example: April 26, 2016 = 20160426)
dwTimeMs	4	unsigned int32	Time since midnight in milliseconds (example: 08:12:51.234 = 29570234)
wCounter	2	unsigned int32	Sequential counter associated with each datagram. In M3, it is the ping sequential counter associated with data. Only exception is the counter in the installation datagram, where the counter starts from 0 and increases by 1 whenever a new installation datagram is received.
wSysSerialNum	2	unsigned int32	System serial number. Set it to the lower two bytes of the first M3 head sonar info.
wSecHeadSerialNum	2	unsigned int32	Secondary system serial number and only used by Installation parameter. Set it to the lower two bytes of the second M3 sonar info. Currently it is always 0.

2.2 Datagram Footer

Field	Item size (bytes)	Data type	Description
byETX	1	Byte	End identifier, always 03h
wCheckSum	2	unsigned int16	Sum of bytes between STX and ETX

2.3 Datagram body Description

2.3.1 Installation Parameter (I , i or r, 049h or 069h)

This datagram is an ASCII datagram except for the header which is formatted as in all other output datagrams. The datagram is issued as a start datagram when logging is switched on and as a stop datagram when logging is turned off, i.e. at the start and end of a survey line.

In the datagram all ASCII fields start with a unique three character identifier followed by "=". This should be used when searching for a specific field as the position of a field within the datagram is not guaranteed. The number or character part following is in a variable format with a minus sign and decimal point if needed, and with "," as the field delimiter. The format may at any time later be expanded with the addition of new fields at any place in the datagram.

Note: The .ALL format follows the right-handed Vessel Coordinate System convention, where x is forward, y is starboard and z is downward. This differs from the M3 convention where x is starboard, y is forward, and z is upward.

Field	Format	Data type	Description
WLZ	WLZ=x.x,	ASCII	Water line vertical location in m. Set it to 0 in M3.
SMH	SMH=x.x,	ASCII	System main head serial number. Set to the SonarInfo in M3.
R1S	R1S=x-x,	ASCII	RX no. 1 serial number. Set it to 100 in M3.
R2S	R2S=x-x,	ASCII	RX no. 2 serial number. Set it to 101 in M3.
S1Z	S1Z=x.x,	ASCII	Transducer 1 vertical location in m. +ive DOWN. In M3, set to head -**Z** offset.
S1X	S1X=x.x,	ASCII	Transducer 1 along location in m. +ive forward In M3, set to head **Y** offset.
S1Y	S1Y=x.x,	ASCII	Transducer 1 athwart location in m. +ive starboard-side. In M3, set to head **X** offset.
S1H	S1H=x.x,	ASCII	Transducer 1 heading (yaw) in degrees. +ive clockwise. In M3, set to head -Yaw offset (zRotOffset).
S1R	S1R=x.x,	ASCII	Transducer 1 roll in degrees relative to horizontal. +ive roll starboard. In M3, set to head Roll offset (yRotOffset).
S1P	S1P=x.x,	ASCII	Transducer 1 pitch in degrees, +ive pitch bow UP. In M3, set to head Pitch offset converted to EM coordinate (xRotOffset+90).
S1N	S1N=x-x,	ASCII	Transducer 1 no. of modules. Set to 1 for M3.

S2Z	S2Z=x.x,	ASCII	Transducer 2 vertical location in m. +ive DOWN. In M3, set to 2nd head **-Z** offset. It is 0 until the 2nd head is supported.
S2X	S2X=x.x,	ASCII	Transducer 2 along location in m. +ive forward In M3, set to 2nd head **Y** offset. It is 0 until the 2nd head is supported.
S2Y	S2Y=x.x,	ASCII	Transducer 2 athwart location in m. +ive starboard-side. In M3, set to 2nd head **X** offset. It is 0 until the 2nd head is supported.
S2H	S2H=x.x,	ASCII	Transducer 2 heading (yaw) in degrees. +ive clockwise. In M3, set to 2nd head Yaw offset. It is 0 until the 2nd head is supported.
S2R	S2R=x.x,	ASCII	Transducer 2 roll in degrees relative to horizontal. +ive roll starboard. In M3, set to 2nd head Roll offset. It is 0 until the 2nd head is supported.
S2P	S2P=x.x,	ASCII	Transducer 2 pitch in degrees. +ive pitch bow up. In M3, set to 2nd head Pitch offset. It is 0 until the 2nd head is supported.
S2N	S2N=x-x,	ASCII	Transducer 2 no. of modules. Set to 1 for M3.
GO1	GO1=x.x,	ASCII	System (Sonar head 1) gain offset. No offset for M3. Set to 0.
GO2	GO2=x.x,	ASCII	Sonar head 2 gain offset. No offset for M3. Set to 0.
TSV	TSV=c-c,	ASCII	Transmitter (sonar head 1) software version. It should eventually be set to the Tx Board FW version for M3. A version number is given as 3 alphanumerical fields separated by decimal points, plus date as yymmdd (for example 3.02.11 991124). Currently it is hard coded to 1.00.00 150901 but should be updated with the actual version later.
RSV	RSV=c-c,	ASCII	Receiver (sonar head 1) software version. It should eventually be set to the Rx Controller Board FW version for M3. Currently it is hard coded to 1.00.00 150901 but should be updated with the actual version later.
DSV	DSV=c-c,	ASCII	Datagram format version. We use 850/160692/U .ALL format.
OSV	OSV=c-c,	ASCII	Operator station software version. This is the M3 host software version. Currently it is hard coded to 2.00.00 161001 and should be updated with the actual version later.
APS	APS=x,	ASCII	Active position system number, range from 0 to 2. Set to 0 in M3.

P1M	P1M=x,	ASCII	Position system 1 motion compensation. 1 = the positions are motion compensated 0 = the positions are not motion compensated Set to 0 in M3.
P1T	P1T=x,	ASCII	Position system 1 time stamps used 0 = the system has used its own time stamp for the valid time of the positions 1 = the system has used the time stamp of the position input datagram (external time). Set to 0 for M3.
P1Z	P1Z=x.x,	ASCII	Position system 1 vertical location in m. Set to 0.00 for M3.
P1X	P1X=x.x,	ASCII	Position system 1 along location in m. Set to 0.00 for M3.
P1Y	P1Y=x.x,	ASCII	Position system 1 athwart location in m. Set to 0.00 for M3.
P1D	P1D=x.x,	ASCII	Position system 1 time delay in seconds. In M3, no settings for this. Set to 0.
P1G	P1G=c-c,	ASCII	Position system 1 geodetic datum. The geodetic datum is a coordinate system used to locate places on the Earth. Examples of map datum are: • WGS84: the World Geodetic System • NAD83, the North American Datum which is very similar to WGS 84 • OSGB36 of the Ordnance Survey of Great Britain • ED50, the European Datum In M3, this should be set to describe the Northing/Easting selection in "Setup-Geo-Projection". Currently set to “WGS84”.
MSZ	MSZ=x.x,	ASCII	Motion sensor 1 vertical location in m. In M3, no settings for this. Should set these to the head location. Currently set to 0.
MSX	MSX=x.x,	ASCII	Motion sensor 1 along location in m. In M3, no setting for this. Set to 0.
MSY	MSY=x.x,	ASCII	Motion sensor 1 athwart location in m. In M3, no setting for this. Set to 0.
MRP	MRP=aa,	ASCII	Motion sensor 1 roll reference plane. HO or RP. Set it to HO in M3.
MSD	MSD=x-x,	ASCII	Motion sensor 1 time delay in milliseconds. In M3, no setting for this. Set to 0.
MSR	MSR=x.x,	ASCII	Motion sensor 1 roll offset in degrees. In M3, no setting for this. Set to 0.

MSP	MSP=x.x,	ASCII	Motion sensor 1pitch offset in degrees. In M3, no setting for this. Set to 0.
MSG	MSG=x.x,	ASCII	Motion sensor 1 heading offset in degrees. In M3, no setting for this. Set to 0.
GCG	GCG=x.x,	ASCII	Gyrocompass heading offset in degrees. In M3, no settings for GCG. If external sensor used, set to zero. Else, set to head-Yaw offset. Currently set to 0.
PPS	PPS=x,	ASCII	1PPS clock synchronization 0 – not in use 1 – falling edge detect 2 – rising edge detect In M3, should be set to 2 if "Sonar Setup, Time Sync Mode" = "PPS", else set to 0.
CLS	CLS=x,	ASCII	Clock source. (0 - not set, default) 1 – ZDA 2 – Active POS 3 – Operator station In M3, should be set to 1 if ZDA sensor defined, else set to 3 (host PC) if head time has been set to host time, else set to 0. For now, set to 3 in all cases since head time is always set to the host PC time. The ZDA option in M3 just syncs the host PC time.
CLO	CLO=x,	ASCII	Clock offset in seconds. In M3, no setting for it. Set to 0.
bySpareByte	0	0 or 1 byte	Spare byte if required to get even length

2.3.2 Runtime Parameters (R, 052h)

Field	Item size (bytes)	Data type	Description
byOperStationStatus	1	Byte	Operator Station status, not used, set to 0
byProcUnitStatus	1	Byte	Processing Unit Status (CPU), not used, set to 0
byBSPStatus	1	Byte	BSP status, not used, set to 0
byHeadOrTransceiverStatus	1	Byte	Sonar Head or Transceiver status, not used, set to 0

byPingMode	1	Byte	Carrier Frequency (EM 2040) • xxxx 0000 - 200 kHz • xxxx 0001 - 300 kHz • xxxx 0010 - 400 kHz • xxxx 0011 - 500 kHz (specially for M3) TX pulse form: •xx00 xxxx – CW •xx01 xxxx - Mixed •xx10 xxxx – FM Dual Swath mode: •00xx xxxx - Dual swath = Off •01xx xxxx - Dual swath = Fixed •10xx xxxx - Dual swath = Dynamic An example: single head, and CW pulse: 0000 0011(0x03); single head, FM pulse: 0010 0011 (0x23). The frequency is not recognized by DotAll viewer, but can ask them for support later.
byFilterIdentifier	1	Byte	Indicate which type of filter is used and turned on. We have a medium spike filter which is always on (xxxx xx10) in current M3. So set this value to 0x02.
wMinDepthMeter	2	unsigned int16	Minimum depth for current profiling application in meter. Use current minimum slant range provided by M3 Database.
wMaxDepthMeter	2	unsigned int16	Maximum depth for current profiling application in meter. Use current maximum range provided by M3 Database.
AbsorpCoeff	2	unsigned int16	Absorption coefficient in 0.01dB/Km, ranging from 1 to 20000. Calculated by $\alpha = \frac{0.0036 f^2}{f^2 + 3600} + 3.2x10^{-7} f^2$ where f is the carrier frequency.
wTransPulseLengthUs	2	unsigned int16	Transmit pulse length in us. It is the actual pulse length for CW pulse, but is given by 1/(transmit Bandwidth) for LFM pulse.
wTxBeamWidth10Deg	2	unsigned int16	Transmit beamwidth in 0.1 degree. For current M3, the Tx has a 3-degree beam, so set it to 30.
nTxPowerReMaxdB	1	__int8	Transmit power re maximum in dB, ranging from 0 to -50. There are two Tx power level mode in M3: High and low and they have power difference of 20dB. We set the high power mode to 0, then the low power mode is -20dB. For M3, we use the high power mode except for the range of 5m. Set this field to 0 now. In the future, we will add more support to this field.

byRxBeamWidth10Deg	1	Byte	Receive beamwidth in 0.1 degrees. The value in the M3 data spec sheet is 1.6 degrees, so set to 16 for M3.
byRxBandWidthIn50Hz	1	Byte	Receive bandwidth in 50Hz units. Receiver bandwidth values 1 to 254 for receiver bandwidth 50 Hz to 12.7 kHz. A value of 255 indicates the bandwidth larger than 12.7 kHz.
byMode2OrRxFixedgain	1	Byte	Receiver fixed gain setting in dB. The M3 receiver frontend fix gain is 20dB. Set it to 20.
byTVGLawCrossOverAngleDeg	1	Byte	TVG law crossover angle in degrees. Not used in M3 and set to 2.
bySrcSoundSpeedAtTransducer	1	Byte	**Source of sound** speed at transducer depth: • 0000 0000 - From real time sensor • 0000 0001 - Manually entered by operator • 0000 0010 - Interpolated from currently used sound speed profile • 0000 0011 - Calculated by ME70BO TRU • xxx1 xxxx - Extra detections enabled • xx1x xxxx - Sonar mode enabled • x1xx xxxx - Passive mode enabled • 1xxx xxxx – 3D scanning enabled For M3, we use 0x00 or 0x01.
wMaxPortSwathWidthMeter	2	unsigned int16	Maximum Port Swath width in m. The maximum range supported by the M3 is 150m, and the maximum port coverage angle is 60 degrees. So the maximum port swath width equals 150*sin(60)= 130m.

byBeamSpacingIdenti	1	Byte	Beam Spacing identifier. One head: 0000 0xxx (the lower 3 bits xxx indicate the beam spacing type) Two heads: 1yyy 0xxx (xxx is for head 1 beam spacing type, and yyy is for head 2 beam spacing type) Beam spacing type identifier: FFT beamformer: xxxx x000 Equidistant: xxxx x001 Equiangle: xxxx x010 High density equidistant: xxxx x011 M3 Example: one head, FFT beamformer: 0000 0000; one head, equiangle:0000 0010
byMaxPortCoverageDeg	1	Byte	Maximum port coverage in degrees, ranging from 10 to 110. It is 60 degrees for the M3.
byYawPitchStabilizationMode	1	Byte	• xxxx xx00 - No yaw stabilization • xxxx xx01 - Yaw stabilization to survey line heading (Not used) • xxxx xx10 - Yaw stabilization to mean vessel heading • xxxx xx11 - Yaw stabilization to manually entered heading • xxxx 00xx - Heading filter, hard • xxxx 01xx - Heading filter, medium • xxxx 10xx - Heading filter, weak • 1xxx xxxx - Pitch stabilization is on. No yaw and pitch stabilization, or heading filter are used in M3, but no such option here. Set it to 0x08 (no yaw stabilization, weak heading filter).
byMaxStarboardCoverageDeg	1	Byte	Maximum starboard coverage in degrees, from 10 to 110. It is 60 degrees for the M3.
wMaxStarboardSwathWidthMeter	1	unsigned int16	Maximum starboard swath width in meters. Same to the Maximum Port Swath width and set to 130m.
nTxAlongTilt10Deg	2	__int 16	Transmit along tilt in 0.1 degree units. used to offset the along-ship tilting of transmit fan (called “Along Direction” in SIS and can be set from the Runtime parameters ->Sounder Main menu). Set this field to 0 because the M3 does not tilt the transmit pulse.

byFilterIdenti2	1	Byte	Filter identifier 2. Penetration filter: • xxxx xx00 - Penetration filter = Off • xxxx xx01 - Penetration filter = Weak • xxxx xx10 - Penetration filter = Medium • xxxx xx11 - Penetration filter = Strong Detect mode: • xxxx 00xx - Detect mode: Normal • xxxx 01xx - Detect mode: Waterway • xxxx 10xx - Detect mode: Tracking • xxxx 11xx - Detected mode: Minimum depth Phase ramp: • xx00 xxxx - Short phase ramp • xx01 xxxx - Normal phase ramp • xx10 xxxx - Long phase ramp Special TVG: • x0xx xxxx - Normal TVG • x1xx xxxx - Special TVG Special amp detect: • 0xxx xxxx - Normal amp detect •1xxx xxxx - Special amp detect For M3, no Penetration filter, normal detect mode, normal phase ramp, normal TVG, and normal amp detect, so set this byte to 0x10.

2.3.3 Raw Range and Beam Angle 78 Datagram (N, 04eh)

Field	Item size (bytes)	Data type	Description
wSoundSpeed10	2	unsigned int16	Sound speed at transducer in 0.1m/s units, ranging from 13000 to 19000 for the M3.
wNtx	2	unsigned int16	Number of transmit sections. It is 1 for M3.
wNrx	2	unsigned int16	Number of receiver beams in datagram
wNumValidDets	2	unsigned int16	Number of valid detections. Currently set to the number of receiver beams (wNrx) to support Hypack. QINSy is not affected by this change. The user can find the actual Number of valid detections in the datagram of XYZ88.
fSamplingFreqHz	4	float	Sampling frequency in Hz. Set to 1/sample_interval in M3.

dwDscale	4	unsigned int32	The Doppler correction applied in FM mode is documented here to allow the uncorrected slant ranges to be recreated if desired. The correction is scaled by a common scaling constant for all beams and then included in the datagram using a signed 8 bit value for each beam. Not used in M3. Set to 1.
Repeat cycle 1- Ntx entries of:	24* Ntx		For M3, Ntx =1.
nTiltAngle100Deg	2	__int16	Tilt angle re Tx array in 0.01 degree units. Not used in M3. Set to 0.
wFocusRangeCm	2	unsigned int16	Focus range in 0.1m units. 0 = no focusing applied. The M3 does not have Tx focusing, so set this field to 0.
fSignalLenSec	4	float	Signal length in seconds. It is the actual pulse duration for both CW and LFM pulse.
fSectorTxDelaySec	4	float	Sector transmit delay re first Tx pulse, in seconds. Set this field to 0 because M3 does not have multiple Tx sectors.
fCenFreqHz	4	float	Center frequency in Hz
wMeanAbsorbCoeff100dB	2	unsigned int16	Mean absorption coefficient In 0.01dB/Km units. In M3 calculated by $\alpha = \frac{0.0036 f^2}{f^2 + 3600} + 3.2x10^{-7} f^2$ where f is the carrier frequency.
bySignalWaveformIdenti	1	Byte	Signal waveform identifier. 0 = CW, 1 = FM up sweep, 2= FM down sweep. In M3, all FM pulses are up sweep. So this field is either 0 or 1.
byTxSectorNumor ArrayIdx	1	Byte	Transmit sector number/Tx array index, ranging from 0 to (Ntx-1). For M3, set this field to 0.
fSignalBwHz	4	float	Signal bandwidth in Hz. For CW pulse, it is 1/(pulse length). For LFM pulse, this info is not saved in MMB and PMB, so set this filed to RxFilterBW.
End of Repeat Cycle 1			
Repeat Cycle 2- Nrx entries of:	16* Nrx		
nBeamAng100Deg	2	__int16	Beam pointing angle re RX array in 0.01 degree units. The angles are relative to the transducer array center.

byTxSectorNum	1	Byte	Transmit Sector Number (index). It is the transmit sector number parameter in the Rx loop. For M3, set this field to 0.
byDetInfo	1	Byte	Detection information. The most significant bit (bit7) is used to specify if the beam has a valid detection. Bit 0-3 is used to specify how the range for this beam is calculated. A) Valid detection: (bit7) = 0. 0= Amplitude detect (0xxx 0000 or 0x00h) 1= Phase detect (0xxx 0001, or 0x01h) 2-15= Future use B) Invalid detection: (bit7) = 1 0= Normal detection (1xxx 0000, or 0x80h) 1= Interpolated or extrapolated from neighbour detections (1xxx 0001, or 0x81h) 2= Estimated (1xxx 0010, or 0x82h) 3= Rejected candidate (1xxx 0011, or 0x83h) 4= No detection data is available for this beam (all parameters are set to zero) (1xxx 0100, or 0x84h) 5-15= Future use In M3, we use 0x00h, 0x01h or 0x84h.
wDetWinLenSamples	2	unsigned int16	Detection window length in samples. Set to 0 if no valid detection for this beam in M3.
byQualityFactor	1	Byte	Quality factor = 2500*sd/dr, where sd is the standard deviation (sd) of the range detection and dr is the detected range. Set to 0 if no valid detection for this beam in M3.
nDCorr	1	__int8	The Doppler Correction applied in FM mode. The uncorrected range (two-way travel time) can be reconstructed by subtracting the correction from the range in the datagram: T(uncorrected) = T(datagram)- D(corr)/D(scale) In M3, no correction is applied, so set this field to 0.
fTwoWTravelTimeSec	4	float	Two way travel time in seconds. It is the Doppler corrected range. But In M3, it equals the range of the profiling point. T=2R/c, where R is the actual profiling point range, and c is the sound velocity. Set to 0 if no valid detection for this beam in M3.

nReflectivity10dB	2	__int16	Reflectivity in 0.1 dB resolution. (Example: -20.1 dB = FF37h= 65335) In M3, we assign this field with the profiling point intensity. It is not the reflectivity, but can be used as an indicator. Set to -201 (arbitrarily small number) if no valid detection for this beam in M3.
nRealTimeCleanInfo	1	__int8	Real time cleaning information. For future use. A real time data cleaning module may flag out beams. Bit 7 will be set to 1 if the beam is flagged out. Bit 0-6 will contain a code telling why the beam is flagged out. Set this field to 0 in M3.
bySpare	1	Byte	Spare byte. Set to 0.
End of Repeat Cycle 2			
bySpare1	1	byte	Spare byte. Set to 0.

2.3.4 Depth XYZ88 (X, 058h or 88d)

Field	Item size (bytes)	Data type	Description
wVesselHeading100Deg	2	unsigned int16	Heading of vessel at Tx time in 0.01 degree units.
wSoundSpeed10	2	unsigned int16	Sound speed at transducer in 0.1m/s, ranging from 13000 to 19000 for the M3.
fTxTransducerDepthMeter	4	float	Transmit transducer depth in m re water level at time of ping. In M3, set to head **-Z** offset. The transmit transducer depth should be added to the beam depths to derive the depths re the water line. Note that the transducer depth will be negative if the actual heave is large enough to bring the transmit transducer above the water line. This may represent a valid situation, but may also be due to an erroneously set installation depth of either the transducer or the water line.
wNumBeams	2	unsigned int16	Number of receiver beams in datagram (N).
wNumValidDets	2	unsigned int16	Number of valid detections.
fSamplingFreqHz	4	float	Sampling frequency in Hz. Set to 1/sample_interval in M3.
byScanInfo	1	Byte	Scanning info used only by EM2040. Set this field to 0 for M3.
bySpare3[3]	3	Byte	Spare bytes, set to 0.
Repeat cycle – N entries of:	20*N		

fDepthFromTransducerMeter	4	float	Depth (z) from transmit transducer in m. This field is corrected using the pitch and roll motion sensors. The heave and real time sound speed profile corrections are not supported in M3. Set to 0 if no valid detection for this beam in M3.
fAcrossTrackDistMeter	4	float	Acrosstrack distance (y) in meters. This field is corrected using the pitch and roll motion sensors. The heave and real time sound speed profile corrections are not supported in M3. Set to 0 if no valid detection for this beam in M3.
fAlongtrackDistMeter	4	flat	Alongtrack distance (x) in meters. This field is corrected using the pitch and roll motion sensors. The heave and real time sound speed profile corrections are not supported in M3. Set to 0 if no valid detection for this beam in M3.
wDetWinLenSamples	2	unsigned int16	Detection window length in samples. Set to 0 if no valid detection for this beam in M3.
byQualityFactor	1	Byte	Quality factor = 2500*sd/dr, where sd is the scaled standard deviation (sd) of the range detection and dr is the detected range. Set to 0 if no valid detection for this beam in M3. Note that the factor in the Kongsberg .ALL documentation is 250 and it is incorrect.
nBeamInciAngleAdj10Deg	1	__int8	Due to raybending, the beam incidence angle at the bottom hit will usually differ from the beam launch angle at the transducer and also from the angle given by a straight line between the transducer and the bottom hit. The difference from the latter is given by the beam incidence angle adjustment (IBA). The M3 does not have ray bending correction, so set this field to 0.
byDetInfo	1	Byte	Detection information. Same as the detection information defined in the Raw Range and Angle 78 datagram.
nRealTimeCleanInfo	1	__int8	Real time cleaning information. For future use. A real time data cleaning module may flag out beams. Bit 7 will be set to 1 if the beam is flagged out. Bit 0-6 will contain a code telling why the beam is flagged out. Set this field to 0 in M3.
nReflectivity10dB	2	__int16	Reflectivity in 0.1dB resolution. (Example: -20.1 dB = FF37h= 65335) In M3, we assign this field with the profiling point intensity. It is not the reflectivity, but can be used as an indicator. Set to -201 (arbitrarily small number) if no valid detection for this beam in M3.
End of Repeat cycle			

bySpare	1	Byte	Spare byte. Set to 0.

2.3.5 Clock Datagram (C, 043h)

Field	Item size (bytes)	Data type	Description
dwDateExtInput	4	unsigned int32	Date = year*10000 + month*100 + day (from external clock input) (Example: Feb 26, 1995 = 19950226). Currently the M3 sets this field to the system date based on an internal timer when running head, but set to a slightly adjusted ping time when playing back a file.
dwTimeMsExtInput	4	unsigned int32	Time since midnight in milliseconds from external clock datagram. (Example: 08:12:51.234 = 29570234) Currently the M3 sets this field to the system time based on an internal timer when running head, but set to slightly adjusted ping time when playing back a file.
By1PPSUse	1	Byte	Shows if the system clock is synchronised to an external 1 PPS signal or not. 0 = inactive 1=active In M3 set to 0 now.

2.3.6 Attitude Datagram (A, 041h)

Field	Item size (bytes)	Data type	Description
wNumEntries	2	unsigned int16	Number of entries (N), indicates how many sets of motion sensors are used for sonar system. Set to 1 in M3.
Repeat cycle –N entries of	**12*N**		
wTimeMsSinceRec	2	unsigned int16	Time in milliseconds since record starts. It is always 0 for M3 because the M3 records at most one value per ping.
wSenStatus	2	unsigned int16	Sensor status copied from the input datagram's two sync bytes if the sensor uses the EM format. Please refer to the following note about the EM Attitude input format. Set this field to 0x9090 in the M3 based on the note.
nRoll100Deg	2	__int16	Roll in 0.01 degree unis and is positive with port side up with ±18000 valid range.
nPitch100Deg	2	__int16	Pitch in 0.01 degree units and is positive with bow up with ±18000 valid range.
nHeaveCm	2	__int16	Heave in cm and is positive up. With -1000 to 10000 valid range.

wHeading100Deg	2	unsigned int16	Heading in 0.01 degree units and is positive clockwise with 0 to 35999 valid range.
End of repeat cycle			
bySenSysDescriptor	1	Byte	show which sensor the data is derived from, and which of the sensor's data have been used in real time by bit coding: • xx00 xxxx – motion sensor number 1 • xx01 xxxx – motion sensor number 2 • xxxx xxx1 – heading from the sensor is active • xxxx xx0x – roll from the sensor is active • xxxx x0xx – pitch from the sensor is active • xxxx 0xxx – heave from the sensor is active. In M3, set it to 0x01 and represent that the motion sensor #1 is used, and the heading, roll, pitch and heave from sensor are active. Note that in M3 the .ALL will only record the motion sensor selected for motion (pitch, roll, and heave) either from the internal sensor or an external sensor.

2.3.6.1 Note: EM Attitude input format

The EM attitude format is a 10-bytes long message defined as follows

- Byte 1: Sync byte 1 = 00h, or Sensor status = 90h-AFh
- Byte 2: Sync byte 2 = 90h
- Byte 3: Roll LSB
- Byte 4: Roll MSB
- Byte 5: Pitch LSB
- Byte 6: Pitch MSB
- Byte 7: Heave LSB
- Byte 8: Heave MSB
- Byte 9: Heading LSB
- Byte 10: Heading MSB

where LSB = least significant byte, MSB = most significant byte. All data are in 2's complement binary. Non-valid data are assumed when a value is outside the valid range.

How roll is assumed to be measured is operator selectable, either with respect to the horizontal plane (the Hippy 120 or TSS convention) or to the plane tilted by the given pitch angle (i.e. as a rotation angle around the pitch tilted forward pointing x-axis). The latter convention (called Tate-Bryant in the POS/MV documentation) is used inside the system in all data displays and in logged data (a transformation is applied if the roll is given with respect to the horizontal). Note that heave is displayed and logged as positive downwards (the sign is changed) including roll and pitch induced lever arm translation to the system's transmit transducer.

This format has previously been used with the EM 950 and the EM 1000 with the first synchronisation byte always assumed to be zero. The sensor manufacturers have been requested to include sensor status in the format using the first synchronisation byte for this purpose. It is thus assumed that

- 90h in the first byte indicates a valid measurements with full accuracy
- any value from 91h to 99h indicates valid data with reduced accuracy (decreasing accuracy with increasing number)
- any value from 9Ah to 9Fh indicates non-valid data but normal operation (for example configuration or calibration mode)
- and any value from A0h to AFh indicates a sensor error status.

2.3.7 Position Datagram (P, 050h)

Field	Item size (bytes)	Data type	Description
nLatitude20000000Deg	4	__int32	Latitude in decimal degrees * 20000000. The value is negative if southern hemisphere. Example: 32° 34' S = -651333333
nLongitude10000000Deg	4	__int32	Longitude in decimal degrees * 10000000. The value is negative if western hemisphere. Example: 110.25° E = 1102500000
wPosFixQualityCM	2	unsigned int16	Measure of position fix quality in cm. These data will be valid only if available as input. The calculation is done according to the selected position input format. See the following note about *Position fix quality*. Set this field to 50 in the M3 if there is no position input available or if playing back previous recording before M3 V2.0. 50cm means 0.5m.
wVesselSpeedCms	2	unsigned int16	Speed of vessel over ground in cm/s starting from 0. The speed is set to 65534 in M3 if no speed value is available.
wVesselCourse100Deg	2	unsigned int16	Course of vessel over ground in 0.01 degrees units ranging from 0 to 35999. The M3 does not support this field yet, so set it to 0.
wVesselHeading100Deg	2	unsigned int16	Heading of vessel in 0.01 degrees ranging from 0 to 35999.

byPosSystemDescriptor	1	Byte	Position system descriptor • xxxx xx01 - position system no 1 • xxxx xx10 – position system no 2 • xxxx xx11 – position system no 3 • 10xx xxxx – the position system is active, system time has been used • 11xx xxxx - the position system is active, input datagram time has been used • xxxx 1xxx – the position may have to be derived from the input datagram which is then in SIMRAD 90 format Set this field to 0x81, representing the position system 1 is active and the system time has been used.
byNumBytesInInputGram	1	Byte	Number of bytes in input datagram.
byPositionInputDatagramReceived	variable	Byte	Position input datagram as received in GGA string format. Complete input datagram except header and tail. See following note for an example of the GGA string format.
BySpare	0-1	Byte	Spare byte if required to get even length.

2.3.7.1 Note: Position Fix Quality

The M3 accepts position data in the following formats

• NMEA GGA • GGK • GGL

If GGA datagram:

The HDOP (Horizontal Dilution Of Precision) value will be scaled and copied to the ”Measure of position fix quality” field in the position output datagram. The scale factor depends upon the GPS quality indicator’s value:

- 1 - (SPS or standard GPS) => 1000
- 2 - (differential GPS) => 100
- 3 - (PPS or precise GPS) => 200, but 10 if GGA is treated as RTK.
- 4 - (kinematic GPS with fixed integers) => 10
- 5 - (kinematic GPS with floating integers) => 50
- 6 - (estimated or dead reckoning mode) => 1000
- 7 - (manual input mode) => 1000
- 8 - (test mode) => 1000, but 10 if GGA is treated as RTK.

If GGK datagram:

The DOP (Dilution of Precision) value will be scaled and copied to the “Measure of position fix quality” field in the position output datagram. The scale factor depends upon the GPS quality indicator’s value

- 1 – (Standard GPS) => 1000.0;
- 2 – (RTK float) => 50.0;
- 3 – (RTK fix) => 10.0;

- 4 – (DGPS) => 100.0;
- 5 – (WAAS/EGNOS) => 100.0;
- 6 – (Network Float) => 50.0;
- 7 – (Network fix) => 10.0;

Note: The “Measure of position fix quality” field will be set to 65534 (largest valid number) if the indicator is zero (non-valid position). This scaling is used to give at least a relatively correct position fix quality change (in the order of cm) if there are dropouts in differential, precise or kinematic measurements, although HDOP or DOP is not a meter value. The GPS manufacturers may have different GPS quality indicators.

2.3.7.2 Note: A GGA String Example

```
aGGAExample = _T(
    "
    1) INGGA,
    2) 235743.73,          strUTC
    3) 4120.989726,        strLat
    4) S,                  North/South
    5) 17449.341962,       strLon
    6) E,                  East/West
    7) 2,                  GPS quality indicator. e.g., 2 = DGPS fix, 1 = GPS fix (SPS)
    8) 11,                 Number of satellites being tracked
    9) 0.9,                HDOP, Horizontal dilution of position
    10) -1.46,             Altitude, Meters, above mean sea level
    11) M,                 altitude unit meter
    12) 16.04,             Height of geoid (mean sea level) above WGS84 ellipsoid
    13) M,                 height unit meter
    14) 18.0,              time in seconds since last DGPS update, not available in M3
    15) 1013               DGPS station ID number, not available in M3
    16) *5A                the checksum data, always begins with *
    ");
```

2.3.8 Surface Sound Speed Datagram (G, 047h)

Field	Item size (bytes)	Data type	Description
wNumEntries	2	unsigned int16	Number of entries (N), indicates how many surface sound speed sensors are used in the system. Set it to 1 in M3.
Repeat cycle –N entries of	**4*N**		

wTimeSecStartRec	2	unsigned int16	Time in seconds since record starts. Set this field to 0 because at most one value per ping.
wSoundSpeed10	2	unsigned int16	Sound speed at transducer in 0.1m/s units (excluding offset), ranging from 13000 to 19000 for the M3.
End of repeat cycle			
bySpare	1	Byte	Spare byte. Set to 0.

3 DATAGRAM OUTPUT SEQUENCE

A typical M3 .All datagram output sequence is given below.

- Always start with an Installation Start datagram (I)
- Always followed by three Runtime datagrams (R)
- Output Attitude datagram (A) at the ping rate. In definition, the attitude datagram should be outputted whenever the motion sensors (pitch, roll, heave, and heading) provide new inputs. The input rate is usually faster than 40Hz, the highest ping rate supported by the M3 system. However, the M3 is designed to read the sensor data based on the ping rate, so it is expected to see one Attitude datagram (A) for each ping.
- Output Position datagram (P) whenever the longitude and/or latitude changed. The maximum supported change rate is the ping rate defined in M3 system for a given range. It is expected to see fewer position datagrams than the attitude datagrams if the position sensor input rate is slower than the ping rate.
- Output raw range datagram (N), depth XYZ datagram (X) and surface sound speed (G) at the ping rate.
- Output Clock datagram (C) at a rate of 1Hz with uncertainty less than 1ms. The current M3 system does not support direct 1PPS synchronization of host/head time. Instead, a timer (with 1ms uncertainty) is defined internally when running head to trigger the clock datagram output every second. The date/time reported by the clock datagrams is therefore the computer time when running head (the timer in the sonar head that timestamps the ping data is also set to the computer time).

  When playing back an M3 recording, it is not a real time operation (e.g., fast-forward could be used). The clock datagram output is still supported in this scenario, but the ping time stamp information in the M3 recording is used to decide when to output a clock datagram. The date/time reported by the clock datagrams when playing back an M3 recording is the slightly modified ping time, to simulate a 1Hz output rate of the recorded time/date with an uncertainty of 1ms.
- Always end with an Installation Stop datagram (I).