U.K. OFFSHORE OPERATORS ASSOCIATION
(SURVEYING AND POSITIONING COMMITTEE)

P2/94 EXCHANGE FORMAT FOR RAW MARINE POSITIONING DATA

EXECUTIVE SUMMARY

The P2/94 format for the exchange of raw positioning data is recommended by UKOOA for general use in the Oil and Gas, Exploration and Production industry.
The format is not mandatory and operators may adopt different format standards in a particular situation where to do so would maintain an equivalent level of quality and performance.

P2/94 has been developed in response to recent and increasing reliance on differential GPS positioning for offshore surveying. It is based upon and may be considered as an extension of it's forerunner, P2/91, which caters especially for the positioning data exchange requirements of modern seismic surveys. It may, however, be used for any applicable kind of positioning data. The aim in developing P2/94 was to add formatting standards for all the parameters needed to re-construct positions based upon DGPS observations while making minimum changes to existing P2/91 records. The intention was to make it possible for operators who do not require to use raw DGPS data to continue using existing software which could simply ignore the additional DGPS records. However, operators should note that in the process of consultation with prospective users, a number of small improvements to the original P2/91 format have been identified and included.

P2/94 has been developed on behalf of the UKOOA Surveying and Positioning Committee by Concept Systems Ltd under guidance of the Topographic Department of Shell UK Expro.
Any comments and suggestions for improvement are welcome and should be addressed to:

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1. INTRODUCTION

The UKOOA P2/91 data exchange format was designed to record positioning data for both 2D and 3D seismic surveys.

"Raw data" is deemed to be the measurements taken by positioning sensors before the application of variable (C-O) corrections and/or variable scale corrections which may result from calibrations.
The format allows individual time-tagging of observations. This is done in a way transparent to computer software not capable of reading and processing the time information.

The design objective of this format was to provide a flexible raw data format, allowing effective storage of positioning data from modern, ever changing survey configurations, within the following framework:

- the format should enable effective data exchange;
- the format should allow computer processing of the data to take place with minimum operator intervention.

The first requirement calls for completeness and has been interpreted to require a text file format, which is sufficiently "logical" and structured to the human brain to allow some degree of visual interpretation and inspection.

The format uses a coded system of records so that certain record types may be omitted entirely if they are not relevant. Any physical data storage medium may be used by prior agreement between the parties involved in exchange of the data.

1.1 Introduction to P2/94

P2/94 adds the recording of raw GPS and DGPS observations to the P2/91 format.

Keeping in mind that P2/94 is not only an exchange format, but also a processing and archiving format, facilities for recording the satellite ephemerides, the ionospheric conditions and the meteorological conditions have also been provided.

The format extensions fit within the previous style and intentions of P2/91. Particularly, the extensions have been made in such a fashion as to ensure that existing software which uses P2/91 revision 1.1 will be able to use the non-GPS data in a P2/94 format file simply by ignoring those records which it does not recognise.

Two additions to the general philosophy of P2/91 made in P2/94 are the introduction of "updateable parameters" (necessary parameters, like the satellite ephemerides, which are recorded in the header but may be updated during the line), and the appearance of numbers in scientific notation (to deal with the extremes of scale involved in astronomical calculations)

The overall style of the additions has attempted to maintain compatibility, in content and precision, with existing standards in the GPS world, whilst alleviating any complexities or inefficiencies which arise from using these formats in marine seismic.

2. LOGICAL FILE STRUCTURE

Record length
The data is stored in 80 byte "card image" records, the columns of which are numbered 1 through 80.

Record types
The format defines four main types of record which are identified by the first character of the record:

H : survey header data
C : comments
E : event data (implicit time reference)
T : inter-event data (explicit time reference)

Every file/line must start with records H0000 to H00@9, in sequential order. Although no further sequence is imposed on the survey header records, it is strongly recommended to adhere to the definition sequence in this document. Comment records are allowed to be inserted anywhere in a file, but not before record H00@9.

Record codes
Characters 2-5 contain a numeric code which describes the nature of the data stored in the record and allows easy grouping of related records. For example the numbering of the E- and T-records runs parallel to the numbering of H-records in which the definition of the relevant data is stored. Hence, an E25@0 record contains streamer depth sensor data, while an H25@O record contains the matching definition.

The vessel reference number is shown in the record code definitions as '@' where the data in the record refers to one vessel with its towed configuration in particular. It is provided merely to facilitate the sorting of the data according to vessel in multi-vessel surveys should the user wish to process subsets of data per vessel. In all cases the '@' in the record code is redundant information.

Time records
T-records may be used to supplement or replace corresponding E-records, subject to client requirements. The sequence of E-records and T-records is strictly chronological: if the time recorded in a T-record is between event time 'i' and event time 'j', it is inserted after the E-records relating to event time 'i', but before the General Event Record defining event time 'j'. It is stressed that, although absolute time is recorded on the T-records to allow unambiguous identification of the data, only the relative times are important.

Times in records
With the inclusion of GPS and DGPS information, the question of time frame becomes important. The following time frames are identified in P2/94 :

System Time - the master vessel's time system, stated in H1310 to be related to GMT. This is the time used for E1000 and all T record time tags.

Vessel Times - any other vessel's time, defined in relation to System Time by H13@0.
GPS Time - the GPS time standard as established by the GPS Control Segment. Differential corrections' "time of applicability" is recorded in this time frame.

Receiver Times - the time frames held by individual GPS receivers, not including the receivers' estimate of its clock offset. The "receiver time of receipt" of GPS data is in this time frame.
Data fields
The following types of data fields are defined (x = total field length):

- Fx.y Fixed format numeric fields; sign and decimal point included;
  y = number of digits after decimal point;
  usually specified only to indicate the number of significant digits required; in some cases, e.g. geographical co-ordinates, the field format is consistent to facilitate efficient computer conversion.
- Nx Free format numeric field; sign and decimal point included.
- Ix Integer field.
- Ax Text field.
- Ex.y Scientific format numeric fields; these consist of, in left to right sequence :
  Optional sign
  Mantissa, with y digits after the decimal point
  E (the character "E")
  Optional sign of exponent

Integer exponent

Note that scientific notation is permissible only in fields so specified - it is not allowable in Nx fields.

<u>One line per file</u>
The data for each seismic line must be recorded as a separate file, starting with a complete set of header records. If any of the survey header data changes, a complete set of revised header records should be inserted but no new file should be started mid-line. This is required to allow easy transcription of data from high capacity storage media to lower capacity media and to facilitate random access to individual lines for processing.

Data for a seismic line may in general not be split over different storage media such as tapes, diskettes etc.

<u>Exceptions to the "one line per file" rule</u>
Two exceptions exist:

a) Very long lines
The data for very long lines may physically not fit on the chosen storage medium. The first option should be to consider a more suitable physical storage medium. However, if this impracticable, the data should be split over different media, starting on the new medium with a new file and hence a complete set of header records.

b) Multi-vessel surveys.
Although it is strongly recommended to store all data relating to one seismic event and to one seismic line on the same physical storage medium, regardless of the number of vessels involved, it is realised that this principle may occasionally lead to practical difficulties.

Subject to client requirements it is therefore considered acceptable to split multi-vessel data according to acquisition vessel and store each subset on separate storage media as if it concerned different seismic lines, each subject to the above rules. However, the following conditions should then be satisfied:

- No data is stored more than once, except the following categories:
  - all survey header data common to all vessels;
  - General Event Data (E1000 record)

  This data must be repeated on each of the vessel subsets of the line data.
- The data for one seismic line relating to one vessel may not be split further over different storage media, except when the line is too long.

<u>Complete, not over-complete, headers</u>
The set of header records supplied for the line should only contain definitions for observations and elements of the survey spread that are intended to be used during the survey.

This rule is intended to prevent vastly over-complete sets of header data being supplied with e.g. all radio positioning systems in the North Sea defined.

The header records should therefore contain close to the minimum information required to define all recorded positioning data. However, the definitions of observations that are intended to be used in the survey but are missing on an exceptional basis do not need to be excluded from the block of headers for those lines for which the data is not available.

<u>Redundant information</u>
In a number of places the format requires redundant information to be recorded. The purpose of this is to allow integrity checks on the supplied data to take place. Redundant information should therefore not conflict with information supplied elsewhere in the format.

<u>Nominal offsets</u>
The complete nominal, or design, confirmation of the survey spread should be supplied in the header data. This specifically holds for points that are surveyed in, for example, the front ends of the streamers.

3. STORAGE MEDIA AND PHYSICAL FILE SPECIFICATION

It is accepted that **new mediums may be introduced** during the life of this format and it is emphasised that **any physical storage medium which is agreed by all parties involved in the data exchange is acceptable**.

Specifications for two common media are detailed below.
Variations are acceptable by prior arrangement of the parties involved.

Tape	- type	:	0.5 inch, 9-track, IBM standard;
	- data density	:	6250 bpi
	- record size	:	80 bytes
	- block size	:	8000 bytes, blocks separated by an inter-record gap
	- character code	:	ASCII or EBCDIC

Exabyte	- type	:	8500
	- capacity	:	5Gb
	- density	:	1Mb/inch

A tape file should be closed off by an IBM end-of-file mark, the last file on a tape by two consecutive IBM end-of-file marks.

Diskette	- type	:	3.5 inch, DOS IBM-PC compatible
	- capacity	:	1.44 Mb
	- record size	:	maximum 80 data bytes, followed by a CR/LF
	- character code	:	ASCII

Each tape, diskette or other storage media should be labelled clearly with the specifications of the stored data.

4. GENERAL RULES

In addition to the rules given in chapters 2 and 3 the following general rules shall apply.

a) All records shall be 80 characters long, i.e. padded with spaces if necessary; all non-specified columns shall therefore contain blanks. (In the case of storage of data on DOS diskette this rule is waived: records shall be up to 80 characters long and shall be terminated by a CR/LF)

b) Data fields or records for which no data is available may be omitted (records) or left blank (data fields)

c) Nil-data returns from positioning sensors shall be recorded as blanks.

d) All correction items shall be defined to add to the raw values.

e) Files/lines should begin records H0000 to H0 in sequential order. The sequence of the remainder of the survey header records is not crucial but they should follow the logical groupings indicated in this document. If using GPS or DGPS, records H0100 to H0140 are also required.

f) Comment cards should be inserted as close as possible to the data items they refer to. They may not be inserted before record H00@9.

g) An event occurs at the moment of the seismic shot. All data recorded for that event in E-records is assumed to apply to that moment in time.

h) The time tags recorded for inter-event data shall refer to the time system of the master vessel.

i) Unless otherwise specified, all text items (specifier A) shall be left adjusted and all numeric items (specifiers E, F, N and I) shall be right adjusted.

j) All feet referred to in this document are international feet, defined as follows: 1 international foot = 0.30480 metres.

k) For recording raw GPS data, H51, H52 and H54 records are required (as with network data) to define the nodes and observations used, H6300 is required to define the strategy adopted for providing ephemeris, almanac, UTC and ionospheric parameters, and H631 must be provided for initial ephemerides. Note that H620 is **not** required, since this information is supplied through the H51 and H52 records.

l) To record raw DGPS data, H65 and H66 records must be supplied for each differential correction source.

5. SUMMARY OF RECORD CODES

H0... Survey Definitions

H00.. General Definitions

H0000	Line Name
H0001	Project Name
H0002	Project Description
H0003	Media and Format Specification
H0004	Client
H0005	Geophysical Contractor
H0006	Positioning Contractor
H0007	Positioning Processing Contractor
H00@8	Line Parameters
H00@9	Additional Waypoint Definitions
C0001	Additional Information - Entire Project Related
C0002	Additional Information - Line Related
C0003	Additional Information - (Inter-)Event Related

H01.. Geodetic Definitions

H0100	Magnetic Variation - General Information
H0101	Magnetic Variation - Grid Data
H011#	Datum and Spheroid Definitions
H0120	Seven Parameter Cartesian Datum Shifts
H0130	Other Datum Shift Parameters
H0140	Projection Type
H0150	(Universal) Transverse Mercator Projection
H0160	Mercator Projection
H0170	Lambert Projection
H0180	Skew Orthomorphic and Oblique Mercator Projection
H0181	Skew Orthomorphic and Oblique Mercator Projection (cont)
H0190	Stereographic Projection
H0199	Any Other Projection

H02.. Survey Summary Data

H0200	General Summary Information
H0210	Vessel Summary Information
H0220	Streamer Summary Information
H0230	Gun Array Summary Information
H0240	Towed Buoy Summary Information

H1... Vessel Definitions

H10@0	Vessel Reference Point Definition
H11@0	Steered Point Definition
H12@0	Onboard Navigation System Description
H12@1	Definition of Quality Indicators for Field Positioning Derived Data
H13@0	Vessel Time System Definition
H14@#	Echo Sounder Definition
H1500	Observed Velocity of Sound - Definitions
H1501	Observed Velocity of Sound - Profile
H16@0	USBL Definition
H16@1	USBL Definition (continued)
H16@2	Definition of Quality Indicator Type for USBL
H17@0	Pitch, Roll and Heave Sensor Definitions
H17@1	Definition of Quality Indicator Type for Pitch, Roll and Heave

H2... Streamer Definitions

H21@0	Streamer Geometry Definitions
H21@1	Streamer Geometry Definitions (continued)
H21@2	Definition of Quality Indicator Type for Streamer Compasses
H21@3	Definition of Quality Indicator Type for Streamer Depth Sensors
H22@0	Compass Locations
H2300	Compass Correction Derivation (Static)

H23@0 Compass Corrections (Static)
H2301 Compass Correction Derivation (Dynamic)
H23@1 Compass Corrections (Dynamic)
H24@0 Seismic Receiver Group Definitions
H24@1 Auxiliary Seismic Channel Definition
H25@0 Streamer Depth Sensor Definitions

H3... **Gun Array Definitions**
H31@0 Gun Array Geometry Definitions
H31@1 Individual Gun Definition
H32@0 Description of Gun Array Depth Sensors
H32@1 Gun Array Depth Sensor Definitions
H32@2 Definition of Quality Indicator Type for Gun Array Depth Sensors
H33@0 Definition of Intended Gun Firing Sequence
H34@0 Gun Array Pressure Sensor Definitions
H34@1 Description of Gun Array Pressure Sensors

H4... **Other Towed Buoy Definitions**
H41@0 Towed Buoy Geometry Definitions

H5... **Survey Network Definitions**
H5000 Node Definition (fixed locations)
H51@0 Node Definition (vessel, gun array, streamer, towed buoy)
H52## Observation Definition
H5306 Differential Observation - follow up record
H5307 Composite Range - follow up record
H54## Observation Definition (continued)
H5500 Definition of System Specific Quality Indicator
H56@0 Instrument Correction

H6... **Satellite System Definitions**
H600# Satellite System Description
H610# Definition of Differential Reference Stations
H620# Satellite Receiver Definition
H6300 GPS parameter recording strategy
H6301 DGPS differential correction recording strategy
H631# GPS clock and ephemerides parameters
H632# GPS ionospheric model & UTC parameters
H6330 Meteorological parameters
H65## DGPS differential correction source definition
H66## DGPS differential correction source description
H67@0 GPS ellipsoidal height estimate

H7... **User Defined Observation Sets**
H7000 Definition of User Defined Observation Sets
H7010 Data Field Definitions
H7020 User Defined Observation Parameters
H7021 Definition of Quality Indicator Type for User Defined Observations

E1... **Vessel Related and General Event Data**
E1000 General Event Data
E12@0 Field Positioning Derived Data
E14@0 Echo Sounder Data
E16@0 USBL Acoustic Data
E17@0 Pitch, Roll and Heave Sensor Data

E2... **Streamer Data**
E22@0 Streamer Compass Data
E24@1 Auxiliary Seismic Channel Data
E25@0 Streamer Depth Sensor Data

E3... **Gun Array Data**
E32@0 Gun Array Depth Sensor Data

E33@0 Gun Fired Mask
E34@0 Gun Pressure Sensor Data

E5... **Network Data**

E52## Network Observations
E54## Network Observation Parameters
E55## Network GPS Observations
E56## Network GPS Observations (continued)

E6... **Satellite Positioning & Correction Data**

E620# GPS or DGPS positioning data
E621# GPS or DGPS positioning data (continued)
E6303 TRANSIT Satellite Data
E640# Satellite Data (other systems)
E65## Inter-event DGPS corrections

E7... **User Defined Event Data**

E7010 User Defined Observation Set Data

T1... **Inter-event Vessel Related and General Event Data**

T14@0 Inter-event Echo Sounder Data
T16@0 Inter-event USBL Data
T17@0 Inter-event Pitch, Roll and Heave Sensor Data

T5... **Inter-event Network Data**

T52## Inter-event Network Data
T54## Inter-event Network Observation Parameters
T55## Inter-event Network GPS Observations
T56## Inter-event Network GPS Observations (continued)
T57@0 GPS ellipsoidal height estimate

T6... **Inter-event Satellite Positioning, Parameters & Correction Data**

T620# Inter-event GPS or DGPS Data
T621# Inter-event GPS or DGPS Data (continued)
T6303 Inter-event TRANSIT Satellite Data
T631# GPS clock and ephemerides parameters update
T632# GPS ionospheric model parameters update
T6330 Meteorological parameters update
T640# Inter-event Satellite Data (other systems)
T65## Inter-event DGPS corrections
T67@0 Inter-event GPS ellipsoidal height estimate

T7... **Inter-event User Defined Event Data**

T7010 Inter-event User Defined Observation Set Data

6. DESCRIPTION OF HEADER RECORDS

6.1 SURVEY DEFINITIONS

6.1.1 GENERAL DEFINITIONS

H0000 Line Name

"Line Name:"	[6,15]	A10	
Line name	[29,44]	A16	
Line sequence number	[46,49]	I4	
Line description	[50,80]	A31	free text

NOTE:
The line sequence number is a sequential number to be allocated to each line in the order it was shot, starting with 1. The line description should contain information about the type of line, e.g. straight, circle, cycloid, etc.

H0001 Project Name

"Project Name:"	[6,18]	A13	
Project identifier	[29,36]	A8	
Project name	[38,62]	A25	free text
Start date of survey	[64,71]	I4,I2,I2	YYYYMMDD
End date of survey	[73,80]	I4,I2,I2	YYYYMMDD

NOTE:
Data may be generated and delivered before the end of the survey. In that case the 'End date of survey' field shall be left blank.

H0002 Project Description

"Project Description:"	[6,25]	A20	
Survey type, location	[29,80]	A52	free text

H0003 Media and Format Specification

"Media Specification:"	[6,25]	A20	
Date of issue	[29,36]	I4,I2,I2	YYYYMMDD
Media label	[38,47]	A10	
Prepared by	[49,64]	A16	free text
Format name	[66,76]	A11	e.g. UKOOA P2/94
Format revision code	[78,80]	F3.1	e.g. 1.0

H0004 Client

"Client:"	[6,12]	A7	
Description of client	[29,80]	A52	free text

H0005 Geophysical Contractor

"Geophysical Contractor:"	[6,28]	A23	
Description of geophysical contractor	[29,80]	A52	free text

H0006 Positioning Contractor

"Positioning Contractor:"	[6,28]	A23	
Description of positioning contractor	[29,80]	A52	free text

H0007 Positioning Processing Contractor

"Processing Contractor:"	[6,27]	A22	
Description of positioning processing contractor	[29,80]	A52	free text

H00@8 Line Parameters

@ = 0, CMP position
@ = 1..9, Vessel reference number

"Line Parameters Vessel:"	[6,28]	A23	
Vessel reference number (0 for CMP)	[30,30]	I1	
Flag for geographical or grid co-ordinates	[32,32]	I1	0 = geographical 1 = grid
Start Of Line Latitude	[34,45]	I3,I2,F6.3,A1	dddmmss.sss N/S
Start Of Line Longitude	[46,57]	I3,I2,F6.3,A1	dddmmss.sss E/W
or:			
Start Of Line Northing	[34,44]	N11	
"N"	[45,45]	A1	
Start Of Line Easting	[46,56]	N11	
"E"	[57,57]	A1	
First shotpoint number	[59,64]	I6	
Shotpoint number increment	[66,68]	I3	
Shotpoint interval	[70,75]	F6.2	
Length unit	[77,77]	I1	metres or feet 0 = metres 1 = feet
Number of additional way points defined in H00@9 records	[79,80]	I2	

NOTE:
The Start Of Line is defined as the planned position of the vessel reference point at the first shot of the line

The End Of Line should, when appropriate, be defined in record H00@9.

The "Number of additional way points defined in record H00@9" shall not include the Start Of Line, which is defined in this record.
In the case of a straight line only the End Of Line shall be defined as an additional waypoint and this number therefore equals 1 for straight lines.

Complex line shapes, such as circles and cycloids, should only have one waypoint defined, viz. the Start Of Line. No H00@9 records should be supplied in that case. The properties of the complex line should be described in one or more C0002 records, following the H00@9 record.

H00@9 Additional Waypoint Definitions

@ = 0, CMP position
@ = 1..9, Vessel reference number

Vessel reference number

(0 for CMP)	[7, 7]	I1	
Waypoint number	[9,11]	I3	
Waypoint Latitude	[13,24]	I3,I2,F6.3,A1	dddmmss.sss N/S
Waypoint Longitude	[26,37]	I3,I2,F6.3,A1	dddmmss.sss E/W
or:			
Waypoint Northing	[13,23]	N11	
"N"	[24,24]	A1	
Waypoint Easting	[26,36]	N11	
"E"	[37,37]	A1	

May be repeated for one more waypoint definition in columns [39,67].
Vessel reference number is not repeated. Record may be repeated.

NOTE:
Waypoint co-ordinates should be supplied in the same type of co-ordinates as the Start Of Line (geographical. or grid) and should define successive positions of the vessel reference points.

The End Of Line is defined as the planned position of the vessel reference point at the last shot of the line. The End of Line should be the last of the waypoints defined.

C0001 Additional Information - Entire Project Related

Project related additional information	[6,80]	A75	free text

C0002 Additional Information - Line Related

Line related additional information	[6,80]	A75	free text

C0003 Additional Information - (Inter-)Event Related

(Inter-)event related additional information	[6,80]	A75	free text

Additional Comments

Three comment records are available for general, free text comments, considered relevant to the survey.

C0001 - for information related to the entire project;
C0002 - for information related to the seismic line only;
C0003 - for information related to (inter-)event data.

Any number of these records may be inserted in the data. C0001 and C0002 records may appear anywhere among the other header records, but after record H00@9.

C0003 records may appear anywhere among the (inter-)event data, but after the relevant General Event record E1000.

Common sense would dictate that whatever comment records are used, they are inserted as close as possible to the records to which the comments refer.

6.1.2 GEODETIC DEFINITIONS

H0100 Magnetic Variation - General Information

Date for which the Magnetic Variation values are valid	[7,14]	I4,I2,I2	YYYYMMDD
Number of points in grid	[16,19]	I 4	
Defined in geographical or grid co-ordinates	[21,21]	I1	0= geographical 1 = grid
Source of Magnetic Variation	[23,80]	A58	free text

H0101 Magnetic Variation - Grid Data

Point number	[7,10]	I4	
If geographical co-ords:			
Latitude of point	[12,23]	I3,I2,F6.3,A1	dddmmss.sss N/S
Longitude of point	[25,36]	I3,I2,F6.3,A1	dddmmss.sss E/W
If rectangular co-ords:			
Northing	[12,22]	N11	
"N"	[23,23]	A1	
Easting	[25,35]	N11	
"E"	[36,36]	A1	
Magnetic Variation	[38,44]	F7.3	+/- degrees decimal
Secular change in Magnetic Variation in this point	[46,51]	F6.4	+/- degr.dec./year

Record may be repeated.

NOTE:
Records H0100 and H0101 together allow a grid of points to be defined to cater for varying Magnetic Variation over the survey area. The grid may either be defined in terms of geographical co-ordinates or in terms of rectangular co-ordinates (e.g. UTM), as defined in records H0140 … H0199.

H011# Datum and Spheroid Definitions

= 1..9, datum & spheroid number

Datum name	[7,24]	A18
Spheroid name	[25,43]	A19
Semi-major axis (a)	[44,55]	N12
Conversion factor to metres	[57,68]	N12
Inverse flattening (1/f)	[70,80]	N11

NOTE:
The conversion factor, multiplied by the semi-major axis, should yield the value of the axis in metres. Hence, if the semi-major axis is supplied in international feet, the conversion factor should equal 0.30480.

H0120 Seven Parameter Cartesian Datum Shifts

From Datum 1 to Datum 2

Datum 1: datum/spheroid number		[7, 7]	I1	
Datum 2: datum/spheroid number		[9, 9]	I1	
Rotation convention		[11,11]	I1	0 = position vector rotation (Bursa-Wolf) 1 = co-ordinate frame rotation
X shift	(δX)	[13,22]	F10.2	metres
Y shift	(δY)	[24,33]	F10.2	"
Z shift	(δZ)	[35,44]	F10.2	"
X rotation	(θx)	[46,53]	F8.4	seconds of arc
Y rotation	(θy)	[55,62]	F8.4	"
Z rotation	(θz)	[64,71]	F8.4	"
Scale correction	(S)	[73,80]	F8.4	ppm

NOTE:
Up to 9 different datum/spheroids may be defined. Datum/spheroid number 1 is referred to as the Survey Datum and shall apply to all co-ordinates recorded in this format where the datum/spheroid is implied, such as the co-ordinates of surface radio positioning systems.

Additional datum/spheroid definitions may be made only to cover different satellite systems. The appropriate datum/spheroid number should be included in the definition of any satellite system in record H600# (for recording of GPS position only) or H65## (for recording of raw DGPS information) (see section 6.7), thus explicitly linking them to a datum different from the Survey Datum.

The datum shift parameters actually used in the field should be recorded in these records.

Datum conversion formulae - rotation conventions
Two different conventions for rotation definitions are in use in the survey industry, which has led to considerable confusion. Nevertheless both are valid when applied consistently. For this reason the format allows datum shift parameters for either rotation convention to be recorded. It is advised to exercise great care in filling in this record and to verify the information supplied against the worked example included in this section.

The two rotation conventions can be referred to as:
1. Position vector rotation (Bursa-Wolf model, commonly used in Europe)
2. Co-ordinate frame rotation (commonly used in the USA)

1. Position vector rotation (Bursa-Wolf model)

   The set of conversion formulae associated with this convention is commonly referred to as the Bursa-Wolf model. Rotations are defined as positive clockwise, as may be imagined to be seen by an observer in the origin of the co-ordinate frame, looking in the positive direction of the axis about which the rotation is taking place. However, the rotation is applied to the position vector. Hence a positive rotation about the Z-axis of θz will rotate the position vector further east. For example, after applying a datum shift describing only a positive rotation about the Z-axis from datum 1 to datum 2 the longitude of a point will be larger on datum 2 than it was on datum 1.

   The associated conversion formula is:

$$\underbrace{\begin{pmatrix} X \\ Y \\ Z \end{pmatrix}}_{\text{Datum 2}} = \begin{pmatrix} \delta X \\ \delta Y \\ \delta Z \end{pmatrix} + (1 + S*10^{-6})* \begin{pmatrix} 1 & -\theta z & +\theta y \\ +\theta z & 1 & -\theta x \\ -\theta y & +\theta x & 1 \end{pmatrix} * \underbrace{\begin{pmatrix} X \\ Y \\ Z \end{pmatrix}}_{\text{Datum 1}}$$

   where Datum 1 and Datum 2 must be defined in record H011#.

   NOTE:
   The rotation angles as supplied in record H0120 above must be converted to radians for use in the above formula.

   Example:

	Datum 1: WGS84	Datum 2: ED87
Semi-major axis (a)	6378137 m	6378388 m
Inverse flattening (1/f)	298.257	297
Latitude	57°00'00"N	57°00'02.343"
Longitude	2°00'00"E	2°00'05.493"
Spheroidal Height	100 m	55.12 m
X	3479923.02 m	3480006.35 m
Y	121521.59 m	121617.29 m
Z	5325983.97 m	5326096.93 m

δX	+ 82.98 m	
δY	+ 99.72 m	
δZ	+ 110.71 m	
θx	+ 0.1047"	= $+0.5076*10^{-6}$ rad
θy	- 0.0310"	= $-0.1503*10^{-6}$ rad
θz	- 0.0804"	= $-0.3898*10^{-6}$ rad
S	+ 0.3143 ppm	

2. Co-ordinate frame rotation

The 3x3 matrix in the formula associated with this convention derives from a type of matrix known in mathematics as a rotation matrix. A rotation matrix describes a rotation of a right-handed co-ordinate frame about its origin. Frame rotations are defined as positive clockwise, as may be imagined to be seen by an observer in the origin of the co-ordinate frame, looking in the positive direction of the axis about which the rotation is taking place. Hence a positive rotation about the Z-axis of θz will cause the X-axis of datum 2 (and therefore the zero meridian) to lie east of the X-axis of datum 1. Therefore, after applying a datum shift describing only a positive rotation about the Z-axis from datum 1 to datum 2 the longitude of a point will be smaller on datum 2 than it was on datum 1.

The associated conversion formula is:

$$\begin{pmatrix} X \\ Y \\ Z \end{pmatrix}_{\text{Datum 2}} = \begin{pmatrix} \delta X \\ \delta Y \\ \delta Z \end{pmatrix} + (1 + S*10^{-6})* \begin{pmatrix} 1 & +\theta z & -\theta y \\ -\theta z & 1 & +\theta x \\ +\theta y & -\theta x & 1 \end{pmatrix} * \begin{pmatrix} X \\ Y \\ Z \end{pmatrix}_{\text{Datum 1}}$$

where Datum 1 and Datum 2 must be defined in record H011#.

NOTE:
The rotation angles as supplied in record H0120 above must be converted to radians for use in the above formula.

Example:

	Datum 1: WGS84	Datum 2: ED87
Semi-major axis (a)	6378137 m	6378388 m
Inverse flattening (1/f)	298.257	297
Latitude	57°00'00"N	57°00'02.343"
Longitude	2°00'00"E	2°00'05.493"
Spheroidal Height	100 m	55.12 m
X	3479923.02 m	3480006.35m
Y	121521.59 m	121617.29m
Z	5325983.97 m	5326096.93m

δX		+ 82.98 m	
δY		+ 99.72 m	
δZ		+110.71 m	
θx	Note:-->	- 0.1047"	= $-0.5076*10^{-6}$ rad
θy	Note:-->	+0.0310"	= $+0.1503*10^{-6}$ rad
θz	Note:-->	+0.0804"	= $+0.3898*10^{-6}$ rad
S		+0.3143	ppm

H0130 Other Datum Shift Parameters

From Datum 1 to Datum 2

Datum 1: datum/spheroid number	[7, 7]	I1	
Datum 2: datum/spheroid number	[8, 8]	I1	
Sequence number of record in this definition	[9,10]	I2	
"/" [11,11]	A1		
Total number of records used for this definition	[12,13]	I2	
Description of datum conversion	[15,80]	A65	free text

NOTE:
This record allows datum shifts to be defined using a model different from the 7-parameter Cartesian model in H0120. This may include such datum conversions described by polynomials. The information provided in these records shall contain a complete definition of the datum conversion and shall contain the following information as a minimum:

a) a description of the datum conversion;
b) the formulae used;
c) the parameters required by these formulae.

Example

The example below describes the conversion from ED87 to ED50 as agreed between the mapping authorities of Norway, Denmark, Germany, The Netherlands and Great Britain in 1990. This agreement defines a two step conversion from WGS84 to ED50 in the North Sea, of which the example describes the second step. The following records are required to describe the complete datum conversion of WGS84 to ED50:

. 3x H011#: defining WGS84, ED87 and ED50 as 3 datums;
. 1x H0120: defining the 7-parameter Cartesian co-ordinate conversion from WGS84 to ED87;
.14x H0130: defining the conversion of ED87 latitude and longitude to ED50 latitude and longitude.

```
H0130 12 1/14 CONVERSION OF ED87 LAT/LON TO ED50 BY 4TH DEGREE POLYNOMIAL; REF:
H0130 12 2/14 THE TRANSFORMATION BETWEEN ED50 AND WGS84 FOR EXPLORATION PURPOSES
H0130 12 3/14 IN THE NORTH SEA. B.G. HARSSON; STATENS KARTVERK NORWAY; 1990
H0130 12 4/14 CORR=10^-6*(A0+A1*U+A2*V+A3*U^2+A4*U*V+A5*V^2+A6*U^3+A7*U^2*V+
H0130 12 5/14 +A8*U*V^2+A9*V^3+A10*U^4+A11*U^3*V+A12*U^2*V^2+A 13*U*V^3+A14*V^4)
H0130 12 6/14 U=ED87 LAT.(DEGREES) MINUS 55; V=ED87 LON.(DEGREES)
H0130 12 7/14 LAT.(ED50) = LAT.(ED87)+CORRECTION FROM LAT. COEFF. A0 TO A14
H0130 12 8/14 LON.(ED50) = LON.(ED87)+CORRECTION FROM LON. COEFF. A0 TO A14
H0130 12 9/14 LATITUDE POLYNOMIAL COEFFICIENTS A0 TO A14: 5.56098,1.55391
H0130 1210/14 .40262,.509693,.819775,.247592,-.136682,-.186198,-.12335
H0130 1211/14 -.0568797,.00232217,.00769931,.00786953,.00612216,.00401382
H0130 1212/14 LONGITUDE POLYNOMIAL COEFFICIENTS A0 TO A14: -14.8944,-2.68191
H0130 1213/14 -2.4529,-.2944,-1.5226,-.910592,.368241,.851732,.566713,.185188
H0130 1214/14 -.0284312,-.0684853,-.0500828,-.0415937,-.00762236
```

H0140 Projection Type

Projection type code record	[7, 9]	I3	see note following record H0199
Co-ordinates conversion factor to metres	[11,20]	N10	
Projection type and name	[22,80]	A59	free text

NOTE:
The co-ordinate conversion factor, multiplied by the co-ordinate values as supplied in the data, should yield the co-ordinates in metres.

H0150 (Universal) Transverse Mercator Projection

Zone number	[7, 8]	I2	(UTM only)
Latitude of grid origin	[10,21]	I3,I2,F6.3,A1	dddmmss.sss N/S
Longitude of grid origin	[23,34]	I3,I2,F6.3,A1	dddmmss.sss E/W
Grid Northing at grid origin	[36,46]	N11	
"N"	[47,47]	A1	
Grid Easting at grid origin	[48,58]	N11	
"E"	[59,59]	A1	
Scale factor at longitude of origin	[61,72]	N12	

H0160 Mercator Projection

Latitude of grid origin	[7,18]	I3,I2,F6.3,A1	dddmmss.sss N/S
Longitude of grid origin	[20,31]	I3,I2,F6.3,A1	dddmmss.sss E/W
Grid Northing at grid origin	[33,43]	N11	
"N"	[44,44]	A1	
Grid Easting at grid origin	[45,55]	N11	
"E"	[56,56]	A1	
Scale factor at latitude of origin	[58,69]	N12	

H0170 Lambert Projection

Latitude of (first) standard parallel	[7,18]	I3,I2,F6.3,A1	dddmmss.sss N/S
Latitude of second standard parallel	[20,31]	I3,I2,F6.3,A1	dddmmss.sss N/S
Longitude of grid origin	[33,44]	I3,I2,F6.3,A1	dddmmss.sss E/W
Grid Northing at grid origin	[45,55]	N11	
"N"	[56,56]	A1	
Grid Easting at grid origin	[57,67]	N11	
"E"	[68,68]	A1	
Scale factor at standard parallels	[69,80]	N12	

H0180 Skew Orthomorphic and Oblique Mercator Projection

Latitude of start point	[7,18]	I3,I2,F6.3,A1	dddmmss.sss N/S
Longitude of start point	[19,30]	I3,I2,F6.3,A1	dddmmss.sss E/W
Latitude of end point	[31,42]	I3,I2,F6.3,A1	dddmmss.sss N/S
Longitude of end point	[43,54]	I3,I2,F6.3,A1	dddmmss.sss E/W
Bearing of initial line of projection in end point('true origin')	[55,66]	N12	degrees decimal
Angle from skew to rectified grid in start point ('false origin')	[67,78]	N12	degrees decimal clockwise positive

NOTE:
The "initial line of projection" is often referred to as "central line of projection" in the Oblique Mercator Projection.

Start point and end point refer to two points on the initial line of projection :

- the Start Point is also known as the 'false origin' and is commonly the point where grid Northing and Easting are zero.
- the End Point is also known as the 'true' or grid origin.

Either Latitude or Longitude of the start point should be supplied, or Grid Northing and Grid Easting at the End Point ('true' or grid origin). In the case that Latitude and Longitude of the Start Point are supplied the Bearing of the Initial Line may be omitted.

H0181 Skew Orthomorphic and Oblique Mercator Projection (continued)

Scale factor at end point	[7,18]	N12
Grid Northing at end point	[19,29]	N11
'N'	[30,30]	A1
Grid Easting at end point	[31,41]	N11
'E'	[42,42]	A1

H0190 Stereographic Projection

Latitude of grid origin	[7,18]	I3,I2,F6.3,A1	dddmmss.sss N/S
Longitude of grid origin	[19,30]	I3,I2,F6.3,A1	dddmmss.sss E/W
Grid Northing at grid origin	[32,42]	N11	
"N"	[43,43]	A1	
Grid Easting at grid origin	[44,54]	N11	
"E"	[55,55]	A1	
Scale factor at grid origin	[56,67]	N12	
Standard parallel (for polar version only)	[69,80]	I3,I2,F6.3,A1	dddmmss.sss E/W

H0199 Any Other Projection

Sequence number of record in this definition	[7, 8]	I2	
"/" [9, 9]	A1		
Total number of records used for this definition	[10,11]	I2	
Map projection parameters	[13,80]	A68	free text

Additional comments

The following projection type codes have been defined. The relevant code as detailed in the table below must be entered into record H0140. The associated projection parameters should be recorded using one of the above records, H0150 to H0199 for the appropriate projection.

Code	Projection description	Record
001	U.T.M. North	H0150
002	U.T.M. South	H0150
003	Transverse Mercator (North oriented)	H0150
004	Transverse Mercator (South oriented)	H0150
005	Lambert conic conformal, one standard parallel	H0170
006	Lambert conic conformal, two standard parallels	H0170
007	Mercator	H0160
008	Cassini-Soldner	H0170
009	Skew Orthomorphic and Oblique Mercator	H0180 (and H0181)
010	Stereographic	H0190
011	New Zealand Map Grid	H0160
999	Any other projection	H0199

Not every projection can be defined by these codes and the elements of the projection header records. The intention is that the majority of standard projections can be defined in a computer interpretable form.

Projections not covered by one of the codes 001 to 011 should be indicated by code 999. The associated projection parameters should be provided using several of H0199 records. These records must unambiguously define the map projection.

"Grid Origin" is the origin or centre of the projection, not the origin of the grid co-ordinate system, which may be offset from the grid origin.

Scale factors must be given in real numbers (e.g. 0.9996 as opposed to -400 ppm).

For surveys in a UTM zone crossing the equator from the Southern to the Northern Hemisphere 10,000,000 is commonly added to the Northings on the Northern Hemisphere to avoid discontinuity in these co-ordinates. In that case a warning must be given (in an inserted C0001 record) to explain that convention.

For the definition of US State Plane Co-ordinate Systems (SPCS) reference is made to Transverse Mercator or Lambert Projection definitions.

6.1.3 SURVEY SUMMARY DATA

H0200 General Summary Information

Number of survey vessels	[7, 7]	I1	
Number of relay vessels or buoys	[9,10]	I2	
Number of external network nodes	[12,13]	I2	
Number of datums/spheroids defined	[15,15]	I1	
Offset mode	[17,17]	I1	0 = polar 1 = rectangular
Offset measurement units:			
for offset distances	[19,19]	I1	0 = metres 1 = feet
for offset angles	[21,21]	I1	0 = degrees decimal 1 = grads

NOTE:
Up to 9 survey vessels may be defined (see Additional Comments below). Vessel number 1 must be defined for all surveys and is the master vessel in multi-vessel surveys.

Relay vessels are purely considered as carriers of network nodes, assisting in the positioning of the seismic spread. A relay vessel or buoy carries one or more radio positioning beacons of which the signals are used in the positioning of the seismic spread, while the relay vessel or buoy itself is continually positioned.

The number of external network nodes refers to the number of network nodes outside the survey vessel(s) and its/their towed configurations but includes the nodes defined on relay vessels. See Chapter 6.6.1, Survey Network Definitions, Introduction.

For clarification on offset modes and measurement units: see Chapter 6.1.4.

H021@ Vessel Summary Information

@ = 1..9, Vessel reference number
@ = 0 if relay vessel

Vessel name/description	[6,40]	A35	free text
Vessel reference number	[43,44]	I2	
Number of streamers	[50,51]	I2	
Number of gun arrays	[53,54]	I2	
Number of buoys	[56,57]	I2	
Number of echo sounders	[59,59]	I1	
Pitch/Roll/Heave sensors	[61,61]	I1	0 = no; 1 = yes
Number of USBL systems	[63,63]	I1	
Number of satellite receivers	[65,66]	I2	
Number of network nodes	[68,70]	I3	

NOTE:
The number of buoys refers to the buoys towed directly from the vessel, hence do not include the number of tailbuoys or buoys towed from gun arrays here; they should be defined in record H0220 or H0230 respectively.

The number of sensors and nodes refers only to those on the vessel.

H022@ Streamer Summary Information

@ = 1..9, Vessel reference number

Streamer description	[6,40]	A35	free text
Streamer reference number	[42,44]	I3	
"Towed by" ref. number	[46,48]	I3	
Number of buoys	[56,57]	I2	
Number of network nodes exclusive of magnetic compasses	[68,70]	I3	
Number of magnetic compasses	[72,73]	I2	
Number of depth sensors	[75,76]	I2	
Number of seismic receiver groups	[78,80]	I3	

NOTE:
The number of buoys refers to the buoys towed by the streamer, normally just the tailbuoy.

The number of network nodes is exclusive of the magnetic compasses. These are counted separately in columns [72,73].

H023@ Gun Array Summary Information

@ = 1..9, Vessel reference number

Gun array description	[6,40]	A35	free text
Gun array ref. number	[42,44]	I3	
"Towed by" ref. number	[46,48]	I3	
Number of buoys	[56,57]	I2	
Number of satellite receivers	[65,66]	I2	
Number of network nodes	[68,70]	I3	
Number of depth sensors	[75,76]	I2	

NOTE:
The number of network nodes is inclusive of those satellite receivers for which raw data is recorded under E/T55, 56. Those counted separately in columns [65,66] should only include those for which positions only are logged under the E/T62, 63, 64 records.

H024@ **Towed Buoy Summary Information**

@ = 1..9, Vessel reference number

Towed buoy description	[6,40]	A35	free text
Towed buoy ref. number	[42,44]	I3	
"Towed by" ref. number	[46,48]	I3	
Number of other buoys towed by this buoy	[56,57]	I2	
Number of satellite receivers	[65,66]	I2	
Number of network nodes	[68,70]	I3	

NOTE:
The number of network nodes is inclusive of those satellite receivers for which raw data is recorded under E/T55, 56. Those counted separately in columns [65,66] should only include those for which positions only are logged under the E/T62, 63, 64 records. Tailbuoys, front buoys, etc. should be defined as separate buoys.

Additional Comments
The summary information in records H0200 to H0240 concentrate redundant information in the front end of the file with a dual purpose:

- to facilitate a quick overview of the survey by visual inspection; for that purpose the summary information is arranged in a columnar way: similar data items appear in the same columns for all records above.
- to assist automated (or visual) format integrity checking.

For information on network nodes refer to Chapter 6.6.

Each vessel, streamer, gun array and buoy must be given a unique reference number. The relationship between e.g. vessel and streamer is defined by providing the reference number of the towing vessel in record H0220.

This method has been chosen to provide flexibility in the sense that the towing object does not need to be the vessel.

Reference numbers shall be allocated in accordance to the following convention:

- survey vessels	:	1	…	9
- relay vessels/buoys	:	10	…	99
- streamers	:	200	…	299
- gun arrays	:	300	…	399
- other towed buoys	:	400	…	499

6.1.4 OFFSET CONVENTIONS

Definition of co-ordinate axes
Throughout the document right-handed Cartesian co-ordinate frames are maintained to express offsets.

The axes of the co-ordinate frames are defined as follows:

* Y-axis: Parallel to the vessel's longitudinal axis, positive towards the bow.
  The direction of the positive Y-axis is also referred to in this document as **'ship's head'.**
* X-axis: Horizontal axis, perpendicular to the Y-axis, positive towards starboard.
* Z-axis: Perpendicular to the two horizontal axes, X and Y, the Z-axis completes a right-handed X,Y,Z co-ordinate frame. Hence, positive Z is upwards, synonymous with height.

Reference points
Each ship has its own co-ordinate frame, with its origin defined as the **ship's reference point** in record H10@0.

All towed objects, such as streamers, gun arrays and buoys, have their own **local reference point** and points on these objects are described in terms of **local offsets** relative to the local reference point.

Tow points
The header records of the P2/94 format describe the nominal, or design geometry of the spread, in which all towed objects are towed parallel to the longitudinal axis of the towing vessel, the Y-axis of its co-ordinate frame.

Each towed object 'streams' from a towpoint, which may be offset from the vessel by means of a paravane. This towpoint is defined in P2/94 as the **'towpoint-in-sea'**, as opposed to the point on the vessel the towed object is attached to, which is called the **'towpoint-on-towing-body'.**

This distinction is only relevant in the case where a paravane is used to offset the towed object from the vessel. When the object is towed directly from the vessel or from a boom rigidly attached to the vessel, the 'towpoint-in-sea' and the 'towpoint-on-towing-body' are coincident. (See Figure 1 for clarification.)

Some towed objects are in turn towing another towed object. Examples are a tailbuoy towed by a streamer and a front buoy towed by a gun array. Assuming that the buoy is towed straight behind the streamer or gun array the towpoint-in-sea coincides with the towpoint-on-towing-body, which is the point on the streamer or gun array the buoy is being towed from. Note that the 'towing vessel' in this case is **not** the ship, but the streamer or gun array. (See Figure 2 for clarification.)

Local offsets and reference points
Each towed object has its own local co-ordinate frame of which the axes are parallel to the ship's X, Y and Z axes (that is: in the design, or nominal, geometry). However, the local offsets on each towed object are measured from its **local reference point.**

For all towed objects except the streamers the local reference point is the towpoint-in-sea, defined for that object. The towpoint-in-sea may of course coincide with the towpoint-on-towing-body, as explained above. The only exception to this rule is the local reference point of a streamer, which is defined as the centre of the near receiver group of that streamer, the receiver group closest to the towpoint. Note that therefore Y-offsets along a streamer are negative and decreasing towards the tailbuoy behind the centre of the near receiver group.

Offset mode: polar or rectangular
Horizontal offsets may be given either as polar or rectangular co-ordinates.
The offset mode must be consistent for all offsets defined.

Polar mode:	Offset A =	radial distance from ship's or local reference point to the point defined;
	Offset B =	angle, measured in the ship's or local reference point, clockwise from ship's head to the point defined.
Rectangular mode:	Offset A =	X axis offset from ship's or local reference point to the point defined, measured positive to starboard.
	Offset B =	Y axis offset from ship's or local reference point to the defined point, measured positive towards the bows.

(See Figure 3 for clarification.)

Z-axis offset or height

The third offset co-ordinate, along the Z-axis, is always positive upwards. Depths (of e.g. acoustic transducers) are therefore recorded as **negative heights**, with the minus sign included in the fields provided.

Units of measurement

Offset distances may be expressed in metres decimal or international feet.
Offset angles may be expressed in degrees decimal or in grads.
The same measurement units must be used consistently for all offsets defined.

6.2 VESSEL DEFINITIONS

H10@0 Vessel Reference Point Definition

@ = 1..9, Vessel reference number

Height above sea level	[7,10]	F4.1	metres
Description of reference point	[12,80]	A69	free text

H11@0 Steered Point Definition

@ = 1..9, Vessel reference number

Description of steered point	[7,80]	A74	free text

H12@0 Onboard Navigation System Description

@ = 1..9, Vessel reference number

Details of onboard navigation & processing systems	[7,80]	A74	free text

Record may be repeated to describe more than one onboard system, such as an additional system used for quality control purposes.

H12@1 Definition of Quality Indicators for Field Positioning Derived Data

@ = 1..9, Vessel reference number

Record sequence number	[7, 8]	I2	
Definition of quality indicator types for field positioning derived data	[10,80]	A71	free text

Record may be repeated.

NOTE:
In record E12@0, Field Positioning Derived Data, three fields are provided to record quality indicators describing the quality of that data. These quality indicators should describe the quality of the processed positioning data. Examples are: the standard deviations of Northing and Easting and the standard deviation of unit weight.

A full descriptive definition of these three indicators must be provided in this record.

Up to 99 E12@0 records may be supplied, each identified by its record sequence number, which needs to be recorded here to provide a link of the definitions of the quality indicators and the actual data in the E12@0 record.

H13@0 Vessel Time System Definition

@ = 1..9, Vessel reference number

Time correction to ship's time to convert to GMT	[7,12]	F6.2	+/- hours
Time correction to vessel's time system to convert to the master vessel's time system	[14,21]	N8	seconds

NOTE:
The first time correction is a 'time zone' correction and is therefore defined to fractions of hours only. The correction adds to ship's time and therefore this convention is opposite to that used in the UKOOA P1/90 format.

The second correction enables the supplier of the data to record synchronisation differences between the clocks used for the measurement systems on board the different survey vessels in a multi-vessel survey, should this information be required. It can be defined in fractions of seconds.

H14@# Echo Sounder Definition

@ = 1..9, Vessel reference number
# = 1..9, Echo sounder reference number

Offset A to transducer	[7,13]	F7.1	
Offset B to transducer	[15,21]	F7.1	
Offset Z from reference point to transducer	[23,28]	F6.1	
Propagation velocity used	[30,36]	N7	m/s or ft/s
Calibrated propagation velocity	[38,44]	N7	m/s or ft/s
Velocity unit	[46,46]	I1	0 = m/s 1 = ft/s
Water depth reference level	[47,47]	I1	0 = transducer 1 = sea level
Heave compensated depths?	[48,48]	I1	0 = depths not heave compensated 1 = depths heave compensated
Echo sounder description	[50,80]	A31	free text

NOTE:
Two propagation velocities are to be given for the echo sounder; that at which the sounder was set during the survey or part survey covered by this file and the velocity determined during calibration. Both velocities should be specified even if they are the same. Raw depths recorded by the echo sounder may relate to the transducer or may have been corrected to sea level: the water depth reference level flag should be set appropriately.

The heave compensation flag should be set to 1 if the echo sounder is interfaced to a heave compensator, resulting in an output of heave compensated depths. A description of the heave compensator should then be supplied in record H17@0.

H1500 Observed Velocity of Sound - Definitions

Profile number	[7, 8]	I2	
Date	[10,17]	I4,I2,I2	YYYYMMDD
Time (Master Vessel)	[19,22]	I2,I2	HHMM
Latitude	[24,35]	I3,I2,F6.3,A1	dddmmss.sss N/S
Longitude	[36,47]	I3,I2,F6.3,A1	dddmmss.sss E/W
Depth units	[48,48]	I1	0 = metres 1 = feet
Velocity units	[49,49]	I1	0 = metres/sec 1 = feet/sec
Temperature units	[50,50]	I1	0 = degrees Celsius 1 = degrees Fahrenheit
Salinity/Conductivity	[51,51]	I1	0 = promille (10^{-3}) (salinity) 1 = mmho/cm (conductivity) 2 = Siemens/metre (conductivity)
Instrument description	[53,80]	A28	free text

H1501 Observed Velocity of Sound - Profile

Profile number	[7, 8]	I2
Depth	[10,15]	F6.1
Velocity	[16,21]	F6.1
Temperature	[22,26]	F5.1
Salinity or conductivity	[27,31]	F5.2

May be repeated for two more observations at [33,54] and [56,77] for the same profile; the profile number is not repeated.

Record may be repeated.

NOTE:
Up to 99 velocity of sound depth profiles may be defined by repeating one H1500 and as many H1501 records as required for every profile defined.

H16@0 USBL System Definition

@ = 1..9, Vessel reference number

USBL system ref. number	[7, 7]	I1	
Quality indicator type	[9, 9]	I1	
Sign convention for Z-axis data	[11,11]	I1	0 = positive upward (height) 1 = positive down-ward (depth)
Recorded data corrected for:			
Turn around delays?	[12,12]	I1	0 = no; 1 = yes
Velocity of propagation?	[13,13]	I1	0 = assumed; 1 = calibrated
Horizontal alignment?	[14,14]	I1	0 = no; 1 = ship's axis; 2 = raw gyro
Pitch alignment?	[15,15]	I1	0 = no; 1 = raw VRU, 2 = corrected VRU
Roll alignment?	[16,16]	I1	0 = no; 1 = raw VRU, 2 = corrected VRU
Reduction to ship's reference point?	[17,17]	I1	0 = no; 1 = yes

NOTE:
The "quality indicator type" defines the type of quality indicator used in the (inter-) event fields.
The following types are available:

0 = no quality information recorded
1 = standard deviation
2 = signal/noise ratio
3 = system specific
4 = subjective scale

In the case code 1 is chosen a descriptive definition of the way the standard deviation is derived must be supplied in record H16@2.

In the case code 3 is chosen a descriptive definition must be supplied in record H16@2 of the following aspects of the system specific quality indicator:

- the range of values of the variable;
- the interpretation of its values.

Further details of these codes can be found in Chapter 6.6.3-C, Section C3.

USBL systems may give relative co-ordinate data with the sign convention of the Z-coordinates opposite the convention maintained throughout this format. If the USBL system produces Z data positive downwards (= depth) the flag should be set to 1. Note though that the definition of the transducer location in record H16@1 should adhere to the P2/94 convention that Z offsets are positive upwards.

Since USBL systems do not generally provide raw data, the extent of the processing by the system should be defined in columns [11,16].

H16@1 <u>USBL System Definition (continued)</u>

@ = 1..9, Vessel reference number

USBL system reference number	[7, 7]	I1	
Transducer Node identifier	[9,12]	I4	
Offsets from ship's reference point to USBL transducer:			
Offset A	[14,20]	F7.1	
Offset B	[22,28]	F7.1	
Offset Z	[30,35]	F6.1	
Correction to horizontal alignment	[37,41]	N5	degrees decimal
Correction to pitch alignment	[43,47]	N5	degrees decimal
Correction to roll alignment	[49,53]	N5	degrees decimal
Assumed velocity of propagation	[55,61]	N7	
Calibrated velocity of propagation	[63,69]	N7	
Velocity measurement units	[71,71]	I1	0 = m/s 1 = ft/s
Turn around delay	[73,80]	N8	milliseconds

<u>NOTE</u>:

The three offsets define the logical location of the USBL transducer. Thus if the device corrects to the ship's reference point the offsets should be zero.

The node identifier should be a unique positive number (>0).

If the USBL system has not been set up to reduce for heading, pitch and roll corrections (C-O) these corrections should be supplied in this record.

The horizontal alignment correction is that angle required to reduce the USBL system orientation to the ship's head.

The pitch and roll corrections are those required to correct the Vertical Reference Unit (VRU).

Pitch corrections should be **positive** for the **bow down.**

Roll corrections should be **positive** for the ship **heeling to port.**

H16@2 **Definition of Quality Indicator Type for USBL**

@ = 1..9, Vessel reference number

USBL system ref. number	[7, 7]	I1	
Definition of quality indicator type	[9,80]	A72	free text

Record may be repeated.

H17@0 **Pitch, Roll and Heave Sensor Definitions**

@ = 1..9, Vessel reference number

Sensor reference number	[7, 7]	I1	
Rotation convention pitch	[9, 9]	I1	0 = positive bow up 1 = positive bow down
Rotation convention roll	[10,10]	I1	0 = positive heeling to starboard 1 = positive heeling to port
Angular variable measured	[11,11]	I1	0 = pitch/roll angle 1 = sine of angle
Angular measurement units	[12,12]	I1	3 = degrees decimal 4 = grads 9 = other
Measurement units heave	[13,13]	I1	0 = metres 1 = feet 9 = other
If angular measurement units = 9:			
Conversion factor to degrees decimal	[15,22]	N8	
If heave measurement units = 9:			
Conversion factor to metres	[24,31]	N8	
Quality indicator type pitch and roll	[33,33]	I1	
Quality indicator type heave	[34,34]	I1	
(C-O) pitch observation	[36,42]	N7	
(C-O) roll observation	[44,50]	N7	
(C-O) heave observation	[52,58]	N7	
Description of pitch, roll, heave system	[60,80]	A21	free text

NOTE:

This record should be used in case data is recorded from a pitch/roll/heave system.

The standard rotation conventions for both pitch and roll ought to be code 0 as that convention is consistent with the definition of positive rotations in right-handed Cartesian co-ordinate frames, which the vessel's X,Y,Z system is.

The "conversion factor" for pitch and roll should multiply with the raw readings for pitch and roll to yield degrees decimal values.

The "conversion factor" for heave should multiply with the raw readings for heave to yield values in metres.

The "quality indicator type" defines the type of quality indicator used in the (inter-) event fields.

The following types are available:

- 0 = no quality information recorded
- 1 = standard deviation
- 2 = signal/noise ratio
- 3 = system specific
- 4 = subjective scale

In the case code 1 is chosen a descriptive definition of the way the standard deviation is derived must be supplied in record H17@1.

In the case code 3 is chosen a descriptive definition must be supplied in record H17@1 of the following aspects of the system specific quality indicator:

- the range of values of the variable;
- the interpretation of its values.

Further details of these codes can be found in Chapter 6.6.3-C, Section C3.

H17@1 **Definition of Quality Indicator Type for Pitch, Roll and Heave**

@ = 1..9, Vessel reference number

Sensor reference number	[7, 7]	I1	
Definition of quality indicator type	[9,80]	A72	free text

Record may be repeated.

6.3 STREAMER DEFINITIONS

H21@0 Streamer Geometry Definitions

@ = 1..9, Vessel reference number

Streamer reference number	[7, 9]	I3

Offsets from ship's reference point to:

- towpoint-on-towing-vessel:

Offset A	[11,17]	F7.1
Offset B	[19,25]	F7.1
Offset Z	[27,32]	F6.1

- towpoint-in-sea:

Offset A	[35,41]	F7.1
Offset B	[43,49]	F7.1
Offset Z	[51,56]	F6.1

Local offsets from the centre of the near receiver group to the towpoint-in-sea:

Local Y-offset	[58,64]	F7.1
Local Z-offset	[66,71]	F6.1

NOTE:

The offsets to the towpoints in columns 11 to 56 are measured relative to the ship's reference point.

The local offsets in columns 58 to 71 are measured relative to the local reference point: the centre of the near seismic receiver group.

The towpoint-in-sea is expected to be defined at sea level.

The local Z-offset is measured vertically from the local reference point (the near receiver group) to the towpoint-in-sea.

As the towpoint-in-sea, when defined at sea level, is higher then the local reference point, its local Z-offset is a positive figure and equals the nominal depth of the streamer.

H21@1 Streamer Geometry Definitions - continued

@ = 1..9, Vessel reference number

Streamer reference number	[7, 9]	I3
Nominal front stretch section length	[11,15]	F5.1
Nominal rear stretch section length	[17,21]	F5.1
Number of active sections	[23,25]	I3
Length of first active section	[27,31]	F5.1
Length of second and subsequent live sections	[33,37]	F5.1
Number of inserted compass sections	[39,41]	I3
Length of each inserted compass section	[43,47]	F5.1
Number of inserted acoustic sections	[49,51]	I3
Length of each inserted acoustic section	[53,57]	F5.1
Number of inserted depth sections	[59,61]	I3
Length of each inserted depth section	[63,67]	F5.1
Quality indicator type for streamer compasses	[69,69]	I1
Quality indicator type for streamer depth sensors	[71,71]	I1

NOTE:

The lengths of the streamer sections given in this record should be supplied in the same units as the offsets.

Inserted sections should only be recorded here if they are separate sections. However, if they are integrated with another unit they should not be recorded in this record to prevent inserted sections from being counted twice. Add a C0001 comment record if that is the case.

The "quality indicator type" defines the type of quality indicator used in the (inter-) event data records for all compasses and should be one of the following codes:

0 = no quality information recorded
1 = standard deviation
2 = signal/noise ratio
3 = system specific
4 = subjective scale

In the case code 1 is chosen a descriptive definition of the way the standard deviation is derived must be supplied in record H21@2 and/or record H21@3, as appropriate.

In the case code 3 is chosen a descriptive definition must be supplied in record H21@2 and/or record H21@3 of the following aspects of the system specific quality indicator:

- the range of values of the variable;
- the interpretation of its values.

Further details of these codes can be found in Chapter 6.6.3-C, Section C3.

H21@2 **Definition of Quality Indicator Type for Streamer Compasses**

@ = 1..9, Vessel reference number

Definition of quality indicator type	[7,80]	A74	free text

Record may be repeated.

H21@3 **Definition of Quality Indicator Type for Streamer Depth Sensors**

@ = 1..9, Vessel reference number

Definition of quality indicator type	[7,80]	A74	free text

Record may be repeated.

H22@0 **Compass Locations**

@ = 1..9, Vessel reference number

Streamer reference number	[7, 9]	I3	
Node identifier	[11,14]	I4	
Compass serial number	[16,23]	A8	
Local offset to centre of compass	[25,32]	F8.1	
Clipped-on or inserted?	[34,34]	I1	0 = clipped-on 1 = inserted

May be repeated for one more compass on the same streamer at [36,59]; the streamer reference number is not repeated.

Record may be repeated.

NOTE:
The node number must be a unique positive number (>0) in the context of the entire survey configuration.

The nodes at which the compasses are located should not be defined again in record H51@0.

Local offsets are Y-axis offsets measured from the centre of the near seismic receiver group and are therefore negative towards the tailbuoy. The relevant fields should include the sign.

H2300 **Compass Correction Derivation (Static)**

Description of the origin of the correction, incl. method,location, date.	[7,80]	A 74	free text

NOTE:
Static compass corrections are derived on a magnetically undisturbed onshore site by calibrating the compass by means of e.g. a theodolite.

H23@0 Compass Corrections (Static)

@ = 1..9, Vessel reference number

Compass serial number	[7,14]	A8	
Fixed correction to reading	[15,20]	F6.1	degrees decimal
Line direction 1	[21,23]	I3	degrees
Correction to reading	[24,27]	F4.1	degrees decimal
Line direction 2	[28,30]	I3	degrees
Correction to reading	[31,34]	F4.1	degrees decimal
.			
.			
.			
Line direction 8	[70,72]	I3	degrees
Correction to reading	[73,76]	F4.1	degrees decimal

Record may be repeated.

NOTE:
The correction to a compass reading may be defined as a single fixed correction and/or as a correction applicable for a particular line direction. Corrections for up to 8 approximate line directions may be defined in this record.

Corrected Compass	=	Raw Compass	+	Fixed correction	+	Correction for line direction

H2301 Compass Correction Derivation (Dynamic)

Add to static corrections flag	[7, 7]	I1	0 = no; 1 = yes
Description of the algorithm used for the derivation of the corrections	[9,80]	A72	free text

NOTE:
Dynamic compass corrections are derived while the compasses are deployed on the streamer(s). Most of the methods presently used derive these corrections from the raw individual compass readings according to some model. As it is not usually possible to (easily) reconstruct these corrections from the recorded data the format allows recording of these corrections in record H23@1.

Dynamic compass corrections may have been derived from the compass readings that had already been corrected with the static corrections. In that case the dynamic corrections **add** to the static corrections for the relevant line direction to give the total (C-O) to be added to the recorded compass readings.

Alternatively the dynamic corrections may have been determined from the **uncorrected** compass readings, in which case they would entirely **replace** the static corrections.

This option is expressed in the flag at column 7.

H23@1 Compass Corrections (Dynamic)

@ = 1..9, Vessel reference number

Streamer reference number	[7, 9]	I3	
Compass serial number	[11,18]	A8	
Compass correction	[20,24]	F5.1	degrees decimal

May be repeated for 3 more compasses on the same streamer at [26,39], [41,54] and [56,69]; the streamer reference number is thereby not repeated.

Line direction	[78,80]	I3	degrees

Record may be repeated.

H24@0 Seismic Receiver Group Definitions

@ = 1..9, Vessel reference number

Streamer reference number	[7, 9]	I3
Reference number first seismic receiver group in regular section	[11,14]	I4
Local offset of centre of first receiver group	[16,23]	F8.1
Reference number last seismic receiver group in regular section	[25,28]	I4
Local offset of centre of last receiver group	[30,37]	F8.1
Number of seismic receiver groups in section	[39,41]	I3
Distance between centres of receiver groups	[43,48]	F6.1

Record may be repeated.

NOTE:
This record allows a group or section of regularly spaced and regularly numbered seismic receiver groups to be defined. Breaks in the regularity of spacing of the seismic receiver groups may occur when compass sections or acoustic sections are inserted in the streamer.

Local offsets are Y-axis offsets measured from the centre of the near seismic receiver group and are therefore negative towards the tailbuoy. The relevant fields should include the sign.

The seismic receiver group reference numbers may include zero and may be incremented in either direction.

The distance between centres of receiver groups must be given in the same measurement units as the distance offsets.

H24@1 Auxiliary Seismic Channel Definition

@ = 1..9, Vessel reference number

Streamer reference number	[7, 9]	I3	
Auxiliary channel reference number	[11,14]	I4	
Auxiliary channel type	[16,16]	I1	0 = timebreak 1 = waterbreak 2…9 = user defined; specify on C0001 record
Local offset to centre of auxiliary channel	[18,25]	F8.1	
Description	[27,80]	A54	free text

NOTE:
The purpose of this record is to allow the recording of travel time data from the seismic source to locations within the receiver array. This data can be used to confirm source-receiver geometry.

Timebreak channels record a zero offset figure for the reduction of waterbreak data; if no timebreaks are defined, waterbreak data is referenced to zero.

Include in the description the resolution to which the timebreak and waterbreak data are sampled.

H25@0 Streamer Depth Sensor Definitions

@ = 1..9, Vessel reference number

Streamer reference number	[7, 9]	I3	
Depth sensor reference or serial number	[11,18]	A8	
Local offset to centre of depth sensor	[20,27]	F8.1	
Depth correction (C-O)	[29,33]	F5.1	
Clipped-on or inserted?	[35,35]	I1	0 = clipped-on 1 = inserted

Record may be repeated for one more depth sensor on the same streamer at [37,61]; the streamer reference number is not repeated.

Record may be repeated.

NOTE:
When the depth sensor is integrated with a compass unit **and** inserted in the streamer, the length of the inserted section should be recorded in record H21@1 as "Length of each inserted compass section".

Local offsets are Y-axis offsets measured from the centre of the near seismic receiver group and are therefore negative towards the tailbuoy. The relevant fields should include the sign.

6.4 GUN ARRAY DEFINITIONS

H31@0 Gun Array Geometry Definitions

@ = 1..9, Vessel reference number

Gun array reference number	[7, 9]	I3	
Offsets from Towing Vessel's Reference Point to:			
- towpoint-on-towing-body:			
Offset A	[11,17]	F7.1	
Offset B	[19,25]	F7.1	
Offset Z	[27,32]	F6.1	
- towpoint-in-sea:			
Offset A	[34,40]	F7.1	
Offset B	[42,48]	F7.1	
Offset Z	[50,55]	F6.1	
Local offsets from the towpoint-in-sea to the horizontal centre of the gun array:			
Local offset A	[57,63]	F7.1	
Local offset B	[64,70]	F7.1	
Nominal firing pressure	[72,77]	N6	
Pressure units code	[78,78]	I1	0 = kgf/cm^2 1 = lbs/in^2 2 = bar
Volumes units code	[79,79]	I1	0 = cm^3 1 = in^3
Depth units code	[80,80]	I1	0 = metres 1 = feet

H31@1 Individual Gun Definition

@ = 1..9 Vessel reference number

Gun array reference number	[7, 9]	I3
Gun reference number	[11,13]	I3
Local offset A	[15,21]	F7.1
Local offset B	[23,29]	F7.1
Local offset Z	[31,36]	F6.1
Gun volume	[38,43]	I6

May be repeated for one more gun in the same array at [45,77]; the gun array reference number is not repeated.

Record may be repeated.

NOTE:
The gun reference number should be unique within the array.

H32@0 Description of Gun Array Depth Sensors

@ = 1..9 Vessel reference number

Gun array reference number	[7, 9]	I3	
Quality indicator type	[11,11]	I1	
Description of depth sensors	[13,80]	A62	free text

NOTE:
The "quality indicator type" defines the type of quality indicator used in the (inter-) event data records for all gun depth sensors on this vessel and should be one of the following codes:

0 = no quality information recorded
1 = standard deviation
2 = signal/noise ratio
3 = system specific
4 = subjective scale

In the case code 1 is chosen a descriptive definition of the way the standard deviation is derived must be supplied in record H32@2.

In the case code 3 is chosen a descriptive definition must be supplied in record H32@2 of the following aspects of the system specific quality indicator:

- the range of values of the variable;
- the interpretation of its values.

Further details of these codes can be found in Chapter 6.6.3-C, Section C3.

H32@1 Gun Array Depth Sensor Definitions

@ = 1..9 Vessel reference number

Gun array reference number	[7, 9]	I3
Sensor number	[11,12]	I2
Sensor serial number	[14,21]	A8
Local offset A	[23,29]	F7.1
Local offset B	[31,37]	F7.1
Depth correction (C-O)	[39,44]	F6.1

May be repeated for one more depth sensor on the same gun array at [46,79]; the gun array number is not repeated.

Record may be repeated.

H32@2 Definition of Quality Indicator Type for Gun Array Depth Sensors

@ = 1..9 Vessel reference number

Gun array reference number	[7, 9]	I3	
Definition of quality indicator type	[11,80]	A70	free text

Record may be repeated.

H33@0 Definition of Intended Gun Firing Sequence

@ = 1..9 Vessel reference number

Gun array reference number	[7, 9]	I3	
Starting gun number	[11,13]	I3	
Active gun mask	[15,80]	66*I1	0 = inactive 1 = active

Record may be repeated in case more than 66 guns need to be defined or when the discontinuity in the gun numbers spans more than 66.

NOTE:
This record defines which guns within a gun array are intended to fire (active guns) from those guns defined in the H31@1 records.

The starting gun number is the gun reference number of the first gun of a contiguous series of up to 66 guns for which the mask is provided.

Guns not explicitly set active in this record are not enabled.

The intended sequence of gun array firing is not defined in the format; any relevant information should be supplied in comment records.

H34@0 Gun Array Pressure Sensor Definitions

@ = 1..9 Vessel reference number

Gun array reference number	[7, 9]	I3
Gun number	[11,13]	I3
Sensor serial number	[15,22]	A8
Sensor correction (C-O)	[24,28]	F5.1

May be repeated for 2 more pressure sensors on the same gun array at [30,47] and [49,66]; the gun array reference number is not repeated.

Record may be repeated.

NOTE:
The gun number serves as a sensor identifier.

No offsets are defined, as sensor data is independent of position.

H34@1 Description of Gun Array Pressure Sensors

@ = 1..9 Vessel reference number

Gun array reference number	[7, 9]	I3	
Description of gun array pressure sensors	[11,80]	A70	free text

6.5 TOWED BUOY DEFINITIONS

H41@0 **Towed Buoy Geometry Definitions**

@ = 1..9 Vessel reference number

Towed buoy ref. number	[7, 9]	I3
Towed by: ref. number	[11,13]	I3

Offsets from towing body's Reference Point to:

- towpoint-on-towing-body:

Offset A	[15,21]	F7.1
Offset B	[23,29]	F7.1
Offset Z	[31,36]	F6.1

- towpoint-in-sea:

Offset A	[39,45]	F7.1	
Offset B	[47,53]	F7.1	
Offset Z	[55,60]	F6.1	
Description of the towed buoy	[62,80]	A19	free text

NOTE:
The required offsets should be defined in the co-ordinate frame of the object which tows the buoy (the "towing body"). This may be a ship, a streamer, a gun array or even another buoy.

The vessel reference number ("@") in the record code defines the ship that directly or indirectly tows the buoy.

6.6 SURVEY NETWORK DEFINITIONS

6.6.1 Introduction

The network approach adopted in the UKOOA P2/94 format allows a significant segment of the data to be described and emphasises the geometric nature of the positioning data, rather than the physical measurement principles underlying the data.

The network consists of a group of points: network nodes with observations defined between these nodes. Most observations define a geometric relationship between two or more nodes, e.g. a range between two nodes or a range difference between three, whereas some describe a geometric relationship between a part of the network and the 'outside world', e.g. the vessel's gyro compass which describes the orientation of the ship's head with respect to the earth's rotational axis.

Network architecture allows great flexibility in the definition of observations such as sing around ranges and acoustic ranges between streamers, possibly towed by different vessels. It reflects an integrated approach to positioning.

A number of observations have not been included in the network approach, for reasons of clarity and because nothing would be gained by including them. Examples are data from USBL systems, which are stand alone systems found only on vessels because of their bulk, gun depths, water depth (echo sounder) and streamer compass data.

The network architecture necessitates a generalised approach to the definition of observations. A raw observation can generally be reduced to fit the processing model by applying two corrections: an addition correction (C-O) and a scale correction (C/O), expressed in the following equation:

$$Obs_{reduced} = C/O * \{Obs_{raw} + (C\text{-}O)\}$$

An explanatory chapter 6.6.3 follows the definition of the network header records, rather than the customary "Additional Comments", because of the volume of the explanatory text and the need to arrange it in a structured fashion.

6.6.2 Definition of Survey Network Header Records

H5000 **Node Definition (fixed locations)**

Node identifier	[7,10]	I4	
Name / description	[12,27]	A16	free text
Flag for geographical or grid co-ordinates	[29,29]	I1	0 = geographical 1 = grid
Latitude	[31,42]	I3,I2,F6.3,A1	dddmmss.sss N/S
Longitude	[44,55]	I3,I2,F6.3,A1	dddmmss.sss E/W
or:			
Northing	[31,41]	N11	
"N"	[42,42]	A1	
Easting	[44,54]	N11	
"E"	[55,55]	A1	
Height	[57,63]	N7	metres or feet
Height measurement unit	[65,65]	I1	0 = metres 1 = feet
Height datum	[67,67]	I1	0 = MSL 1 = LAT 2 = LLWS 3 = sea level 4 = spheroid 5 = other (define in separate C0001 record)

H51@0 **Node Definition (vessel, gun array, streamer, towed buoy)**

@ = 1..9, Vessel reference number
@ = 0 if relay vessel or buoy

Node identifier	[7,10]	I4	
Name / description	[12,27]	A16	free text
Located on: ref. number	[29,31]	I3	
(Local) offset A	[33,39]	F7.1	
(Local) offset B	[41,47]	F7.1	
(Local) offset Z	[49,55]	F6.1	

H52## **Observation Definition**

= Observation Type

Observation identifier	[7,10]	I4	
Observation description	[12,27]	A16	free text
"At" Node identifier	[29,32]	I4	
"To" Node 1 identifier	[34,37]	I4	
"To" Node 2 identifier	[39,42]	I4	
Measurement Unit Code	[44,45]	I2	
Positioning system identifier	[47,49]	I3	
Positioning system description	[51,80]	A30	free text

Note : where the positioning system is a GPS receiver, the positioning system description should clearly state the receiver type, model number and software or firmware version number.

H5306 Differential Observation - follow up record

Differential observation identifier	[7,10]	I4	
Observation 1 identifier	[12,15]	I4	
Observation 2 identifier	[17,20]	I4	
Differential observation description	[22,80]	A59	free text

NOTE:
This record should, when used, immediately follow the corresponding H5206 record.

H5307 Composite Range - follow up record

Observation identifier	[7,10]	I4	
"To" Node identifier	[12,15]	I4	
Positive (addition) or negative (subtraction)?	[17,17]	I1	0 = negative range section 1 = positive range section

May be repeated at [19,24], [26,31], [33,38], etc.; the Observation identifier is not repeated.

NOTE:
The last Node identifier will generally be the same as the "At" Node identifier in the corresponding H5207 record, closing the loop.

This record should, when used, immediately follow the corresponding H5207 record.

H54## Observation Definition (cont'd)

= Observation type

Observation identifier	[7,10]	I4	
Propagation speed	[12,23]	N12	m/s or feet/s
Lanewidth on baseline or frequency	[25,36]	N12	metres or feet or Hz
Defined length unit	[38,38]	I1	0 = metres 1 = feet
Lanewidth or frequency?	[40,40]	I1	0 = lanewidth on baseline 1 = comparison frequency
Scale factor	[42,53]	N12	
Fixed system (C-O)	[55,64]	N10	
Variable (C-O)	[66,73]	N8	
A priori standard deviation	[75,78]	N4	
Quality indicator type used in (inter-)event records	[80,80]	I1	0 = no qual. info recorded 1 = standard deviation 2 = signal/noise ratio 3 = system specific 4 = subjective scale

H5500 Definition of System Specific Quality Indicator

Positioning system identifier	[7, 9]	I3	
Definition of quality indicator	[11,80]	A70	free text

H56@0 Instrument Correction

@ = 1..9 vessel number
@ = 0 fixed or relay station

Node identifier	[7,10]	I4	
Positioning system identifier	[12,14]	I3	
Instrument correction	[16,26]	N11	
Instrument description (serial number, etc)	[28,80]	A53	free text

6.6.3 Clarification of Network Definition Records

6.6.3 A: Node definitions (records H5000 and H51@0)

A1 *General*

The **Node Identifier** must be a unique positive number (>0); no duplicates are allowed.

Co-ordinates and offsets should define the antenna electrical centre or transducer plate centre.

A2 *Fixed nodes (record H5000)*

Record H5000 should be used to define fixed nodes, such as shore stations of radio positioning systems. Also moored buoys for which the co-ordinates are assumed to be fixed, should be defined using this record.

The co-ordinates of fixed nodes must be defined on the Survey Datum.

Heights need only be supplied when relevant to the position calculation.

Heights for nodes under the height datum, e.g. LBL acoustic beacons on the sea floor are negative and the sign should be included in the field.

Heights should be above sea level (code 3) in the case the node is mounted on a fixed moored buoy.

A3 *Nodes on the seismic spread and relay vessels (record H51@0)*

Record H51@0 should be used to define any node on the seismic spread. It should also be used for nodes on "relay vessels" or "relay buoys".

Relay vessels and relay buoys are defined as carrying a radio positioning beacon of which the signals are used to position the seismic spread, whilst its own position is continually determined, e.g. by shore based or satellite radio positioning means.

The vessel reference number in the header code, represented by the '@'-character, defines the vessel that tows, directly or indirectly, the object on which the node is located.

In the case where the node is located on that survey vessel itself, the vessel reference number is repeated in column 31.

When the node is located on a relay vessel or relay buoy: @ = 0 (zero) and the relay vessel reference number is entered in columns 30 and 31.
Also in this case @=0 in record H56@0.

The 'Located on' field requires the unique reference number of the vessel, gun array etc. the node is located on.

The local offsets define the nominal or design location of the node.

6.6.3 B: Observation definitions: types

B1 *General comments*

The **Observation Identifier** must be a unique positive number (>0): no duplicates are allowed. This includes differential observations and composite ranges.

The **Positioning System Identifier**, also a unique positive number, allows grouping of observations that share certain characteristics or may be affected by the same type of errors. It may for instance be used to distinguish acoustic ranges from electromagnetic ranges. Electromagnetic and acoustic ranges can be further subdivided by positioning system. A bearing and distance, derived e.g. by differencing the GPS position of a tailbuoy with the GPS position of the towing vessel may be linked by means of the Positioning System Identifier.

A minimum of two records, H52## and H54##, are required to define one network observation. A differential observation or a composite range requires an additional H5306 or H5307 record respectively.

All nodes referred to in any observation definition must be defined in H5100 or H51@0 records, with the exception of USBL transducer nodes and streamer compass nodes, which are defined in records H16@1 and H22@0 respectively.

More than one observation may refer to one particular node. In such a case the node should only be defined once.

B2 *Observation Types*

Observations may be defined as one of the Observation Types and observed in one of the Measurement Units defined below.

Observation Type Codes:

1 = range
2 = hyperbolic, formula 1 (usually phase difference measurement)
3 = hyperbolic, formula 2 (usually time difference measurement)
4 = pseudo-range, common clock bias
5 = pseudo-range, clock bias per pseudo-range
6 = differential observation
7 = composite observation (e.g. sing around range)
8 = angle
9 = direction
10 = bearing, magnetic
11 = bearing, true
12 = differential true bearing (rate gyros)
20 = GPS pseudo-range, clock bias per receiver per measurement
21 = GPS code-phase
22 = GPS carrier phase
23 = GPS instantaneous Doppler frequency[1]

Note that code 20 and code 04 are both defined as pseudo-ranges. The distinction is that code 20 pseudo-ranges need not specify the "To" node in the H52## record, relying instead on the specification of S.V. in the E/T55## record. In addition, code 20 pseudo-ranges, recorded in E/T55## or E/T56## records, have a specifically associated accurate time of measurement, which is lacking from the code 04.

[1] For observation type 23 it should be noted that instantaneous Doppler measurements must be corrected for ionospheric, tropospheric and relativistic effects.

Measurement Unit Codes:

00 = (international) metres
01 = international feet (1 int. foot = 0.30480 int. metre)
02 = lanes
03 = degrees
04 = grads
05 = radians
06 = arc minutes
07 = arc seconds
08 = seconds (time)
09 = milliseconds (time)
10 = Phase cycles (count)
11 = Hertz

All feet referred to in this document are international feet, as defined above.

On the following two pages a table explains how, for each observation type, the nodes associated with the observation definition should be filled in.

Code 01 = Range observation

A range defines a geometric relationship between two nodes. If the client or supplier wishes to distinguish between ranges that are measured according to different physical principles (electromagnetic, optical, acoustic), this should be done by attributing different Positioning System Identifiers to those different groups.

Codes 02, 03 = Hyperbolic observation

Only hyperbolic observations taken from multi-user hyperbolic positioning systems should be recorded as Observation Type 02 or 03. Simple differences between two ranges should be defined using Code 06.

A hyperbolic observation of Code 02 or 03 defines a geometric relationship between three nodes, usually a node on the vessel (indicated below by 'V') and two fixed nodes: often two shore transmitting stations (indicated below by S_1 and S_2).

The hyperbolic observation essentially describes a range difference involving the range S_1V (from station 1 to vessel) and S_2V (from station 2 to vessel).

However, which range is subtracted from which depends on the way the positioning system operates and this gives rise to two different formulae to model the two different types of hyperbolic observation. The two formulae have been indicated in record H52## by Formula 1 (Code 02) and Formula 2 (Code 03).

Code 02 - formula 1

Formula 1 should be applied when the reading of a hyperbolic pattern 1-2 **increases** when moving over the baseline from station 1 to station 2. Most phase difference measurement systems satisfy this requirement.

Formula 1 for an observation L_{12}, made at node V of hyperbolic pattern 1-2, is:

$$L_{12} = (S_1S_2 + S_1V - S_2V)/2\lambda + (C\text{-}O)_{fixed} + (C\text{-}O)_{var.}$$

Code 03 - formula 2

Formula 2 should be applied when the reading **decreases** when moving over the baseline from station 1 to station 2. Most time difference measurement systems satisfy the latter requirement.

Formula 2 for an observation L_{12}, made at node V of hyperbolic pattern 1-2, is:

$$L_{12} = (S_1S_2 - S_1V + S_2V)/2\lambda + (C\text{-}O)_{fixed} + (C\text{-}O)_{var.}$$

where (in both formulae):

L_{12}	= hyperbolic observation
S_1S_2	= distance between Stations 1 and 2
S_1V	= distance between Station 1 and vessel
S_2V	= distance between Station 2 and vessel
λ	= lanewidth at the baseline
$(C\text{-}O)_{fixed}$	= fixed (C-O), see below
$(C\text{-}O)_{variable}$	= variable (C-O), see below

Codes 04, 05 = Pseudo-range observation
A pseudo-range is derived from the measured one-way signal travel time between two nodes. A different time-standard used by transmitter and the receiver causes the observation to be contaminated by a clock offset, which is the difference between the two time systems. These clock offsets need to be solved for in the position computation process.

Pseudo-ranges thus measured by one receiver should be grouped by allocating the same Positioning System Identifier to each of them. If a second receiver is used to measure pseudo-ranges from the same transmitting stations, the second group of pseudo-ranges should be allocated a different Positioning System Identifier. This is regardless of the location of the two receivers: they may be on the same vessel.

Two types of pseudo-ranging systems may be distinguished, leading to two types of pseudo-range observations:

Code 04 - Time-synchronised transmitters

The first type of pseudo-ranging system operates with time-synchronised transmitters, which requires one clock offset to be solved for in the position calculation process. That clock offset is common to all pseudo-ranges of that system observed by the same receiver. An example of a system operating according to this principle is GPS.

Note : Code 20 is provided for GPS pseudo-ranges which are logged in the E/T55## and E/T56## records.

Code 05 - Free-running transmitters

The second type of pseudo-ranging system has transmitters that are driven by free-running, but highly accurate clocks. Such systems require one clock-offset per observed pseudo-range to be solved for in the position calculation process. Pseudo-ranging systems of this type are also referred to as rho-rho systems.

Code 06 = Differential observation

A differential observation is defined as the arithmetic difference between two simultaneously measured observations, termed the "parent" observations below.

The simultaneity should be interpreted in a practical sense: some difference in timing may be acceptable if that has no appreciable impact on the practical interpretation of the differential observation.

A differential observation, together with its two parent observations, is defined by means of the following records:

H52## = Observation definition: parent observation 1
H54## = Observation definition (continued): parent obs. 1
H52## = Observation definition: parent observation 2
H54## = Observation definition (continued): parent obs. 2
H5306 = Differential observation definition

The H5306 record should define the differential observation in the sense:

$$\text{Diff.Obs} = \text{Obs}_1 - \text{Obs}_2$$

The Variable (C-O) and, if relevant, the Fixed System (C-O) of the differential observation are then defined as follows:

$$(\text{C-O})_{\text{Diff.Obs}} = (\text{C-O})_{\text{Obs.1}} - (\text{C-O})_{\text{Obs.2}}$$

with $(\text{C-O})_{\text{Obs.1}}$ and $(\text{C-O})_{\text{Obs.2}}$ recorded on the H54## records of each of the two parent observations.

However, if the differential observation is calibrated itself, rather than its two "parent" observations, a separate H5406 record should be added, which should be blank but for the first field, which should contain the differential observation identifier and the seventh field, which contains the residual (C-O). The Variable (C-O) fields in the H54## records defining the "parent" observations should then be left blank.

Code 07 - Composite range

This observation type is intended to allow definition of sing-around ranges. Sing-around ranges are achieved by relaying a ranging signal over a series of beacons, starting at node 'A', then to node 'B', node 'C' etc. and may be available both in electromagnetic and underwater acoustic positioning systems.

The receiver/interrogator normally measures the one-way total travel-around time, hence the sum of the lengths of the legs of the polygon the signal travelled around.

However, the record does not only allow polygon legs to be added to the total sing-around-range, but also subtracted, hence a generalisation of the name to 'composite range'.

A composite range is defined by means of the following records:

H5207 - Observation definition
H5307 - Composite range - follow up record (repeated if necessary)
H5407 - Observation definition (continued)

Code 08 - Angle

An angle defines a geometric relationship between three nodes: the node at which the angular measurement device is located and two target nodes, node 1 and node 2. By convention the angle is measured clockwise from node 1 to node 2.

In marine applications angular measurement devices are often aligned to ship's head, not to a specific node on the vessel. Ship's head is in this context identified with an imaginary node with identifier 0 (zero). When node 0 is defined the angle must be measured at the vessel.

Most vessel mounted laser systems presently used for fixing targets in the vicinity of the vessel's stern are set up in this way and the angles measured by such systems should be recorded as explained in this section.

Code 09 - Direction

An angle can be seen as the difference between two directions. A direction requires two nodes in order to be defined, the station and the target. However, one direction alone is meaningless: at least one more direction to another target needs to be defined so that the angle between the two target nodes, measured from the station, an be derived.

Defining angular relationships in terms of directions rather than angles (code 08) is only meaningful if:

- the angular measurement device is unorientated, **and:**
- the device measures to multiple targets.

All such directions will share the same orientation unknown, much in the same way as a number of pseudo-ranges may share the same clock-offset, as in GPS.

Code 10, 11 - Bearing

Measured at any station, the bearing from that station to a target is the clockwise angle between the North direction (true or magnetic) and the direction to the target. In general, a bearing defines a geometric relationship between two nodes and the earth's magnetic field.

In the case of a compass mounted on a ship the target node is implied, namely the ship's head.

In the case of compass mounted on a streamer the target is also implied and is in this case the tangent to the curve the streamer assumes at the time of observation.

Bearings may also be measured - or rather derived - by satellite positioning systems operated in local differential or relative mode as is presently the case with many GPS "tailbuoy tracking systems". The bearing output produced by such systems indeed requires two nodes to be explicitly defined: the station and the target. This application is covered by Code 11.

Code 12 - True bearing with unknown index (rate gyros)

Although not yet used (extensively) in the offshore survey industry, **rate gyros** (e.g. ring laser gyros) are able to measure bearing differences, that are continually integrated by the unit. The output is essentially a bearing with an unknown index or addition constant. Code 12 is intended to describe that type of observation.

Code 20 - GPS pseudo-range

This observation is the distance in metres between the satellite and receiver, including the apparent range offset caused by the difference in the satellite and receiver clocks. Although this may be L1 or L2 P-code or L1 C/A code, these different observables should be defined as separate H52## records, per receiver, although it is not necessary to define a separate H52## for each satellite.

Code 20 and code 04 are both defined as pseudo-ranges with a common clock offset. The distinction is that code 20 pseudo-ranges need not specify the "To" node in the H52## record, relying instead on the specification of S.V. in the E/T55## record. In addition, code 20 pseudo-ranges, recorded in E/T55## or E/T56## records have a specifically associated accurate time of measurement (which is lacking from the code 04), which is necessary for the calculation of the satellite position.

The H54## lanewidth or frequency field should in this case be entered as frequency, being the L1 or L2 value.

Code 21 - GPS code phase

Some GPS receivers are only capable of measuring the phase of the GPS code rather than the full pseudorange. These observations have an ambiguity of approximately 293 metres on C/A-code and 29.3 metres on P-code.

If these observations are to be used for navigation, then the ambiguity must be determined by some other means (for example by having another method of roughly measuring position).

Observations made on different codes or frequencies should be defined as separate H52## records, per receiver, although it is not necessary to define a separate H52## for each satellite.

The H54## lanewidth or frequency field should in this case be entered as lanewidth, the value being the length of the unambiguous code-phase lane.

Observed values should be recorded in metres.

Code 22 - GPS carrier phase

The phase of the GPS carrier (L1 or L2) in cycles. This measurement will generally only be useful if related to preceding and subsequent phase measurements by a count of the intervening integer cycles. Any failure to carry over the integer part of this figure from one observation to the other should be reflected in the observation quality indicator.

Observations made on different frequencies should be defined as separate H52## records, per receiver, although it is not necessary to define a separate H52## for each satellite.

Note that this measurement requires that Code 20 pseudo-ranges are also recorded, as, without them, there is no way for the satellite position at the time of measurement to be calculated (the receiver time of receipt is recorded, but not the time of transmission, which needs to be reconstructed from the time of receipt and the pseudo-range).

The H54## lanewidth or frequency field should in this case be entered as frequency, being the L1 or L2 value.

Code 23 - GPS Doppler count
The instantaneous Doppler shift frequency (L1 or L2) observed between the GPS carrier and the receiver, in Hertz.

Observations made on different frequencies should be defined as separate H52## records, per receiver, although it is not necessary to define a separate H52## for each satellite.

Note that this measurement requires that Code 20 pseudo-ranges are also recorded, as, without them, there is no way for the satellite position at the time of measurement to be calculated (the receiver time of receipt is recorded, but not the time of transmission, which needs to be reconstructed from the time of receipt and the pseudo-range).

The H54## lanewidth or frequency field should in this case be entered as frequency, being the L1 or L2 value.

Observation Identifiers and GPS

The definitions of raw GPS observations do not differ in theory from other forms of observations (although it is not necessary to record a "To" node in the H52, as this is covered by the S.V. identifier in the E/T record), however, in practice, a single GPS receiver is capable of producing several kinds of observation. As such, the following describes when GPS observations require different observations IDS :

- Observations of different Observation Types must have different Observation IDs;
- Observations of the same Observation Type, but from different receivers must have different Observation IDs
- Observations of the same Observation Type, but on different codes (C/A or P) must have different Observation IDs;
- Observations of the same Observation Type, but on different frequencies (L1 or L2) must have different Observation IDs;
- Observations of the same Observation Type, but with different stochastic properties (*e.g.* raw *versus* phase-smoothed) must have different Observation IDs;

Observations of the same type, at the same receiver, on the same satellite, may have the same Observation ID if the conditions above are met.

6.6.3 C: Observation definitions: parameters

C1 Parameters assumed fixed (records H54##, H5500, H56@0)

a) Propagation Speed:
The Propagation Speed is the speed built into the receiver where conversion to metric units occurs in the equipment, or the assumed/measured propagation speed, where such is not the case.

b) Lanewidth at Baseline / Comparison Frequency:
The Lanewidth at Baseline is only relevant for hyperbolic observations. In this field the supplier has the option to record either the lanewidth at the baseline or the comparison frequency.

Many positioning systems designed for hyperbolic mode are often used in range-range mode, providing as output ranges expressed in units of half its wavelength ("lanes").

In spite of that the flag "Lanewidth or frequency" in record H54## should in that case be set to 1 and the comparison frequency should be entered in columns [25,36]. See under **Scale Factor** below how to define the measurement unit of such systems.

c) Scale Factor (C/O):
The Scale Factor or C/O should correct the raw observation measurement unit to the standard measurement unit, defined in the "Measurement Unit Code" field of record H52##.

Normally no scale correction needs to be made, in which case the value of the C/O needs to be recorded as 1 (unity). Three notable exceptions are mentioned below.

i) A range-range system providing output in "lanes" requires the following approach.
   - Set "Measurement Unit Code" in record H52## to metres or feet (Code 0 or Code 1).
   - Set "Lanewidth or frequency" flag to 1 (frequency) and enter the comparison frequency in columns [25,36], both in record H54## .
   - The lanewidth of the system, which in this case is the propagation speed divided by twice the comparison frequency should then be entered into record H54## as the "Scale Factor".

ii) Another application of the scale factor may occur when ranges are reduced in the measurement device for two-way travel, while the signal has only travelled one-way as can be the case with sing-around ranges. In such cases the scale factor needs to be set to 2.

iii) The converse happens when a ranging system measuring two-way travel time does not compensate for that, but treats the measurement as a one-way travel time. In that case the scale factor needs to be set to 0.5.

d) Fixed (C-O):
The Fixed (C-O) correction is determined by the mode of operation of the relevant positioning system or sensor. More often than not hyperbolic systems have Fixed (C-O) corrections associated with them. Fixed (C-O) corrections do not vary over time, nor with location. The Fixed (C-O) must be recorded in the same measurement unit as the observation it refers to.

e) Variable (C-O):
The Variable (C-O) correction is related to systematic minor deviations of the measurements from the assumptions underlying the measurement process. Examples are unmodelled signal propagation variations and instrumental variations. Variable (C-O) corrections are determined by calibration. They may be instrument specific and/or time/location dependent. The Variable (C-O) must be recorded in the same unit as the observation it refers to.

f) Variable (C-O) by Instrument Correction (H56@0):

The norm is to supply the calibration correction to an observation in the form of one Variable (C-O). However, for some systems, notably some ranging systems, the Variable (C-O) is split up into component parts, and expressed as instrument or sensor corrections, often derived from bench calibrations of the sensors. These corrections are commonly supplied in the form of receiver, beacon or transponder delays.

Instrument corrections can be supplied in record H56@0 when relevant. They should add to the range measured to/from the relevant node and therefore equal **minus** the instrument delays. When instrument corrections are supplied the Variable (C-O) fields in the H54## records of the affected observations should be left blank. The total variable (C-O) for such a range between node 'A' with instrument 'i' and node 'B' with instrument 'j' is:

$$(C\text{-}O)_{var} = Instr.Corr_i + Instr.Corr_j$$

C2 *Reduction of observations*

a) General reduction formula:

The general observation reduction equation is:

$$Obs_{reduced} = C/O * \{ Obs_{raw} + (C\text{-}O)_{fixed} + (C\text{-}O)_{var} \}$$

The (C-O) and C/O corrections are in principle obtained from record H54##, and, where relevant from records H56@0.

b) Changes to (C-O) and C/O within a line:

This format allows changes to (C-O)s and C/Os which occur within a seismic line to be recorded without having to insert a new block of header records. This option is implemented by means of the E54## and T54## records for (Inter-)event Observation Parameters.
Variable (C-O) and/or C/O (scale) corrections supplied in (inter-)event records take precedence over the values supplied in record H54## and replace the latter.

However, a propagation speed value supplied in an (inter-)event record will replace the propagation speed supplied in record H54##, but the scale correction in record H54## will then still be valid and should be applied in the reduction formula.

A change in e.g. a (C-O) during a line needs to be recorded only **once** by inserting one E54## or T54## record. The new value will be deemed to valid until:

- it is changed again by means of an E54## or T54## record for a later point in time, or:
- the end of the line is reached.

If the new (C-O) value is still valid at the beginning of the next line, the value will need to be consolidated in the relevant H54## record for the new line.

It is important to realise that if data processing is started not at the beginning of the line but at a point further down the line reading of the header data will not be sufficient to set the values of the observation parameters: the data file will have to be scanned from its start for E54## and T54## records.

C3 *Quality parameters*

Provision has been made in the format for the recording of two types of observation quality indicator:

1. the <u>a priori</u> or <u>expected</u> quality, as for instance assumed in the design of the network;
2. the <u>actual</u> quality as occurring during the survey.

The recording of quality indicators is subject to client requirements and data availability.

a) A priori or expected accuracy

The A Priori Standard Deviation must, when available, be recorded in the same units as the observation and expresses the expected precision of the observation. The decimal point must be included.

b) Actual quality

The Quality Indicator may be recorded in the (inter-)event records of the network observations and some other observations.

A four character field is provided, and is intended to hold a numeric value with decimal point where appropriate.

The following options are available:

Code	Name	Definition
0		No quality information recorded
1	Standard deviation	Standard statistical variable; measure of the noise level of the observation. Unit: same as the observation unit of measurement.
2	Signal/noise ratio	Standard physical variable. Unit: dB.
3	System specific	Positioning system specific quality indicator (see below), often a measure of signal strength. When used it should apply to all observations grouped into the same positioning system and an H5500 record must be provided defining this parameter.
4	Subjective scale	0 = poor quality; unusable; 1 = poor quality but usable; 2 = fair quality; 3 = good quality.

Note

For raw GPS observations, it is recommended that Code 1 (Standard Deviation) be used for pseudoranges from those receivers which provide this figure (*e.g.* those using phase smoothing), and Code 2 (Signal/Noise ratio) for those which do not.

c) System specific quality indicator (record H5500)

Many positioning systems provide a parameter with each observation which is a measure of the quality of the signal, often signal strength. For that reason an H5500 record should be inserted when Code 3 is defined for an observation quality indicator. This record should provide a descriptive definition of the following aspects of the system specific quality indicator:

- the range of the variable,
- the interpretation of its values.

The same Code 3 should then apply to all observations of the relevant positioning system.

6.7 SATELLITE SYSTEM DEFINITIONS

The records in the next section (6.7.1) are for use by systems which record (in records E/T620#, E/T621#, E/T6303, E/T640#) positions derived from satellite systems, rather than their raw observations. These records are not necessary for the recording of raw GPS / DGPS data, but are merely an option if no raw data is available.

The records in the second section (6.7.2) record the orbital, ionospheric and meteorological parameters necessary to derive positions from raw GPS or DGPS observations. These records are necessary for the recording of raw GPS / DGPS data.

The records in the third section (6.7.3) define DGPS correction systems. These records are necessary for the recording of raw DGPS data.

6.7.1 Satellite derived positioning

H600# **Satellite System Description**

= 1..9, Satellite system reference number

Name	[7,14]	A8	free text
Datum and spheroid number	[16,16]	I1	
Diff. system operator	[18,35]	A18	free text
Diff. system name	[37,46]	A10	free text
Software description, version number and additional information	[48,80]	A33	free text

NOTE:
Satellite system numbers must be numbered according to the following convention:

1	= GPS autonomous positioning
2	= Differential GPS (DGPS)
3	= TRANSIT
4..9	= User definable

The datum and spheroid referred to must be defined in record H011#.

In the case that multiple GPS or DGPS systems are used and those systems do not all produce coordinates referenced to the same datum/spheroid, the User Definable numbers, 4..9 shall be used to distinguish systems working on different datum/spheroids. However, it is recommended to use only one datum/spheroid for all DGPS or GPS systems in one survey.

*Note that this record forms part of the set of records needed to record satellite derived positions only, and is **not** required for the recording of raw GPS and DGPS only.*

H610# **Definition of Differential Reference Stations**

= 2, 4..9, Satellite system reference number

Reference station number	[6, 7]	I2	
Reference station name	[9,20]	A12	free text
Latitude	[22,33]	I3,I2,F6.3,A1	dddmmss.sss N/S
Longitude	[35,46]	I3,I2,F6.3,A1	dddmmss.sss E/W
Spheroidal height	[48,54]	F7.2	metres
Geoid-Spheroid separation	[56,62]	F7.2	metres
Geoidal model	[64,80]	A17	free text

NOTE:
The co-ordinates of the reference station must be defined on the same datum/spheroid as the satellite system. The geoid-spheroid separation at the station and the geoidal model from which the separation was derived is only relevant if the co-ordinates of the reference station have been converted from a local datum to the satellite system datum. If they were determined by means of observations from that same satellite system, the spheroidal height would have been determined directly and no geoid-spheroid separation and geoidal model need be recorded in this record.

*Note that this record forms part of the set of records needed to record satellite derived positions only, and is **not** required for the recording of raw GPS and DGPS only.*

H620# **Satellite Receiver Definition**

= 1..9, Satellite system reference number

"At" Node identifier	[7,10]	I4	
Receiver number	[12,12]	I1	
Located on: ref. number	[14,16]	I3	
Offset A	[18,24]	F7.1	
Offset B	[26,32]	F7.1	
Offset Z	[34,39]	F6.1	
Receiver name, description and additional information	[41,80]	A40	free text

NOTE:

The Node identifier must be a unique positive number.

The second field, "Located on: ref. number" is the reference number of the vessel, gun array, streamer or buoy the receiver is mounted on.

Offsets define the nominal location of the antenna electrical centre.

*Note that this record forms part of the set of records needed to record satellite derived positions only, and is **not** required for the recording of raw GPS and DGPS only.*

6.7.2 GPS parameters

H6300 GPS parameter recording strategy

Meteorological records	[7, 7]	A1
Ionospheric model records	[8, 8]	A1
Clock model & ephemerides	[9, 9]	A1

This record is provided to allow recording systems to inform processing software of their intentions with respect to recording slowly changing GPS parameters. Each of the fields will take one of three values :

0 = Not logged at all, even in header
H = Recorded in header, but not updated in T records
T = Recorded in header and updated in corresponding T records.

however, the following restrictions will apply :

- Clock & ephemerides records (H631#) must be "T" (logged and updated). This is necessary since the ephemerides of the constellation in view at start of line (or header writing time) will not necessarily be sufficient to cover all constellations used during the line.

- The ionospheric records must be either "H" (logged in header) or, for very long lines, "T" (logged and updated).

*Note that this record forms part of the set of records needed to record raw GPS and DGPS observations, and is **not** required for the recording of satellite derived positions only.*

H6301 DGPS differential correction recording strategy

Correction Type	[7,10]	I4
Type Description	[11,24]	A14
Correction Type	[25,28]	I4
Type Description	[29,42]	A14
Correction Type	[43,46]	I4
Type Description	[47,60]	A14
Correction Type	[61,64]	I4
Type Description	[65,78]	A14
etc.		

This record is provided to allow recording systems to inform processing software of their intentions with respect to recording DGPS correction types parameters. If a Correction Type is declared here, then it is the recording system's intention that corrections of that type will be recorded when available. A description of the correction must also be included to a void ambiguity between the arbitrary message types used by different service providers.

The correction type field, and the record itself, may repeated as often as is necessary.

*Note that this record forms part of the set of records needed to record raw GPS and DGPS observations, and is **not** required for the recording of satellite derived positions only.*

The following H631# records define the clock model and ephemerides for a particular satellite.

It is not necessary to record H631# for every satellite, but it is necessary to record either H631# or the corresponding T631# for a satellite prior to any observation data being recorded in E/T55##.

For each satellite recorded, all of these records must be present in order.

Satellites are identified by S.V. codes. The "System type code" is to allow future expansion beyond GPS alone. This single character field should currently be blank or "G".

H6310 GPS ephemerides & clock

S.V.	[6, 8]	A1,I2	System type code, 1-32
Transmission time of message	[9,26]	E18.12	GPS week seconds

*Note that this record forms part of the set of records needed to record raw GPS and DGPS observations, and is **not** required for the recording of satellite derived positions only.*

H6311 GPS clock parameters

S.V.	[6, 8]	A1,I2	System type code, 1-32
S.V. clock drift rate a_{f2}	[9,26]	E18.12	seconds/second²
S.V. clock drift a_{f1}	[27,44]	E18.12	seconds / second
S.V. clock bias a_{f0}	[45,62]	E18.12	seconds
Time of Clock t_{oc}	[63,80]	E18.12	GPS week seconds

These parameters are available from the GPS message sub-frame 1.

*Note that this record forms part of the set of records needed to record raw GPS and DGPS observations, and is **not** required for the recording of satellite derived positions only.*

H6312 GPS ephemerides, 1

S.V.	[6, 8]	A1,I2	System type code, 1-32
Issue of Data, Ephemerides IODE	[9,26]	E18.12	
C_{rs} [27,44]	E18.12	metres	
Δn	[45,62]	E18.12	radians / second
M_0 [63,80]	E18.12	radians	

C_{rs} amplitude of the sine harmonic correction term to the orbit radius.
Δn mean motion difference from computed value.
M_0 mean anomaly at reference time.

These parameters are available from the GPS message sub-frames 2 and 3.

*Note that this record forms part of the set of records needed to record raw GPS and DGPS observations, and is **not** required for the recording of satellite derived positions only.*

H6313 GPS ephemerides, 2

S.V.	[6, 8]	A1,I2	System type code, 1-32
C_{uc}	[9,26]	E18.12	radians
eccentricity e	[27,44]	E18.12	
C_{us}	[45,62]	E18.12	radians
$\sqrt{A}$	[63,80]	E18.12	$\sqrt{}$(metres)

C_{uc} amplitude of the cosine harmonic correction term to the argument of latitude.
C_{us} amplitude of the sine harmonic correction term to the argument of latitude.
$\sqrt{A}$ square root of the semi-major axis.

These parameters are available from the GPS message sub-frames 2 and 3.

*Note that this record forms part of the set of records needed to record raw GPS and DGPS observations, and is **not** required for the recording of satellite derived positions only.*

H6314 GPS ephemerides, 3

S.V.	[6, 8]	A1,I2	System type code, 1-32
Time of ephemeris, toe	[9,26]	E18.12	GPS week seconds
C_{ic} [27,44]	E18.12	radians	
Ω_0 [45,62]	E18.12	radians	
C_{is} [63,80]	E18.12	radians	

C_{Ic} amplitude of the cosine harmonic correction term to the angle of inclination.
Ω_0 right ascension at reference time.
C_{IS} amplitude of the sine harmonic correction term to the angle of inclination.

These parameters are available from the GPS message sub-frames 2 and 3.

*Note that this record forms part of the set of records needed to record raw GPS and DGPS observations, and is **not** required for the recording of satellite derived positions only.*

H6315 GPS ephemerides, 4

S.V.	[6, 8]	A1,I2	System type code, 1-32
i_0	[9,26]	E18.12	radians
C_{rc} [27,44]	E18.12	metres	
argument of perigee ω	[45,62]	E18.12	radians
rate of right ascension $\Omega\bullet$	[63,80]	E18.12	radians / second

i_0 inclination angle at reference time.
C_{RC} amplitude of the cosine harmonic correction term to the orbit radius.

These parameters are available from the GPS message sub-frames 2 and 3.

*Note that this record forms part of the set of records needed to record raw GPS and DGPS observations, and is **not** required for the recording of satellite derived positions only.*

H6316 GPS ephemerides, 5

S.V.	[6, 8]	A1,I2	System type code, 1-32
Rate of inclination angle $i\bullet$	[9,26]	E18.12	radians / second
Codes on L_2	[27,44]	E18.12	
GPS week number	[45,62]	E18.12	
L_2 P data flag	[63,80]	E18.12	

These parameters are available from the GPS message sub-frames 2 and 3.

Note that this record forms part of the set of records needed to record raw GPS and DGPS observations, and is ***not*** *required for the recording of satellite derived positions only.*

H6317 GPS ephemerides, 6

S.V.	[6, 8]	A1,I2	System type code, 1-32
S.V. accuracy	[9,26]	E18.12	
S.V. health	[27,44]	E18.12	
T_{GD}	[45,62]	E18.12	
Issue of data clock, IODC	[63,80]	E18.12	

i_0 inclination angle at reference time.
C_{RC} amplitude of the cosine harmonic correction term to the orbit radius.

These parameters are available from the GPS message sub-frames 2 and 3.

*Note that this record forms part of the set of records needed to record raw GPS and DGPS observations, and is **not** required for the recording of satellite derived positions only.*

The following triplet of records (or their T632# equivalents) must appear at least once prior to the recording of any raw GPS observations.

H6320 GPS UTC parameters

term of UTC polynomial A_0	[6,23]	E18.12	seconds
term of UTC polynomial A_1	[24,41]	E18.12	seconds / second
reference time of time, t_{ot}	[42,50]	I9	seconds
UTC week reference no. WN_t	[51,59]	I9	
Leap seconds delta time Δt_{LSF}	[60,65]	I6	seconds

These parameters are available from the GPS message sub-frame 4, page 18.

*Note that this record forms part of the set of records needed to record raw GPS and DGPS observations, and is **not** required for the recording of satellite derived positions only.*

H6321 GPS ionospheric model parameters, 1

α_0	[6,17]	E12.4	seconds
α_1	[18,29]	E12.4	seconds / semicircle
α_2	[30,41]	E12.4	seconds / semicircle^2
α_3	[42,53]	E12.4	seconds / semicircle^3

These parameters are available from the GPS message sub-frame 4, page 18.

*Note that this record forms part of the set of records needed to record raw GPS and DGPS observations, and is **not** required for the recording of satellite derived positions only.*

H6322 GPS ionospheric model parameters, 2

β_0	[6,17]	E12.4	seconds
β_1	[18,29]	E12.4	seconds / semicircle
β_2	[30,41]	E12.4	seconds / semicircle^2
β_3	[42,53]	E12.4	seconds / semicircle^3

These parameters are available from the GPS message sub-frame 4, page 18.

*Note that this record forms part of the set of records needed to record raw GPS and DGPS observations, and is **not** required for the recording of satellite derived positions only.*

H6330 Meteorological data

Surface air pressure	[6,12]	F7.1	millibars
Dry air temperature	[13,19]	F7.1	degrees Celsius
Wet air temperature	[20,26]	F7.1	degrees Celsius
Relative humidity	[27,33]	F7.1	percent

Either, but not both, of the last two fields may be left blank.

*Note that this record forms part of the set of records needed to record raw GPS and DGPS observations, and is **not** required for the recording of satellite derived positions only.*

6.7.2 DGPS definitions

The following pair of records define a Differential Correction Source (DCS).

Whilst a DCS may be a Differential GPS reference station, it need not be : a single reference station is, theoretically, capable of providing more than one stream of corrections (by using different receivers, or the same receiver and parallel software), in which case it would be multiple DCSs, whilst it is also possible that signals from several stations are combined to provide a single correction stream, which would then constitute a single DCS.

H65## Differential Correction Source Definition

is the Differential Correction Source Identifier

DCS short name	[7,14]	A8	free text
Datum & Spheroid number	[16,16]	I1	from H011x
Latitude of correction source	[17, 28]	I3,I2,F6.3,A1	dddmmss.sss N/S
Longitude of correction source	[29, 41]	I3,I2,F6.3 A1	dddmmss.sss E/W
Spheroidal height	[42, 48]	F7.2	metres
Geoid - spheroid separation	[49, 55]	F7.2	metres
Geoidal model	[56, 72]	A17	free text

NOTE:
The geoid-spheroid separation at the station and the geoidal model from which the separation was derived are only relevant if the co-ordinates of the reference station have been converted from a local datum to the satellite system datum. If they were determined by means of observations from that same satellite system, the spheroidal height would have been determined directly and no geoid-spheroid separation and geoidal model need be recorded in this record.

H66## Differential Correction Source Description

is the Differential Correction Source Identifier

DCS system operator	[7, 24]	A18	free text
DCS component name	[25, 43]	A18	free text
DCS component description	[44, 80]	A37	free text

It is intended that the component described here include, specifically, receiver types, processing software used and transfer protocols (*e.g.* RTCM), and that their descriptions include their model numbers, and version numbers of firmware and software and formats.

This record may be repeated for the same DCS ID in contiguous records as often as is appropriate to complete the description of each of the DCS's components.

H67@0 Height aiding values

@ = 1..9 vessel number
@ = 0 fixed or relay station

Node identifier	[6, 9]	I4	
Positioning system identifier	[10,12]	I3	
Ellipsoid height of antenna	[13,23]	N11	metres
Description of source of value	[24,80]	A57	free text

This record is intended to allow the recording system to log any estimates of GPS antenna height used in assisting the GPS computations. The record is entirely analogous to the H56@0 instrument correction, and should be interpreted in the same way. Note that since such a value is effectively on a *per* antenna basis, the combination of Node ID and Positioning system ID should be used to uniquely identify the antenna, and to provide a link between the Header record and its updates.

The description field should record the models (geoid, tidal, *etc.*) used to derive the height, and their resolution (*e.g.* 10 Km).

Note that this record forms part of the set of records needed to record raw GPS and DGPS observations, and is ***not*** *required for the recording of satellite derived positions only.*

6.8 USER DEFINED OBSERVATION SETS

H7000 Definition of User Defined Observation Sets

Observation set reference number	[7, 9]	I3	
Number of data fields associated with this set	[11,12]	I2	
Description of observation set	[14,80]	A67	free text

Record may be repeated.

NOTE:
This record type allows the definition of observations with supporting data, which are not covered by the format otherwise. The observations with their supporting data, such as the co-ordinates at which the observations refer to, date and time, etc. should be defined as one observation set.

Include sensor type, make, serial number, calibration details and other relevant information. Expand by repeating the record if necessary, leaving the second field ("Number of data fields associated with this set") blank.

Examples are gravity data, magnetic data, current data etc.

H7010 Data Field Definitions

Observation set reference number	[7, 9]	I3	
Data field number	[11,12]	I2	
Data field width	[14,15]	I2	
Data field description	[17,80]	A64	free text

Record may be repeated.

NOTE:
Include items such as sensor channel number, units of measurement and any other information required for interpretation and processing. Repeat the record if more descriptive space is required, leaving the third field ("Data field width") blank.

H7020 User Defined Observation Parameters

Observation set reference number	[7, 9]	I3
Data field number	[11,12]	I2
Quality indicator type	[14,14]	I1
(C-O) correction	[16, ..]	Nx

NOTE:
The "quality indicator type" defines the type of quality indicator used in the (inter-) event data records for the relevant data field; it should be one of the following codes:

0 = no quality information recorded
1 = standard deviation
2 = signal/noise ratio
3 = system specific
4 = subjective scale

In the case code 1 is chosen a descriptive definition of the way the standard deviation is derived must be supplied in record H7021.

In the case code 3 is chosen a descriptive definition must be supplied in record H7021 of the following aspects of the system specific quality indicator:

- the range of values of the variable;
- the interpretation of its values.

Further details of these codes can be found in Chapter 6.6.3-C, Section C3.

The width of the (C-O) field must be the same as the width of the data field it refers to, as defined in record H7010.

H7021 Definition of Quality Indicator Type for User Defined Observations

Observation set reference number	[7, 9]	I3	
Data field number	[11,12]	I2	
Definition of quality indicator type	[14,80]	A67	free text

Record may be repeated.

Example of user defined observations

Header data

H7000 001 01	Gravity data: standard sensor S/N 31
H7000 001	Last in-port gravity tie: Aberdeen 31 October 1991
H7010 001 01 06	Gravity count in milligals
H7010 001 02 06	Spring tension in milligals
H7010 001 03 04	Average beam
H7010 001 04 04	Total cross coupling
H7010 001 05 04	Total correction
H7010 001 06 04	Vertical cross coupling
H7010 001 07 04	Along cross coupling
H7010 001 08 04	Across cross coupling
H7010 001 09 04	Vertical correction
H7010 001 10 04	Average across acceleration
H7010 001 11 04	Average along acceleration
H7010 001 12 04	Second order cross coupling
H7010 001 13 04	Offset calibration

Event data

E701000101123412345602123412345603123412 34
E7010001041234123405123412340612341234071 2341234
E7010001081234123409123412341012341234111 2341234
E70100011212341234131 2341234

Inter-event data

T7010001011234010203112345602123401020311 23456
T70100010312340102031 1234

7. EVENT DATA RECORDS (implicit time tag)

7.1 GENERAL AND VESSEL RELATED EVENT DATA

E1000 General Event Data

Line name	[7,22]	A16	
Shot/Event number	[24,31]	I8	
Seismic record identifier	[33,48]	A16	
Year, month, day	[50,57]	I4,I2,I2	YYYYMMDD
Time	[59,66]	I2,I2,F4.1	HH,MM,SS.S
Gun Array Fired	[68,70]	I3	

NOTE:
Only one General Event Data record is required regardless of the number of vessels. However, this can only be achieved if all data relating to one event plus the inter-event data observed after that but before the next event are stored on one medium. In the case that the data is divided by vessel over various storage media the General Event Data record must be repeated for each storage medium containing data related to that event. See also Chapter 2.

The Gun Array Fired field contains the Gun Array Reference Number defined in the H31@0 record. It is provided to allow redundancy and to cover those cases where individual gun data is not available.

The Seismic record identifier would typically contain both File and Reel identifier in the 16 character field provided.

All positioning data in subsequent records not explicitly time-tagged is assumed to relate to the event time, defined in this record.

E12@0 Field Positioning Derived Data

@ = 1..9, Vessel reference number

Record sequence number	[6, 7]	I2	
Node identifier	[8,11]	I4	
Flag for geographical or grid co-ordinates	[12,12]	I1	0 = geographical 1 = grid
If geographicals:			
Latitude	[13,24]	I3,I2,F6.3,A1	dddmmss.sss N/S
Longitude	[25,36]	I3,I2,F6.3,A1	dddmmss.sss E/W
If grid:			
Northing	[13,23]	N11	
"N"	[24,24]	A1	
Easting	[25,35]	N11	
"E"	[36,36]	A1	
Course made good or (nominal) ship's heading	[37,42]	F6.2	degrees decimal
Flag for course made good or ship's heading	[43,43]	I1	0 = course made good 1 = ship's heading
Quality indicator 1	[44,47]	N4	
Quality indicator 2	[48,51]	N4	
Quality indicator 3	[52,55]	N4	
Processing details	[56,80]	A25	free text

Record may be repeated.

NOTE:
The Field Positioning Derived Data record allows the position of any node, as computed on-board, to be recorded. Alternatively the co-ordinates of the same node, but computed for the secondary, tertiary etc. positioning system may be recorded, details of which may be entered in the last field of the record.

This is achieved by allowing up to 99 of these records to be included, to be numbered uniquely by the supplier by means of the record sequence number. A record sequence should refer to the same type of data throughout the line, e.g. primary system antenna position, secondary system antenna position, tailbuoy position, etc.

The quality indicators should describe the quality of the processed positioning data. Examples are: the Standard Deviations of Northing and Easting and the Standard Deviation of Unit Weight. A full descriptive definition of the quality indicator(s) recorded should be supplied in record H12@1.

E14@0 **Echo Sounder Data**

@ = 1..9, Vessel reference number

Echo sounder ref. number	[6, 6]	I1	
Echo sounder reading	[7,12]	F6.1	metres

May be repeated for four more echo sounders mounted on the same vessel at [21,27], [36,42], [51,57] and [66,72].

E16@0 **USBL Acoustic Data**

@ = 1..9, Vessel reference number

USBL system ref. number	[6, 6]	I1	
Target Node identifier	[7,10]	I4	
X co-ordinate of target	[11,17]	N7	metres
Y co-ordinate of target	[18,24]	N7	metres
Z co-ordinate of target	[25,31]	N7	metres
Quality indicator	[32,35]	N4	

May be repeated for one more USBL system mounted on the same vessel at [44,73].

Record may be repeated.

NOTE:
The Z co-ordinate should conform to the sign convention defined in record H16@0.

E17@0 **Pitch, Roll and Heave Sensor Data**

@ = 1..9, Vessel reference number

Sensor reference number	[6, 6]	I1
Pitch angle	[7,16]	N10
Roll angle	[17,26]	N10
Heave	[27,36]	N10
Quality indicator pitch	[37,40]	N4
Quality indicator roll	[41,44]	N4
Quality indicator heave	[45,48]	N4

7.2 STREAMER EVENT DATA

E22@0 **Streamer Compass Data**

@ = 1..9, Vessel reference number

Streamer reference number	[6, 8]	I3	
Node identifier	[9,12]	I4	
Compass reading	[13,17]	F5.1	degrees decimal
Quality indicator	[18,21]	N4	

May be repeated for 4 more compasses on the same streamer at [22,34], [35,47], [48,60], [61,73]; the streamer reference number is not repeated.

Record may be repeated.

E24@1 **Auxiliary Seismic Channel Data**

@ = 1..9, Vessel reference number

Auxiliary channel reference number	[6, 9]	I4	
Time observed	[10,17]	N8	milliseconds

May be repeated for 5 more channels at [18,29] … [66,77].

NOTE:
This record is intended to contain first arrival travel time information to enable checking of source versus receiver group geometry. A timebreak channel gives a zero offset to reduce any waterbreak data. If no timebreak channel is defined, waterbreak data starts at zero.

E25@0 **Streamer Depth Sensor Data**

@ = 1..9, Vessel reference number

Streamer reference number	[6, 8]	I3
Depth sensor reference or serial number [9,16]	A8	
Depth reading	[17,21]	N5
Quality indicator	[22,25]	N4

May be repeated for 3 more depth sensors on the same streamer at [26,42], [43,59], [60,76]; the streamer reference number is not repeated.

Record may be repeated.

7.3 GUN ARRAY EVENT DATA

E32@0 Gun Array Depth Sensor Data

@ = 1..9, Vessel reference number

Gun array reference number	[6, 8]	I3
Sensor reference number	[9,10]	I2
Depth reading	[11,15]	N5
Quality indicator	[16,19]	N4

May be repeated for 5 more depth sensors on the same gun array, at [20,30], [31,41] ... [64,74]; the gun array reference number is not repeated.

Record may be repeated.

E33@0 Gun Fired Mask

@ = 1..9, Vessel reference number

Gun array reference number	[6, 8]	I3	
Starting gun number	[9,11]	I3	
Guns fired mask	[15,80]	66*I1	0 = not fired 1 = fired

Record may be repeated as necessary to define all guns that have fired on any event.

NOTE:
Guns not explicitly set as fired in this record are deemed not to have fired.

This record should be supplied in addition to the "gun array fired" code in the E1000 record to allow cross checking against the array definition in record H31@1 and the defined gun firing sequence in record H33@0. If individual gun data is not available, array sequence checking is only available via the array numbers supplied in the E1000 records.

E34@0 Gun Pressure Sensor Data

@ = 1..9, Vessel reference number

Gun array reference number	[6, 8]	I3
Gun number	[9,11]	I3
Pressure reading	[12,17]	N6

May be repeated for 7 more sensors in the same gun array at [18,26], [27,35] ... [72,80]; the gun array reference number is not repeated.

7.4 NETWORK EVENT DATA

E52## **Network Observations**

= Observation type

Observation identifier	[6, 9]	I4
Observation	[10,19]	N10
Quality indicator	[20,23]	N4

May be repeated at [31,48] and at [56,73] for two more observations:
- of the same observation type, and provided that:
- the observations were also observed at the same event time.

Record may be repeated.

E54## **Network Observation Parameters**

= Observation type

Observation identifier	[6, 9]	I4	
Variable (C-O)	[10,17]	N8	
C/O or propagation speed	[18,29]	N12	
Flag for C/O or speed	[30,30]	I1	0 = C/O (=scale factor) 1 = propagation speed

May be repeated for one more set of observation parameters at [38,62]:
- relating to the same observation type, and provided that:
- the change in observation parameters relate to the same event time.

Record may be repeated.

NOTE:

a) This record should only be inserted at events at which the above parameters change. The parameters are deemed to be valid from that event onward until the end of the line or until the event related to the next E54## or T54## record.

b) Variable (C-O) replaces Variable (C-O) in record H54##.

c) Scale (C/O) replaces Scale Factor in record H54##.

d) Propagation speed, if supplied, replaces the propagation speed in record H54##; the Scale Factor in record H54## is then still valid.

E55## **Network GPS Observations**

= Observation type

Observation ID	[6, 9]	I4	
Receiver time of receipt	[10,23]	I2,I2, F10.7	HH,MM, SS.sssssss
S.V. PRN	[24,26]	A1,I2	System type code, 1 to 32
Observation	[27,40]	N14	metres, phase cycles or Hertz
Quality indicator	[41,44]	N4	
Satellite health	[45,46]	I2	0 to 63
Lost Lock Indicator	[47,47]	I1	0 or 1
S.V. PRN	[48,49]	I2	1 to 32
Observation	[50,63]	N14	metres, phase cycles or Hertz
Quality indicator	[64,67]	N4	
Satellite health	[68,69]	I2	0 to 63
Lost Lock Indicator	[70,70]	I1	0 to 7

Observation type and Observation ID are as in E52## - i.e. they tie the record to an H52##.

Receiver time of receipt is the accurate time of observation in the receiver's own time frame (not including any estimates of clock bias). The date of this time is to be inferred from the E1000 record.

Satellites are identified by PRN codes. The "System type code" is to allow future expansion beyond GPS alone. This single character field should currently be blank or "G". Note that only the first S.V. includes the system type code, subsequent S.V.s in the same record must be from the same receiver (see below) and of the same observable, and thus of the same system.

Lost Lock indicator is a single digit which indicates whether or not the receiver has lost lock since the previous record. 0 indicates no loss or unknown, 1 indicates loss of lock.

Quality indicator is as for E52##, however, it is recommended that for receivers which pre-process (e.g. smooth) pseudo-ranges, that the Standard Deviation quality indicator is used, whilst for others the signal-to-noise ratio be recorded. Note that the corresponding H54## record should reflect this.

Satellite health is a value from 0 to 63 representing the current 6-bit health number broadcast by the GPS satellite. Note that this figure is an indication only, as it is not updated at the same rate as the observations themselves.

Multiple observations can be packed into the same record - but only those with the same Observation ID and Receiver Time of Receipt - this means that C/A code pseudo-ranges may be packed together, or L1 phases, but not pseudo range together with phase, nor C/A and P-code, nor L1 and L2 phases, nor observations from different receivers.

*Note that this record forms part of the set of records needed to record raw GPS and DGPS observations, and is **not** required for the recording of satellite derived positions only.*

E56## Network GPS Observations (continuation record)

= Observation type

Observation ID	[6, 9]	I4	
S.V. PRN	[10,11]	I2	1 to 32
Observation	[12,25]	N14	metres, phase cycles or Hertz
Quality indicator	[26,29]	N4	
Satellite health	[30,31]	I2	0 to 63
Lost Lock Indicator	[32,32]	I1	0 or 1
S.V. PRN	[33,34]	I2	1 to 32
Observation	[35,48]	N14	metres, phase cycles or Hertz
Quality indicator	[49,52]	N4	
Satellite health	[53,54]	I2	0 to 63
Lost Lock Indicator	[55,55]	I1	0 or 1
S.V. PRN	[56,57]	I2	1 to 32
Observation	[58,71]	N14	metres, phase cycles or Hertz
Quality indicator	[72,75]	N4	
Satellite health	[76,77]	I2	0 to 63
Lost Lock Indicator	[78,78]	I1	0 or 1

This record allows further observations from the same GPS receiver at the same time to be recorded without the overhead of stating the accurate time of receipt. This record must be preceded by an E55## record or another E56## record.

Note that the observation ID can change from that in the preceding E55##, thus, whilst each E56## must contain observations of the same receiver, observable, frequency etc., subsequent E56##s need only share a common receiver, satellite system and receiver time of receipt.

*Note that this record forms part of the set of records needed to record raw GPS and DGPS observations, and is **not** required for the recording of satellite derived positions only.*

7.5 SATELLITE POSITIONING EVENT DATA

E620# GPS or DGPS Data

= 1, GPS
= 2, DGPS

"At" Node identifier	[6, 9]	I4	
Receiver reference number	[10,10]	I1	
Latitude	[11,22]	I3,I2,F6.3,A1	dddmmss.sss N/S
Longitude	[23,34]	I3,I2,F6.3,A1	dddmmss.sss E/W
Height	[35,40]	F6.1	metres
Height datum	[41,41]	I1	0=height above ellipsoid 1=height above geoid (~MSL)
Satellites used	[42,61]	10*I2	(GPS SV numbers)
Reference stations used	[62,70]	9*I1	
Position calculation mode	[71,72]	I2	see below

NOTE:
If GPS is used in autonomous mode the field "Reference stations used" should be left blank.

Although it is not envisaged, nor recommended that DGPS data is usable without a time tag, the implicit time of observation is here, as per convention, event time.

The identifiers used to indicate the satellites used in the position fix must be the official GPS SV numbers.

The "Reference stations used" field refers to record H610#. Only those reference station identifiers should be recorded here of which the differential corrections have been used in the calculation of the position recorded in this record.

Position calculation mode codes:

1 = 3D solution; 4+ SVs
2 = 3D solution; 3+ SVs; height fixed
3 = 3D solution; 3+ SVs; height aided
4 = 3D solution; 3+ SVs; clock aided
5 = 3D solution; 2+ SVs; height aided and clock aided
6 = 3D solution; 2+ SVs; height fixed and clock aided
7 = 2D solution; 3+ SVs
8 = 2D solution; 2+ SVs; height fixed
9 = 2D solution; 2+ SVs; height aided
10 = 2D solution; 2+ SVs; clock aided
11 = 2D solution; 1+ SVs; height aided and clock aided
12 = 2D solution; 1+ SVs; height fixed and clock aided

*Note that this record forms part of the set of records needed to record satellite derived positions only, and is **not** required for the recording of raw GPS and DGPS only.*

E621# GPS or DGPS Data (continued)

= 1, GPS
= 2, DGPS

"At" Node identifier	[6, 9]	I4		
Receiver reference number	[10,10]	I1		
Standard deviations of:				
- Latitude:	[11,15]	N5	metres	
- Longitude:	[16,20]	N5	metres	
- Height:	[21,25]	N5	metres	
DOP type	[26,26]	I1	0	= GDOP
			1	= PDOP
			2	= HDOP
			3	= TDOP
			4	= VDOP
			5..9	= user defined on comment records
DOP figure	[27,30]	N4	unitless	

The "DOP type" and "DOP figure" fields may be repeated for other DOPs or quality indicators in columns [31,35] … [51,55] as required.

NOTE:
The standard deviations of latitude, longitude and height should be estimates of the quality of the fix, as produced by the onboard software.

The standard deviation of the height should be zero in the case where height is not solved for in the position calculation, such as in "height fixed" mode.

*Note that this record forms part of the set of records needed to record satellite derived positions only, and is **not** required for the recording of raw GPS and DGPS only.*

E6303 **TRANSIT Satellite Data**

"At" Node identifier	[6, 9]	I4	
Latitude	[10,21]	I3,I2,F6.3,A1	dddmmss.sss N/S
Longitude	[22,33]	I3,I2,F6.3,A1	dddmmss.sss E/W
Position includes dead reckoning?	[34,34]	I1	0 = no 1 = yes
Standard deviations of last accepted satellite fix:			
- Latitude	[35,39]	N5	metres
- Longitude	[40,44]	N5	metres

Record may be repeated.

NOTE:
The position supplied should refer to the satellite receiver antenna electrical centre.

If a dead reckoning system involving TRANSIT is being used, then the estimated current position should be recorded and the "dead reckoning flag" should be set.

No attempt is made to record raw data for the TRANSIT system and the standard deviations of the co-ordinates are recorded as an estimate of the quality of the fix, as supplied by the (onboard) processing software.

*Note that this record forms part of the set of records needed to record satellite derived positions only, and is **not** required for the recording of raw GPS and DGPS only.*

E640# **Satellite Data (other systems)**
= 4..9, Satellite system reference number

"At" Node identifier	[6, 9]	I4	
Latitude	[10,21]	I3,I2,F6.3,A1	dddmmss.sss N/S
Longitude	[22,33]	I3,I2,F6.3,A1	dddmmss.sss E/W
Height	[34,39]	F6.1	metres
Height datum	[40,40]	I1	0 = height above ellipsoid 1 = height above geoid (~MSL)
Standard deviations of:			
- Latitude:	[41,45]	N5	metres
- Longitude:	[46,50]	N5	metres
- Height:	[51,55]	N5	metres

NOTE:
The standard deviations of latitude, longitude and height should be estimates of the quality of the fix, as produced by the onboard software.

*Note that this record forms part of the set of records needed to record satellite derived positions only, and is **not** required for the recording of raw GPS and DGPS only.*

E65## **Differential correction data**
is the Differential Correction Source (DCS) Identifier.

Correction type	[6, 9]	I4	
Correction sequence	[10, 11]	I2	
GPS Time of Applicability	[12, 19]	I2,I2, F4.1	HH, MM, SS.s
DCS status/health	[20, 21]	I2	0 to 7
IOD (Issue of data) key	[22, 24]	I3	0-255
S.V. PRN	[25, 27]	A1,I2	
$Value_1$	[28, 41]	A14	
$Value_2$	[42, 55]	A14	
$Value_3$	[56, 69]	A14	

This record is a template for a whole family of records, distinguished by the Correction Type field.

Correction types 0001 through to 0063 are assigned to the current RTCM SC-104 Version 2, and all other types are reserved for future use by UKOOA (allowing for future support of other or modified standards).

For those correction messages which contain more than 3 values of interest, the Correction sequence number is intended to be used as a record continuation mechanism. Thus, should RTCM type 17 records (ephemeris) records be implemented, the first three fields would be recorded in type 17 / sequence 0, fields 4 through 6 of the ephemeris in type 17 / sequence 1, *etc.*

The fields common to all records are :

The time of applicability is the GPS time (not receiver time) at which the corrections held in the record are valid.

DCS status / health is the RTCM 8-value status code for Station Health which reflects whether the station is working at all, and, if so, the approximate "staleness" of the data.

The IOD figure is an 8-bit number (*i.e.* in the range 0 to 255) used to identify the ephemerides being used to compute the corrections (it is tied to the IODE of the ephemeris in use).

If this figure is not known or not meaningful to the correction type being transmitted (*e.g.* in a system which is providing $\Delta\phi$, $\Delta\lambda$), then it should be recorded outside of the 0-255 range.

Satellites are identified by S.V. codes. The "System type code" is to allow future expansion beyond GPS alone. This single character field should currently be blank or "G".

Variable fields :

The meaning of Value_i is dependent upon the Correction Type and Correction Sequence :

In addition, the fields are given as A14, rather than N14 - this is to allow both the transmission of textual information and splitting of the 14 character field into two or more sub-fields where applicable.

Example messages and sub field formats immediate implementation are shown below

E65##0001 DGPS correction, Type 1 range & range rate

is the Differential Correction Source (DCS) Identifier.
No sequence number is required (blank or 0).

Value_1 Pseudo-range correction	[28, 41]	N14	metres
Value_2 Range-rate correction	[42, 55]	N14	metres/second
Value_3 S.D. of correction	[56, 69]	N14	metres

This record is analogous to the RTCM Type 1 correction. Where the S.D. of the correction is given as a range of values (as in an RTCM UDRE), the top of the range should be recorded.

E65##0002 DGPS correction, Type 2, interim delta corrections

is the Differential Correction Source (DCS) Identifier.
No sequence number is required (blank or 0).

Value_1 Delta pseudo-range correction	[28, 41]	N14	metres
Value_2 Delta range-rate correction	[42, 55]	N14	metres/second
Value_3 S.D. of correction	[56, 69]	N14	metres

This record is analogous to the RTCM Type 2 correction.

This correction is sent out when a DCS has correction information calculated using an ephemeris which may not yet be available to the mobile, and as such it is not envisaged that it will be necessary to actually record these corrections, as they are essentially real-time "stop-gaps", which will not be necessary in post-processing. It is included for completeness.

E65##0004 <u>**DGPS correction, Type 4**</u>

is the Differential Correction Source (DCS) Identifier.
No sequence number is required (blank or 0).

$Value_1$			
Pseudo-range correction	[28, 41]	N14	metres
$Value_2$			
Complete instantaneous phase	[42, 55]	N14	cycles
$Value_3$			
Cumulative loss of lock count	[56, 69]	N14	

This record is analogous to the RTCM type 4 message.

E65##0016 <u>**DGPS correction, Type 16**</u>

is the Differential Correction Source (DCS) Identifier.
Sequence number is required: if full message will not fit in single type 16 record, first part goes into sequence 0 and second part into sequence 1.

Free text	[28, 72]	A45

This record is analogous to the RTCM type 16 message and may be used for providing information about the reference stations used in network solutions.

7.6 USER DEFINED EVENT DATA

E7010 User Defined Observation Set Data

Observation set reference number	[6, 8]	I3
Data field number	[9,10]	I2
Quality indicator	[11,14]	N4
Observation	[15, ..]	Nx

NOTE:
Observation data field width as specified in the H7010 record, hence no column number can be specified here.

The last three fields (triplet) in this record may be repeated until the record is full. However, partially filled triplets are not permitted.

8. INTER-EVENT DATA RECORDS (explicit time tag)

8.1 INTER-EVENT VESSEL RELATED DATA

T14@0 **Inter-event Echo Sounder Data**

@ = 1..9, Vessel reference number

Echo sounder ref. number	[6, 6]	I1	
Echo sounder reading	[7,12]	F6.1	metres
Time of observation	[13,19]	I2,I2,I3	HH,MM,SSs

May be repeated for four more echo sounders mounted on the same vessel at [21,34], [36,49], [51,64] and [66,79].

Record may be repeated.

T16@0 **Inter-event USBL Acoustic Data**

@ = 1..9, Vessel reference number

USBL system ref. number	[6, 6]	I1	
To Node number	[7,10]	I4	
X range to node	[11,17]	N7	metres
Y range to node	[18,24]	N7	metres
Z range to node	[25,31]	N7	metres
Quality indicator	[32,35]	N4	
Time of observation	[36,42]	I2,I2,I3	HH,MM,SSs

May be repeated for one more USBL system mounted on the same vessel at [44,80].

Record may be repeated.

T17@0 **Inter-event Pitch, Roll and Heave Sensor Data**

@ = 1..9, Vessel reference number

Sensor reference number	[6, 6]	I1	
Pitch angle	[7,16]	N10	
Roll angle	[17,26]	N10	
Heave	[27,36]	N10	
Quality indicator pitch	[37,40]	N4	
Quality indicator roll	[41,44]	N4	
Quality indicator heave	[45,48]	N4	
Time of observation	[49,55]	I2,I2,I3	HH,MM,SSs

8.2 INTER-EVENT NETWORK DATA

T52## Inter-event Network Data

= Observation type

Observation Identifier	[6, 9]	I4	
Observation	[10,19]	N10	
Quality indicator	[20,23]	N4	
Time of observation	[24,30]	I2,I2,I3	HH,MM,SSs

May be repeated at [31,55] and at [56,80] for two more observations of the same observation type.

T54## Inter-event Network Observation Parameters

= Observation type

Observation Identifier	[6, 9]	I4	
Variable (C-O)	[10,17]	N8	
C/O or propagation speed	[18,29]	N12	
Flag for C/O or speed	[30,30]	I1	0 = C/O (=scale factor) 1 = propagation speed
Time of observation	[31,37]	I2,I2,I3	HH,MM,SSs

May be repeated for one more set of observation parameters at [38,69] relating to the same observation type.

Record may be repeated.

NOTE:

a) This record is optional and should only be inserted for points in time at which one or all of the above parameters change. The new parameters shall be valid from the time recorded in this record until the time recorded in the next T54## or E54## record inserted.

b) Variable (C-O) replaces Variable (C-O) in record H54##.

c) Scale (C/O) replaces Scale Factor in record H54##.

d) Propagation speed, if supplied, replaces propagation speed in record H54##; the scale factor in record H54## is then still valid.

T55## Inter-event network GPS Observations

= Observation type

Observation ID	[6, 9]	I4	
Receiver time of receipt	[10,23]	I2,I2, F10.7	HH,MM, SS.sssssss
S.V. PRN	[24,26]	A1,I2	System type code, 1 to 32
Observation	[27,40]	N14	metres, phase cycles or Hertz
Quality indicator	[41,44]	N4	
Satellite health	[45,46]	I2	0 to 63
Lost Lock Indicator	[47,47]	I1	0 or 1
S.V. PRN	[48,49]	I2	1 to 32
Observation	[50,63]	N14	metres, phase cycles or Hertz
Quality indicator	[64,67]	N4	
Satellite health	[68,69]	I2	0 to 63
Lost Lock Indicator	[70,70]	I1	0 to 7
System Time of Receipt	[71,77]	I2,I2,I3	HH,MM, SSs

This record is identical to the E55## record, except for the explicit addition of the recording system's time of receipt.

*Note that this record forms part of the set of records needed to record raw GPS and DGPS observations, and is **not** required for the recording of satellite derived positions only.*

T56## Network GPS Observations (continuation record)

= Observation type

Observation ID	[6, 9]	I4	
S.V. PRN	[10,11]	I2	1 to 32
Observation	[12,25]	N14	metres, phase cycles or Hertz
Quality indicator	[26,29]	N4	
Satellite health	[30,31]	I2	0 to 63
Lost Lock Indicator	[32,32]	I1	0 or 1
S.V. PRN	[33,34]	I2	1 to 32
Observation	[35,48]	N14	metres, phase cycles or Hertz
Quality indicator	[49,52]	N4	
Satellite health	[53,54]	I2	0 to 63
Lost Lock Indicator	[55,55]	I1	0 or 1
S.V. PRN	[56,57]	I2	1 to 32
Observation	[58,71]	N14	metres, phase cycles or Hertz
Quality indicator	[72,75]	N4	
Satellite health	[76,77]	I2	0 to 63
Lost Lock Indicator	[78,78]	I1	0 or 1

This record is identical to the E56## record, except that the preceding T55## recording system's time of receipt should be taken as the time stamp for this record.

*Note that this record forms part of the set of records needed to record raw GPS and DGPS observations, and is **not** required for the recording of satellite derived positions only.*

8.3 INTER-EVENT SATELLITE DATA

T620# Inter-event GPS or DGPS Data

= 1, GPS
= 2, DGPS

"At" Node identifier	[6, 9]	I4	
Receiver reference number	[10,10]	I1	
Latitude	[11,22]	I3,I2,F6.3,A1	dddmmss.sss N/S
Longitude	[23,34]	I3,I2,F6.3,A1	dddmmss.sss E/W
Height	[35,40]	F6.1	metres
Height datum	[41,41]	I1	0 = height above ellipsoid 1 = height above geoid (~MSL)
Satellites used	[42,61]	10*I2	(GPS SV numbers)
Reference stations used	[62,70]	9*I1	
Position calculation mode	[71,72]	I2	see below
Time of Observation	[73,79]	I2,I2,I3	HH,MM,SSs

NOTE:
If GPS is used in autonomous mode the field "Reference stations used" should be left blank.

The time recorded should be in the same time system as other time tagged observations.

The identifiers used to indicate the satellites used in the position fix must the official GPS SV numbers.

The "reference stations used" field refers to record H610#. Only those reference station identifiers should be recorded here of which the differential corrections have been used in the calculation of the position recorded in this record.

Position calculation mode codes:

1 = 3D solution; 4+ SVs
2 = 3D solution; 3+ SVs; height fixed
3 = 3D solution; 3+ SVs; height aided
4 = 3D solution; 3+ SVs; clock aided
5 = 3D solution; 2+ SVs; height aided and clock aided
6 = 3D solution; 2+ SVs; height fixed and clock aided
7 = 2D solution; 3+ SVs
8 = 2D solution; 2+ SVs; height fixed
9 = 2D solution; 2+ SVs; height aided
10 = 2D solution; 2+ SVs; clock aided
11 = 2D solution; 1+ SVs; height aided and clock aided
12 = 2D solution; 1+ SVs; height fixed and clock aided

*Note that this record forms part of the set of records needed to record satellite derived positions only, and is **not** required for the recording of raw GPS and DGPS only.*

T621# Inter-event GPS or DGPS Data (continued)

\# = 1, GPS
\# = 2, DGPS

"At" Node identifier	[6, 9]	I4		
Receiver reference number	[10,10]	I1		
Standard deviations of:				
- Latitude:	[11,15]	N5	metres	
- Longitude:	[16,20]	N5	metres	
- Height:	[21,25]	N5	metres	
DOP type	[26,26]	I1	0	= GDOP
			1	= PDOP
			2	= HDOP
			3	= TDOP
			4	= VDOP
			5..9	= user defined on comment cards
DOP figure	[27,30]	N4	unitless	
Time of Observation	[74,80]	I2,I2,I3	HH,MM,SSs	

The "DOP type" and "DOP figure" fields may be repeated for other DOPs or quality indicators in columns [31,35] … [51,55] as required.

<u>NOTE</u>:
The standard deviations of latitude, longitude and height should be estimates of the quality of the fix, as produced by the onboard software.

The standard deviation of the height should be zero in the case where height is not solved for in the position calculation, such as in 'height fixed' mode.

*Note that this record forms part of the set of records needed to record satellite derived positions only, and is **not** required for the recording of raw GPS and DGPS only.*

T6303 Inter-event TRANSIT Satellite Data

"At" Node identifier	[6, 9]	I4	
Latitude	[10,21]	I3,I2,F6.3,A1	dddmmss.sss N/S
Longitude	[22,33]	I3,I2,F6.3,A1	dddmmss.sss E/W
Position includes dead reckoning?	[34,34]	I1	0 = no 1 = yes
Standard deviations of last accepted satellite fix:			
- Latitude	[35,39]	N5	metres
- Longitude	[40,44]	N5	metres
Time of Observation	[45,51]	I2,I2,I3	HH,MM,SSs

Record may be repeated.

NOTE:
The position supplied should refer to the satellite receiver antenna electrical centre.

If a dead reckoning system involving TRANSIT is being used, then the estimated current position should be recorded and the "dead reckoning flag" should be set. The Time of Observation then refers to this dead reckoned position, not the bare satellite fix.

No attempt is made to record raw data for the TRANSIT system and the standard deviations of the co-ordinates are recorded as an estimate of the quality of the fix, as supplied by the (onboard) processing software.

T6310 Updated GPS ephemerides & clock

S.V.	[6, 8]	A1,I2	System type code, 1-32
Transmission time of message	[9,26]	E18.12	GPS week seconds
Time of receipt of data	[27,26]	I2,I2,I3	Recording system time HH, MM, SSs

This record is analogous to H6310, but represents an update to a satellite's ephemeris during a line. This may be caused by the satellite becoming visible for the first time, or by an updated ephemeris message.

All records T6310 to T6317 must be recorded sequentially.

T6311 Updated GPS clock parameters
T6312 Updated GPS ephemerides, 1
T6313 Updated GPS ephemerides, 2
T6314 Updated GPS ephemerides, 3
T6315 Updated GPS ephemerides, 4
T6316 Updated GPS ephemerides, 5
T6317 Updated GPS ephemerides, 6

All records T6311 to T6317 have exactly the same format as H6311 to H6317.

*Note that these records forms part of the set of records needed to record raw GPS and DGPS observations, and are **not** required for the recording of satellite derived positions only.*

The following records contain updates to the Ionospheric and UTC parameters. All three records must appear together in sequence.

T6320 Updated GPS UTC parameters

term of UTC polynomial A_0	[6,23]	E18.12	seconds
term of UTC polynomial A_1	[24,41]	E18.12	seconds / second
reference time of time, t_{ot}	[42,50]	I9	seconds
UTC week reference no. WN_t	[51,59]	I9	

Leap seconds delta time Δt_{LSF}	[60,65]	I6	seconds
Time of receipt of data	[66,72]	I2,I2,I3	Recording system time HH, MM, SSs

These parameters are available from the GPS message sub-frame 4, page 18.

*Note that this record forms part of the set of records needed to record raw GPS and DGPS observations, and is **not** required for the recording of satellite derived positions only.*

T6321 Updated GPS ionospheric model parameters, 1
T6322 Updated GPS ionospheric model parameters, 2

All records T6321 to T6322 have exactly the same format as H6321 to H6322.

*Note that these record forms part of the set of records needed to record raw GPS and DGPS observations, and are **not** required for the recording of satellite derived positions only.*

T6330 Updated Meteorological data

Surface air pressure	[6,12]	F7.1	millibars
Dry air temperature	[13,19]	F7.1	degrees Celsius
Wet air temperature	[20,26]	F7.1	degrees Celsius
Relative humidity	[27,33]	F7.1	percent
Time of receipt of data	[34,40]	I2,I2,I3	Recording system time HH, MM, SSs

Either, but not both, of the two fields "Wet air temperature" and "Relative humidity" may be left blank.

*Note that this record forms part of the set of records needed to record raw GPS and DGPS observations, and is **not** required for the recording of satellite derived positions only.*

T640# Inter-event Satellite Data (other systems)

= 4..9, Satellite system reference number

"At" Node identifier	[6, 9]	I4	
Latitude	[10,21]	I3,I2,F6.3,A1	dddmmss.sss N/S
Longitude	[22,33]	I3,I2,F6.3,A1	dddmmss.sss E/W
Height	[34,39]	F6.1	metres
Height datum	[40,40]	I1	0 = height above ellipsoid 1 = height above geoid (~MSL)
Standard deviations of:			
- Latitude:	[41,45]	N5	metres
- Longitude:	[46,50]	N5	metres
- Height:	[51,55]	N5	metres
Time of Observation	[56,62]	I2,I2,I3	HH,MM,SSs

NOTE:
The standard deviations of latitude, longitude and height should be estimates of the quality of the fix, as produced by the onboard software.

*Note that this record forms part of the set of records needed to record satellite derived positions only, and is **not** required for the recording of raw GPS and DGPS only.*

T65## Inter-event differential correction data

is the Differential Correction Source (DCS) Identifier.

Correction type	[6, 9]	I4	
Correction sequence	[10, 11]	I2	
GPS Time of Applicability	[12, 19]	I2,I2,	HH, MM,

		F4.1	SS.s
DCS status/health	[20, 21]	I2	0 to 7
IOD (Issue of data) key	[22, 24]	I3	0-255
S.V. PRN	[25, 27]	A1,I2	
$Value_1$	[28, 41]	A14	
$Value_2$	[42, 55]	A14	
$Value_3$	[56, 69]	A14	
System Time of Receipt	[70, 76]	I2,I2,I3	HH, MM, SSs

This record is identical to the E65## records, with the addition of the recording system's time of receipt.

Note that this record forms part of the set of records needed to record raw GPS and DGPS observations, and is ***not*** *required for the recording of satellite derived positions only.*

T67@0 Updated height aiding values

@ = 1..9 vessel number
@ = 0 fixed or relay station

Node identifier	[6, 9]	I4	
Positioning system identifier	[10,12]	I3	
Ellipsoid height of antenna	[13,23]	N11	metres
Time of receipt of data	[34,40]	I2,I2,I3	Recording system time HH, MM, SSs

This record is intended to allow the recording system to log any estimates of GPS antenna height used in assisting the GPS computations. The record is entirely analogous to the H56@0 instrument correction, and should be interpreted in the same way. Note that since such a value is effectively on a *per* antenna basis, the combination of Node ID and Positioning system ID should be used to uniquely identify the antenna, and to provide a link between the Header record and its updates.

Note that this record forms part of the set of records needed to record raw GPS and DGPS observations, and is ***not*** *required for the recording of satellite derived positions only.*

8.4 INTER-EVENT USER DEFINED DATA

T7010 Inter-event User Defined Observation Set Data

Observation set reference number	[6, 8]	I3	
Data field number	[9,10]	I2	
Quality indicator	[11,14]	N4	
Time of observation	[15,21]	I2,I2,I3	HH,MM,SSs
Observation	[22, ..]	Nx	

NOTE:
Observation data field width as specified in the H7010 record, hence no column width can be specified here.

The last four fields (quadruplet) in this record may be repeated until the record is full. However, partially filled quadruplets are not permitted.

APPENDIX A. Discussion of the raw GPS / DGPS extensions

A.1 - GPS data

GPS observations are modelled on the existing network observations records E/T52##, but with the addition of time and S.V. PRN[2], and with an addition to the quality indicators to specifically reflect S.V. health. The relationship between these new records and the H52## records will be exactly the same as between E/T52## and H52##.

Observation Type Codes

In the H52## records, new Observation Type Codes (OTC) are needed, beyond the 12 current types. To keep things tidy, and leave space for others, a new range of codes is used.

OTC	Observation type
20	GPS pseudo range[3]
21	GPS ambiguous code-phase
22	GPS carrier phase
23	GPS Doppler frequency

It is proposed that so long as the observable type itself does not change (this is in the spirit of generalisation already present in the OTCs), there is no need to extend the list of new observables to include P-code and C/A-code, and L1 and L2 versions of the observables.

Note that it is possible to declare multiple observables using the same OTC (although their observation IDs must be different), *e.g.*

```
H52201234C/A code .............
H52201235P code   .............
```

Indeed, it is not only possible, it is essential in order to distinguish L1 and L2 versions of the same observable, C/A-code from P-code and, indeed, partial processing by the receiver (*e.g.* smoothing of pseudo ranges) from raw data.

Observation Identifiers

The definitions of raw GPS observations do not differ in theory from other forms of observations (although it is not necessary to record a "To" node in the H52, as this is covered by the S.V. identifier in the E/T record), however, in practice, a single GPS receiver is capable of producing several kinds of observation. As such, the following describes when GPS observations require different observations IDS :

- Observations of different Observation Types must have different Observation IDs;
- Observations of the same Observation Type, but from different receivers must have different Observation IDs
- Observations of the same Observation Type, but on different codes (C/A or P) must have different Observation IDs;
- Observations of the same Observation Type, but on different frequencies (L1 or L2) must have different Observation IDs;
- Observations of the same Observation Type, but with different stochastic properties (*e.g.* raw *versus* phase-smoothed) must have different Observation IDs;

Observations of the same type, at the same receiver, on the same satellite, may have the same Observation ID if the conditions above are met.

The raw data records

E55## **Network GPS Observations**
= Observation type

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[2]Note that the inclusion of the S.V. in the measurement record, rather than in the H52xx means that the data records are larger (2 bytes) than they could be. Whilst possible to avoid this and have an H52xx for each S.V. and for each receiver, in practice there would always need to be 24 H52xx's for each receiver, as it is unrealistic to expect logging software to predict the satellites to be used.

[3]Note that OTC 04 is also defined as pseudo-range. The distinction is that OTC 20 pseudo-ranges need not specify the "To" node in the H52## record, relying instead on the specification of S.V. in the E/T55## record. In addition, OTC 20 pseudo-ranges, recorded in E/T55## or E/T56## records, have a specifically associated accurate time of measurement, which is lacking from the OTC 04.

Observation ID	[6, 9]	I4	
Receiver time of receipt	[10,23]	I2,I2, F10.7	HH,MM, SS.sssssss
S.V. PRN	[24,26]	A1,I2	System type code, 1 to 32
Observation	[27,40]	N14	metres, phase cycles or Hertz
Quality indicator	[41,44]	N4	
Satellite health	[45,46]	I2	0 to 63
Lost Lock Indicator	[47,47]	I1	0 or 1
S.V. PRN	[48,49]	I2	1 to 32
Observation	[50,63]	N14	metres, phase cycles or Hertz
Quality indicator	[64,67]	N4	
Satellite health	[68,69]	I2	0 to 63
Lost Lock Indicator	[70,70]	I1	0 to 7

T55## Inter-event network GPS Observations

= Observation type

Observation ID	[6, 9]	I4	
Receiver time of receipt	[10,23]	I2,I2, F10.7	HH,MM, SS.sssssss
S.V. PRN	[24,26]	A1,I2	System type code, 1 to 32
Observation	[27,40]	N14	metres, phase cycles or Hertz
Quality indicator	[41,44]	N4	
Satellite health	[45,46]	I2	0 to 63
Lost Lock Indicator	[47,47]	I1	0 or 1
S.V. PRN	[48,49]	I2	1 to 32
Observation	[50,63]	N14	metres, phase cycles or Hertz
Quality indicator	[64,67]	N4	
Satellite health	[68,69]	I2	0 to 63
Lost Lock Indicator	[70,70]	I1	0 to 7
System Time of Receipt	[71,77]	I2,I2,I3	HH,MM, SSs

The Observation ID and Quality indicator have the same format and meaning as in the existing E/T52##'s. The S.V. PRN, observation units, range and precision are compatible with RINEX 2[4]. The time is to a precision compatible with RINEX 2, but presented in a format compatible with decoding routines designed for existing records. Satellite health is a value from 0 to 64 representing the current[5] 6-bit health number broadcast by the satellite. Lost lock indicator is as per RINEX 1[6].

The "System type code" is to allow future expansion beyond GPS alone[7]. The single character field should currently be blank or "G", as in RINEX 2. Note that for reasons of space, it is recorded only once per set.

Note that two times of receipt occur in the T record :

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[4]RINEX asks for F14.3 for its observations.

[5]This is believed to be in the spirit of P2/91 in so far as it records the validity of the observation, even though the update rate of this quality figure is different from the update rate of the observation itself.

[6]RINEX 2 uses this field to record not only the Lost Lock but also whether the observation was made under antispoofing. Although it would be possible to adopt the RINEX 2 convention, it is not seen as necessay for our purposes.

[7]Note that although we have taken account of the possible extensions of this scheme to include GLONASS, Transit, *etc.*, the format does not yet explicitly support them.

- The more accurate first one (which also appears in the E record) is the receiver's time (uncorrected for receiver clock offset), necessary for computation of the satellite's time of transmission.

- The second time is the recording system's time, necessary to reference the GPS observations to other sensors' time-frames (*e.g.* seismic events, radio-navigation, streamer acoustics). In the E record this is not needed, as it is inherited from the E1000 record.

Rather than repeating the redundant time information in subsequent records, a continuation record (which is the same for both E and T forms) E/T56## is allowed which uses the same times of receipt (both receiver and system) as the preceding E/T55## or E/T56##:

E/T56## Network GPS Observations (continuation record)

= Observation type

Observation ID	[6, 9]	I4	
S.V. PRN	[10,11]	I2	1 to 32
Observation	[12,25]	N14	metres, phase cycles or Hertz
Quality indicator	[26,29]	N4	
Satellite health	[30,31]	I2	0 to 63
Lost Lock Indicator	[32,32]	I1	0 or 1
S.V. PRN	[33,34]	I2	1 to 32
Observation	[35,48]	N14	metres, phase cycles or Hertz
Quality indicator	[49,52]	N4	
Satellite health	[53,54]	I2	0 to 63
Lost Lock Indicator	[55,55]	I1	0 or 1
S.V. PRN	[56,57]	I2	1 to 32
Observation	[58,71]	N14	metres, phase cycles or Hertz
Quality indicator	[72,75]	N4	
Satellite health	[76,77]	I2	0 to 63
Lost Lock Indicator	[78,78]	I1	0 or 1

Four important corollaries arise from this scheme :

1) the processing software is required to keep track of the date from E1000 records, in order to compute satellite positions from ephemerides.
2) the times of transmission will be available only if pseudo-range information is logged - to log phase alone would be insufficient, since there would then be no way of computing satellite position. As such, we must insist that pseudo-range information is always recorded for any S.V. which also logs phase or Doppler.
3) Multiple observations can be packed into the same record - but only those with the same Observation ID and Receiver Time of Receipt[8] - this means that C/A code pseudo-ranges may be packed together, or L1 phases, but not pseudo range together with phase, nor C/A and P-code, nor L1 and L2 phases, nor observations from different receivers.
4) In contrast to the above, "E/T55, E/T56" sequences of records and continuation records may contain different observation IDs, however, the requirement that they share the same Receiver Time of Receipt implies that they must share a common receiver. This in turn implies that there must be at least one E/T55 record for each receiver being logged[9].

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[8]Strictly, they must also have the same System Time of Receipt.

[9]Actually, if the receiver is not multi-channel, or has less channels than S.V.s being observed, then an E/T55 will be required for each channel or group of channels.

A.2 - GPS parameters

An innovation, "Updateable header records" or H/T records is introduced to support those values needed as parameters for the GPS / DGPS computations, but also capable of changing over the course of a survey line. These records are logged originally as header records, but may be updated as identical format T records during the line should an update become available.
The parameters are :

- Clock models;
- Ephemerides;
- Ionospheric model parameters;
- UTC parameters;
- Meteorological data;
- Height aiding ellipsoidal values

In addition, the recording system may choose whether or not to update them, and a record specifying whether or not these parameters are logged is required :

H6300 GPS parameter recording strategy

Meteorological records	[7, 7]	A1
Ionospheric model records	[8, 8]	A1
Clock model & ephemerides	[9, 9]	A1
Height aiding	[10,10]	A1

Each of these will take one of three values :

0 = Not logged at all, even in header
H = Recorded in header, but not updated in T records
T = Recorded in header and updated in T records.

however, the following restrictions will apply :

- Clock & ephemerides must be T (logged and updated). This is necessary since the ephemerides of the constellation in view at start of line (or header writing time) will not necessarily be sufficient to cover all constellations used during the line.

- The ionospheric records must be either H (logged in header) or T (logged and updated) for very long lines.

Particularly for the ephemerides, the parameters are very sensitive to rounding error, thus we must be careful about the accuracy to which they are recorded. RINEX has adopted D19.12. Although scientific notation has no precedent in P2, it is the only sensible way to represent numbers of the magnitudes[10] required without using *ad hoc* scales (*e.g.* radians / nanosecond). In fact, these fields have been implemented as D18.12, since the extra character in RINEX is used to separate the fields with spaces.

Note that in each of the groups, only the first of a set of T records has a time stamp, the subsequent ones inheriting the first. This means that the sequence of the records must be strictly adhered to.

H/T631x GPS clock & ephemerides

Contents are exactly as per sub frames 1, 2 and 3, with the addition of time of receipt and S.V.

Note that time of receipt is recording system time, not GPS time.

H6310 GPS ephemerides & clock

S.V.	[6, 8]	A1,I2	System type code, 1-32
Transmission time of message	[9,26]	E18.12	GPS week seconds

T6310 Updated GPS ephemerides & clock

[10] Several of the figures have SI multipliers up to 10^{-12} - to achieve this with a precision equivalent to RINEX (*i.e.* 12 digits) would require F26.23

S.V.	[6, 8]	A1,I2	System type code, 1-32
Transmission time of message	[9,26]	E18.12	GPS week seconds
Time of receipt of data	[27,26]	I2,I2,I3	Recording system time HH, MM, SSs

H/T6311 GPS clock parameters

S.V.	[6, 8]	A1,I2	System type code, 1-32
S.V. clock drift rate a_{f2}	[9,26]	E18.12	seconds/second²
S.V. clock drift a_{f1}	[27,44]	E18.12	seconds / second
S.V. clock bias a_{f0}	[45,62]	E18.12	seconds
Time of Clock t_{oc}	[63,80]	E18.12	GPS week seconds

H/T6312 GPS ephemerides, 1

S.V.	[6, 8]	A1,I2	System type code, 1-32
Issue of Data, Ephemerides IODE	[9,26]	E18.12	
C_{rs} [27,44]	E18.12	metres	
Δn	[45,62]	E18.12	radians / second
M_0 [63,80]	E18.12	radians	

C_{rs} amplitude of the sine harmonic correction term to the orbit radius.
Δn mean motion difference from computed value.
M_0 mean anomaly at reference time.

H/T6313 GPS ephemerides, 2

S.V.	[6, 8]	A1,I2	System type code, 1-32
C_{uc}	[9,26]	E18.12	radians
eccentricity e	[27,44]	E18.12	
C_{us}	[45,62]	E18.12	radians
$\sqrt{A}$	[63,80]	E18.12	$\sqrt{}$(metres)

C_{uc} amplitude of the cosine harmonic correction term to the argument of latitude.
C_{us} amplitude of the sine harmonic correction term to the argument of latitude.
$\sqrt{A}$ square root of the semi-major axis.

H/T6314 GPS ephemerides, 3

S.V.	[6, 8]	A1,I2	System type code, 1-32
Time of ephemeris, toe	[9,26]	E18.12	GPS week seconds
C_{ic} [27,44]	E18.12	radians	
Ω_0 [45,62]	E18.12	radians	
C_{is} [63,80]	E18.12	radians	

C_{Ic} amplitude of the cosine harmonic correction term to the angle of inclination.
Ω_0 right ascension at reference time.
C_{IS} amplitude of the sine harmonic correction term to the angle of inclination.

H/T6315 GPS ephemerides, 4

S.V.	[6, 8]	A1,I2	System type code, 1-32
i_0	[9,26]	E18.12	radians
C_{rc} [27,44]	E18.12	metres	
argument of perigee ω	[45,62]	E18.12	radians

rate of right ascension $\dot{\Omega}$	[63,80]	E18.12	radians / second

i_0 inclination angle at reference time.
C_{RC} amplitude of the cosine harmonic correction term to the orbit radius.

H/T6316 GPS ephemerides, 5

S.V.	[6, 8]	A1,I2	System type code, 1-32
Rate of inclination angle $\dot{i}$	[9,26]	E18.12	radians / second
Codes on L_2	[27,44]	E18.12	
GPS week number	[45,62]	E18.12	
L_2 P data flag	[63,80]	E18.12	

H/T6317 GPS ephemerides, 6

S.V.	[6, 8]	A1,I2	System type code, 1-32
S.V. accuracy	[9,26]	E18.12	
S.V. health	[27,44]	E18.12	
T_{GD}	[45,62]	E18.12	
Issue of data clock, IODC	[63,80]	E18.12	

i_0 inclination angle at reference time.
C_{RC} amplitude of the cosine harmonic correction term to the orbit radius.

H/T632x GPS ionospheric model parameters

Contents are exactly as per subframe 4, page 18, with the addition of time of receipt, in the same format as the H631x.

Note that time of receipt is recording system time, not GPS time.

H6320 GPS UTC parameters

term of UTC polynomial A_0	[6,23]	E18.12	seconds
term of UTC polynomial A_1	[24,41]	E18.12	seconds / second
reference time of time, t_{ot}	[42,50]	I9	seconds
UTC week reference no. WN_t	[51,59]	I9	
Leap seconds delta time Δt_{LSF}	[60,65]	I6	seconds

T6320 Updated GPS UTC parameters

term of UTC polynomial A_0	[6,23]	E18.12	seconds
term of UTC polynomial A_1	[24,41]	E18.12	seconds / second
reference time of time, t_{ot}	[42,50]	I9	seconds
UTC week reference no. WN_t	[51,59]	I9	
Leap seconds delta time Δt_{LSF}	[60,65]	I6	seconds
Time of receipt of data	[66,72]	I2,I2,I3	Recording system time HH, MM, SSs

H/T6321 GPS ionospheric model parameters, 1

α_0	[6,17]	E12.4	seconds
α_1	[18,29]	E12.4	seconds / semicircle
α_2	[30,41]	E12.4	seconds / semicircle^2
α_3	[42,53]	E12.4	seconds / semicircle^3

H/T6322 GPS ionospheric model parameters, 2

β_0	[6,17]	E12.4	seconds
β_1	[18,29]	E12.4	seconds / semicircle
β_2	[30,41]	E12.4	seconds / semicircle²
β_3	[42,53]	E12.4	seconds / semicircle³

H6330 Meteorological data

Surface air pressure	[6,12]	F7.1	millibars
Dry air temperature	[13,19]	F7.1	degrees Celsius
Wet air temperature	[20,26]	F7.1	degrees Celsius
Relative humidity	[27,33]	F7.1	percent

T6330 Updated Meteorological data

Surface air pressure	[6,12]	F7.1	millibars
Dry air temperature	[13,19]	F7.1	degrees Celsius
Wet air temperature	[20,26]	F7.1	degrees Celsius
Relative humidity	[27,33]	F7.1	percent
Time of receipt of data	[34,40]	I2,I2,I3	Recording system time HH, MM, SSs

Either, but not both, of the two fields "Wet air temperature" and "Relative humidity" may be left blank.

H/T67@0 Estimates of ellipsoidal height for height aiding

Should height aiding be applied in the field, the values used should be recorded, both for archival and processing purposes. These records provide a mechanism for doing so.

Note that time of receipt is recording system time, not GPS time.

H67@0 Height aiding values

@ = 1..9 vessel number
@ = 0 fixed or relay station

Node identifier	[6, 9]	I4	
Positioning system identifier	[10,12]	I3	
Ellipsoid height of antenna	[13,23]	N11	metres
Description of source of height	[24,80]	A57	

T67@0 Updated height aiding values

@ = 1..9 vessel number
@ = 0 fixed or relay station

Node identifier	[6, 9]	I4	
Positioning system identifier	[10,12]	I3	
Ellipsoid height of antenna	[13,23]	N11	metres
Time of receipt of data	[34,40]	I2,I2,I3	Recording system time HH, MM, SSs

This record is intended to allow the recording system to log any estimates of GPS antenna height used in assisting the GPS computations. The record is entirely analogous to the H56@0 instrument correction, and should be interpreted in the same way. Note that since such a value is effectively on a *per* antenna basis, the combination of Node ID and Positioning system ID should be used to uniquely identify the antenna, and to provide a link between the Header record and its updates.

A.3 - DGPS data

These records are modelled on the RTCM. There is, and need be, no connection to the GPS records, other than the IOD/IODE ephemeris identification, which is implicit.

Note that the terminology "Differential Correction Source (DCS)" is used, rather than "reference Station" : whilst a DCS may be a Differential GPS reference station, it need not be : a single reference station is, theoretically, capable of providing more than one stream of corrections (by using different receivers, or the same receiver and parallel software), in which case it would be multiple DCSs, whilst it is also possible that signals from several stations are combined to provide a single correction stream, which would then constitute a single DCS.

E65## **Differential correction data**

is the Differential Correction Source (DCS) Identifier.

Correction type[11]	[6, 9]	I4	
Correction sequence	[10, 11]	I2	
GPS Time of Applicability	[12, 19]	I2,I2, F4.1	HH, MM, SS.s
DCS status/health	[20, 21]	I2	0 to 7
IOD (Issue of data) key	[22, 24]	I3	0-255
S.V. PRN	[25, 27]	A1,I2	
$Value_1$	[28, 41]	A14	
$Value_2$	[42, 55]	A14	
$Value_3$	[56, 69]	A14	

T65## **Inter-event differential correction data**

is the Differential Correction Source (DCS) Identifier.

Correction type	[6, 9]	I4	
Correction sequence	[10, 11]	I2	
GPS Time of Applicability	[12, 19]	I2,I2, F4.1	HH, MM, SS.s
DCS status/health	[20, 21]	I2	0 to 7
IOD (Issue of data) key	[22, 24]	I3	0-255
S.V. PRN	[25, 27]	A1,I2	
$Value_1$	[28, 41]	A14	
$Value_2$	[42, 55]	A14	
$Value_3$	[56, 69]	A14	
System Time of Receipt	[70, 76]	I2,I2,I3	HH, MM, SSs

These records are templates for a whole family of records, distinguished by the Correction Type field.

Correction types 0001 through to 0063 are assigned to the current RTCM SC-104 Version 2, and all other types are reserved for future use by UKOOA (allowing for future support of other or modified standards).

For those correction messages which contain more than 3 values of interest, the Correction sequence number is intended to be used as a record continuation mechanism. Thus, should RTCM type 17 records (ephemeris) records be implemented, the first three fields would be recorded in type 17 / sequence 0, fields 4 through 6 of the ephemeris in type 17 / sequence 1, *etc.*

The fields common to all records are :

The time of applicability is the GPS time (not receiver time) at which the corrections held in the record are valid.

DCS status / health is the RTCM 8-value status code for Station Health which reflects whether the station is working at all, and, if so, the approximate "staleness" of the data.

[11]The idea here is to allow an extendible set of corrections. We pay the price that we cannot get more than one S.V.'s correction in one record (which we could do if we went for a fixed Type 1 style of record), but it allows us significantly greater flexibility.

The IOD figure is an 8-bit number (*i.e.* in the range 0 to 255) used to identify the ephemerides being used to compute the corrections (it is tied to the IODE of the ephemeris in use).

If this figure is not known or not meaningful to the correction type being transmitted (*e.g.* in a system which is providing $\Delta\phi$, $\Delta\lambda$), then it should be recorded outside of the 0-255 range.

Satellites are identified by S.V. codes. The "System type code" is to allow future expansion beyond GPS alone. This single character field should currently be blank or "G".

Variable fields :

The meaning of $Value_i$ is dependent upon the Correction Type and Correction Sequence :

In addition, the fields are given as A14, rather than N14 - this is to allow both the transmission of textual information and splitting of the 14 character field into two or more sub-fields where applicable.

The actual messages and sub field formats immediate implementation are shown in below

E65##0001 DGPS correction, Type 1 range & range rate

is the Differential Correction Source (DCS) Identifier.
No sequence number is required (blank or 0).

$Value_1$ Pseudo-range correction	[28, 41]	N14	metres
$Value_2$ Range-rate correction	[42, 55]	N14	metres/second
$Value_3$ S.D. of correction[12]	[56, 69]	N14	metres

This record is analogous to the RTCM Type 1 correction. Where the S.D. of the correction is given as a range of values (as in an RTCM UDRE), the top of the range should be recorded.

E65##0002 DGPS correction, Type 2, interim delta corrections

is the Differential Correction Source (DCS) Identifier.
No sequence number is required (blank or 0).

$Value_1$ Delta pseudo-range correction	[28, 41]	N14	metres
$Value_2$ Delta range-rate correction	[42, 55]	N14	metres/second
$Value_3$ S.D. of correction	[56, 69]	N14	metres

This record is analogous to the RTCM Type 2 correction.

This correction is sent out when a DCS has correction information calculated using an ephemeris which may not yet be available to the mobile, and as such it is not envisaged that it will be necessary to actually record these corrections, as they are essentially real-time "stop-gaps", which will not be necessary in post-processing. It is included for completeness.

[12] S.D. of rate is not recorded, a) because RTCM doesn't allow for it and b) because in most cases it may be calculated from the S.D. of the correction.

E65##0004 **DGPS correction, Type 4**

is the Differential Correction Source (DCS) Identifier.
No sequence number is required (blank or 0).

$Value_1$			
Pseudo-range correction	[28, 41]	N14	metres
$Value_2$			
Complete instantaneous phase	[42, 55]	N14	cycles
$Value_3$			
Cumulative loss of lock count	[56, 69]	N14	

This record is analogous to the RTCM type 4 message.

To inform the processing system which correction types the recording system intends to log, a header is provided :

H6301 DGPS differential correction recording strategy

Correction Type	[7, 10]	I4
Correction type	[11, 14]	I4
Correction type	[15, 18]	I4
etc.		

These are declarative records, simply stating that correction records of the stated types will be logged.

The Correction Type field may be repeated as often as is suitable.

Finally, the declarative records needed to name the sources of differential corrections :

H65## Differential Correction Source Definition

is the Differential Correction Source Identifier

DCS short name	[7,14]	A8	free text
Datum & Spheroid number	[16,16]	I1	from H011x
Latitude of correction source	[17, 28]	I3,I2,F6.3,A1	dddmmss.sss N/S
Longitude of correction source	[29, 41]	I3,I2,F6.3 A1	dddmmss.sss E/W
Spheroidal height	[42, 48]	F7.2	metres
Geoid - spheroid separation	[49, 55]	F7.2	metres
Geoidal model	[56, 72]	A17	free text

NOTE:
The geoid-spheroid separation at the station and the geoidal model from which the separation was derived are only relevant if the co-ordinates of the reference station have been converted from a local datum to the satellite system datum. If they were determined by means of observations from that same satellite system, the spheroidal height would have been determined directly and no geoid-spheroid separation and geoidal model need be recorded in this record.

H66## Differential Correction Source Description

is the Differential Correction Source Identifier

DCS system operator	[7, 24]	A18	free text
DCS component name	[25, 43]	A18	free text
DCS component description	[44, 80]	A37	free text

It is intended that the component described here include, specifically, receiver types and processing software used, and that their descriptions include their model numbers, and version numbers of firmware and software.

This record may be repeated for the same DCS ID in contiguous records as often as is appropriate to complete the description of each of the DCS's components.