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

UKOOA DATA EXCHANGE FORMAT

P6/98

DEFINITION OF 3D SEISMIC BINNING GRIDS

Revision 3.0
May 2000

SUMMARY

The Guidelines For The Definition of 3D Seismic Binning Grids and the associated data exchange format – P6/98 - is recommended by UKOOA for general use in the Oil and Gas, Exploration and Production industry and set out what is generally regarded in the industry as good practice. 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.

These guidelines have been written by a working group established by the UKOOA Surveying and Positioning Committee, following discussions and feedback from a wide range of interested parties in the oil industry. Any comments and suggestions for improvement are welcome and should be addressed to:

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Revision	***Date***	***Modification***
Rev 1	Sep ‘94	- First Version Issued
Rev 2	Oct ‘99	- Re-formatted and updated - EPSG coordinate system description included H80 - H81 - Data coverage perimeter definition extended H20 - H35 - Coordinate system check point included H1401 - H1402
Rev 3	May ‘00	- Minor changes to section 5, defining parameters. - Minor changes to section 6, affine transformation definition.

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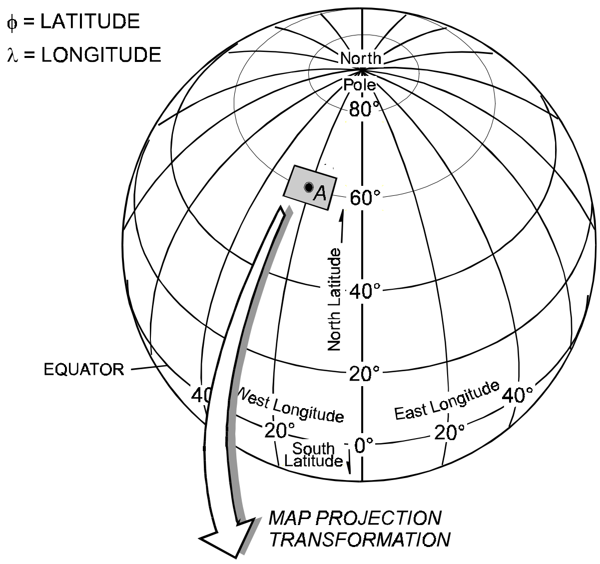
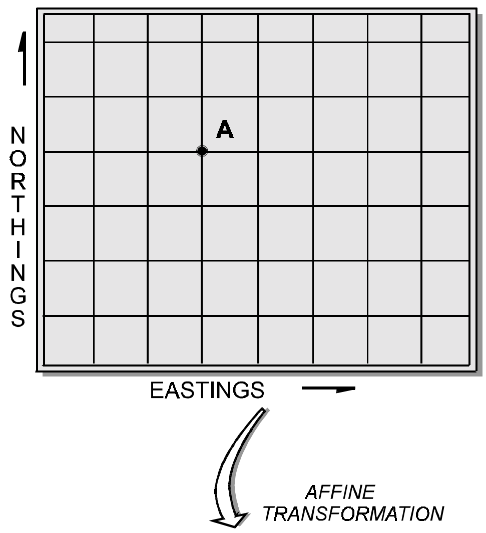
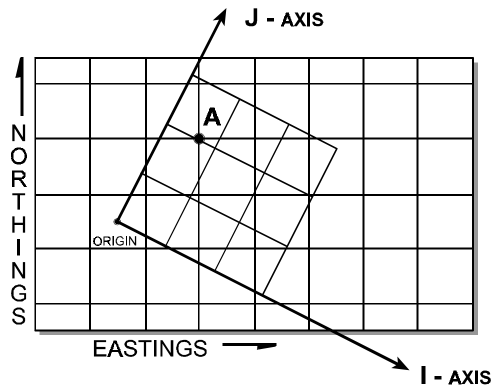
GEOGRAPHICAL COORDINATE SYSTEM (Latitude, Longitude, [Height])



PROJECTED COORDINATE SYSTEM ("Map Grid") (Northing, Easting)



LOCAL COORDINATE SYSTEM - SEISMIC BIN GRID



1. INTRODUCTION

3D seismic data is processed by the grouping of seismic traces. These groups are referenced to a point defined as a bin node and successive bin nodes are regularly spaced to form a matrix.

The location of each of these nodes can be referenced to its location in the real world by using a geodetic coordinate system. Alternatively the relative location of the node within the matrix can be defined by counting the nodes along two orthogonal axes.

A set of defining parameters establish the relationship between the relative matrix location and a chosen geodetic coordinate system.

These guidelines explain the difficulties inherent in the choice of coordinate reference systems, and supply a set of parameters which defines a 3D seismic binning system. The variety of options in current use for the definition of seismic binning will not be supplanted by these parameters but they will provide an exchange mechanism to allow users to uniquely and unambiguously transfer data. From the defined parameter set, users will be able to determine a subset of parameters which satisfy their present definitions.

1.1 Historical Overview

At the acquisition stage of a 3D land or marine seismic survey the survey area and the method of acquisition are defined. In conventional marine 3D seismic streamers are towed along a set of parallel lines with a fixed spacing and energy sources are activated at regular intervals. Conventional land seismic is similar, with geophone strings being laid out along a set of parallel lines with a regular spacing.

This gives rise to the method of associating the trace information with a regular bin, whose dimensions relate to the shot point interval in one direction, and the line spacing in the other. The bins are rectangular, and the geometrical centre of the bin is the point defining the location of the trace data.

The bin centres can be generated as a matrix. To relate the matrix cells to the real world the bin centres must be defined also in terms of cartesian map grid coordinates on a defined projected coordinate system.

For a regular binning grid it is more efficient for a computer, instead of holding the coordinates of each individual bin centre, to calculate them from a set of defining parameters.

Certain terminology associated with the bin axes has become standard. The term **inline** is associated with the direction of the streamer or geophone array and the **crossline** direction is orthogonal to the inline direction.

1.2 Recent Advances

Changes to acquisition and processing techniques have complicated matters and require a more rigorous definition to enable accurate and unambiguous relationships between the bin grid and the map grid coordinates.

1. Surveys have become larger. This strains the ability of any map projection to represent the survey area as undistorted within an acceptable tolerance over the area of the survey .

2. There is a requirement to merge surveys either directly or through reprocessing. This increases the extent of the survey area and poses problems for the bin dimension, as the bin sizes of merged surveys may be different.

3. The concept of inline and crossline has become blurred with modern techniques of shooting across spreads, circular marine acquisition and north-south binning independent of acquisition direction.

4. The concept of a rectangular bin is limiting, as there may be advantages to considering non-rectangular shapes for the bin.

5. As well as the bin centre, there is a need to be able to define other attributes such as the centre of gravity of the bin.

As a result of these changes, much of the 'standard' terminology can no longer accurately describe the 3D seismic binning grid. Moreover, it is apparent that terminology varies between companies, and even within the same company between acquisition, processing and interpretation.

1.3 Relationship to Other Formats

The technical provisions and contents of this P6/98 format are identical to those made for describing bin grid and area of coverage in the SEG-Y revision 1 format file header. The record definitions differ, but only to the extent required to ensure consistency in style within the respective formats.

2. COORDINATE REFERENCE SYSTEMS

The coordinates used for binning grids are the map grid coordinates which provide a geodetic reference frame and the bin grid coordinates which provide a relative reference frame. These reference frames are related by an affine transformation.

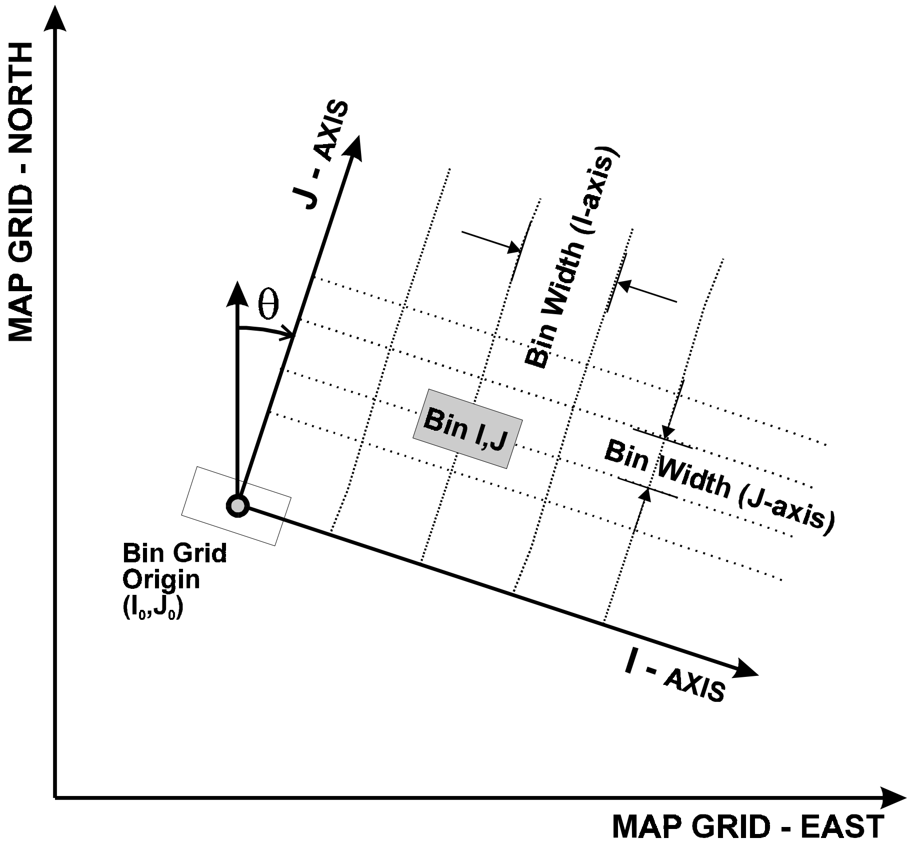


Figure 2: The *Map Grid and Bin Grid reference frames*

The map grid coordinates are referenced to a geodetic coordinate framework. This requires the definition of the geodetic datum, the reference ellipsoid and the map projection.

The ellipsoid is the regular shape chosen to approximate the irregular earth, defining an angular coordinate system - latitude and longitude. The ellipsoid is defined by two parameters, commonly the semi-major axis (a) and the inverse flattening (1/f).

The geodetic datum defines the location of the chosen ellipsoid in space, by defining the relationship between the geoid and the ellipsoid at one or more given points. The datum transformation between two geodetic datums defines the spatial relationship between the axes of the ellipsoids on which the geodetic datums are based and allows coordinates defined in one system to be transformed to another. The latitude and longitude of a point depend on the shape of the chosen ellipsoid, its location in space defined by the geodetic datum and the choice of a prime (reference) meridian.

A projection is chosen as a means of representing the curved surface of the ellipsoid on a flat plane and hence of presenting the data on a map. The choice of projection determines the representation of properties such as shape, area, distance and azimuth. Since the ellipsoid is not a developable surface (it cannot be flattened without distortion) the choice of projection is important. Over a small area a close approximation to uniformity can be achieved but as the area increases the distortions become greater.

The projection system provides a set of **map grid** coordinates designated by Easting along the grid East axis and Northing along the grid North axis. Grid bearings are measured clockwise from grid North. **No grid values can have any meaning unless the related geodetic datum and ellipsoid have already been defined**.

It would be possible to consider a binning system defined on the ellipsoid. This would have advantages in that the measured distances would be 'true', as would the azimuths measured from true North. Whilst it has been common practice to shoot marine seismic lines on the ellipsoid, current workstation software assumes that processing and interpretation are carried out on a Cartesian grid based on a defined **map grid**.

The **bin grid** is the relative coordinate framework which defines a matrix of evenly spaced points referred to as the bin nodes. These nodes are the points to which groups of traces are referenced.

To be able to relate the **bin grid** coordinates with their **map grid** coordinates an affine transformation is used.

From the practical point of view the exchange format removes the concept of 'inline' and 'crossline' by referring to bin nodes. This represents a unified reference frame. However, by allowing negative and non-unit bin grid increments it allows the User to define the exchange format to be fully compatible with the bin grid numbering of any work station set-up.

3. MAP GRID TO BIN GRID DISTORTIONS

The choice of a suitable projection for the binning of 3D seismic data is important. There are distortions associated with the projection which need to be quantified and eliminated or minimised to avoid anomalies between the bin grid and the map grid.

The principle distortions are *Scale Factor*, *Change of Scale Factor* and *Convergence.*

3.1 Scale Factor

The nominal bin grid is often defined as a fixed size corresponding to the distance set out on the ground (land seismic) or the shot point interval (marine seismic). This distance may be either a true distance on the surface of the earth or a grid distance on the chosen map grid, depending on the method used for acquisition.

Assuming that a sensible projection has been chosen, the average map grid scale factor over the area of the bin grid should be close to unity. The difference between the true and the grid dimension of any single bin node separation will be the same to two decimal places. (eg 12.500 · 0.9996 = 12.495 = 12.50 to 2 decimal places).

However, as the distance from the origin increases, the projected distance from origin to bin node will depart from the multiple of the 'true' bin node separation. For example, if the scale factor is 0.9996, then at 10 km there will be a 4 m difference between the map grid coordinate and the product of the bin node separation and the number of nodes from origin. **This difference can result in misidentification of a bin node for large surveys, especially where the bin node separation is small.**

Having identified the problem, it can be solved in various ways:

a) Keep the map grid coordinates together with the associated bin grid node.

b) Multiply the 'true' bin node separation by the map grid scale factor to get the grid distance.

c) Shoot the survey lines as map grid lines rather than great circles. The shot point interval will then be the specified distance 'on the map grid', and the scale factor multiple becomes unity.

d) Define a specific map projection which has a unit scale factor at the grid origin or within the bin grid area.

e) Specify a projection which has the specific property of being equidistant.

In the proposed exchange format the scale factor at a point within the bin grid is a required parameter. Note that this is not the same as the scale factor at the projection origin, for example on the central meridian of a UTM zone. To minimise the secondary effect of the change of scale factor, defined below, a scale factor near the centre of the bin area may be chosen. Normally, however, the map grid scale factor at the bin grid origin is adequate. **If the survey has been acquired by setting out on the map grid, then the scale factor parameter is unity.**

3.2 Change of Scale Factor

For most projections, having addressed the scale factor problem, there is a secondary effect due to the change of scale factor over the survey area. This is a negligible effect for any reasonable projection, producing errors of the order of 0.01 m at 10 km.

It is possible to eliminate this error entirely by leaving the map grid scale factor parameter as a variable and calculating the line scale factor for the bin grid location. However this is an unnecessary refinement which would complicate the transformation calculation.

3.3 Convergence

The orientation of the survey is defined as the Map Grid bearing of the J axis. If the survey is acquired using an azimuth referred to True North then a correction must be made for the convergence (the angular difference between grid north and true north) at the bin grid origin to correctly orient the survey.

If the acquisition is carried out on a map grid bearing, and then the bin grid is defined on a **different** map grid, the **change in the convergence** at the bin grid origin must be applied . This is frequently the case for integration or merging of surveys. In this case a failure to correct the orientation for the change in convergence at the bin grid origin between the two projections can lead to significant errors in the orientation of the binning grid.

A one degree error in the convergence will cause an error of 175 m at 10 km from the origin. At high latitudes the convergence can be very significant (e.g. equal the difference in longitude between the point and the respective central meridian for a TM projection), and for all projections it is crucial that the convergence is correctly applied when converting true azimuths to map grid bearings or when changing map grids.

The best method of handling this problem is for the software to read the geodetic datum, ellipsoid and projection details together with the other defining parameters. If a change in the geodetic reference frame (geodetic datum, ellipsoid, projection) is required, the software should automatically perform the transformation to the new set of parameters defining the survey, including the calculation of the new grid bearing of the J axis.

If no automatic conversion is available, then the conversion must be done 'off-line' and the correct grid bearing of the bin grid J axis entered as the orientation parameter.

4. DESCRIPTION OF TERMS

MAP GRID : The geodetic coordinate reference frame defined by the geodetic datum, ellipsoid and projection is the **map grid.** The map grid axes are defined as the map grid North axis and the map grid East axis. The East axis is rotated 90 degrees clockwise from the North axis. Coordinates in the map grid are defined by the Easting and the Northing of the point **(E , N)**.

BIN NODE : This term is used instead of the term **bin centre**, and refers to the locations where the bin grid lines intersect. The affine transformation requires that the bin nodes are regularly spaced.

BIN : The **bin** is the area surrounding the **bin node**. Typically the bin node will be at the bin centre, but this is not necessary. The bin node is the point representing the bin. The term **bin** is used rather than the term **cell**.

BIN GRID : The **bin grid** is defined by a pair of orthogonal axes designated the I and the J axes, with the I axis rotated 90 degrees clockwise from the J axis.

The order of specifying bin grid coordinates will be the I value followed by the J value **(I , J)**

The choice of I , J axes is made to avoid any confusion between **bin grid (I , J)** and **map grid (E , N)** coordinates.

Axes may be labelled by users as they wish within their own software, including such terms as Inline and Crossline , Row and Column, x and y. However there is no uniformity of opinion on labels and terms such as Inline and Crossline are used in contradictory ways by different users. For the purpose of data exchange the only reference is to the I and J axes.

BIN GRID ORIGIN : The **bin grid origin** is at the bin node designated as (I_O,J_O), and the map grid coordinates of this node are specified parameters.

The bin grid origin coordinates are designated by the sign, 5 integers and 3 decimal places, with leading zeros shown (eg (01001.000 01001.000)). This allows for a non integer bin grid increment. Note that coordinates may be negative or positive. The choice of the numbering convention for the origin is at the discretion of the user. There may be a virtue in offsetting the origin coordinates so that I and J values can be immediately discriminated (eg (00001.000 01001.000), but this is left to the user to chose.

SCALE FACTOR OF BIN GRID : The scale factor of the bin grid is the point scale factor of the map grid coordinate system at a point within the bin grid, and depends upon the chosen projection. This is NOT the same as the scale factor at the projection origin (e.g. the scale factor on the central meridian of a UTM zone). The user may choose any point within the bin grid, although generally the bin grid origin or the centre of the bin grid will be the chosen point. The bin grid coordinates of the point to which the scale factor refers is also required as a check on the validity of the parameter.

If the survey has been acquired on the map grid, then the node interval is a map grid interval and the Scale Factor of the Bin Grid is unity.

If the map grid is changed at the processing or reprocessing stage, then the Scale Factor of the Bin Grid will also change.

BIN NODE INCREMENT	**:**	The **bin node increment** is the numerical increment between successive bin nodes. It must be constant along each axis for the entire bin grid, but can be negative. The bin grid increment does not have to be an integer. This allows for the interpretation of surveys of different bin node separations without reprocessing, or for the resampling of a bin grid.
NOMINAL BIN WIDTH	**:**	The Nominal Bin Width is the nominal separation of the bin nodes in the I and J directions. 'Nominal' is used to distinguish the parameter from the 'actual' bin node separation, which is the product of the Nominal bin width and the Scale Factor of Bin Grid. If a survey is acquired with a true shot point interval of 12.5 metres, then the Nominal Bin Width will be 12.5 metres, and the Scale Factor of the Bin Grid will be a function of the Map Grid. If a survey is acquired with a shot point interval of 12.5 metres set out on the Map Grid, then the Nominal Bin Width will be 12.5 metres and the Scale Factor of the Bin Grid will be unity.
ORIENTATION	**:**	The Bin Grid Orientation is defined by the **map grid bearing (measured clockwise from map grid North) of the J axis.** Any other definition of the orientation of the bin grid, such as the rotation from map grid east, can be derived from the map grid bearing of the bin grid J axis. *If the map grid is changed at the processing or reprocessing stage, then the Orientation of the Bin Grid will also change.*
UNITS	**:**	In all cases the units must be defined for the map grid coordinates and bearings . The conversion factor from the linear measure to international metres must be included in the parameter list. Units must be consistent for all parameters. For example linear units may all be defined as International metres or all as US Survey Feet. Angular units may all be degrees or all grads. Mixed units are not acceptable.
SUB-BIN NODE	**:**	To enable offsets from the regular spaced bin nodes, for irregular events such as the bin centre of gravity, the concept of a SUB-BIN is defined. A **sub-bin node** is the location of a **sub-bin**. There will be 255 by 255 sub-bins uniformly surrounding each bin node. The size of each sub-bin will therefore depend on the bin node spacing. The sub-bin location of the bin node has bin grid coordinates (I,J) [128,128]. An attribute such as the centre of gravity of a bin can be referenced to the bin node by bin grid coordinates (I,J) [i,j] - e.g. (00032.000 , 00145.000) [115,027]. The sub-bin is not part of the exchange format. The purpose of including it in the guidelines is to show how to treat irregular attributes within the context of the bin grid definition.

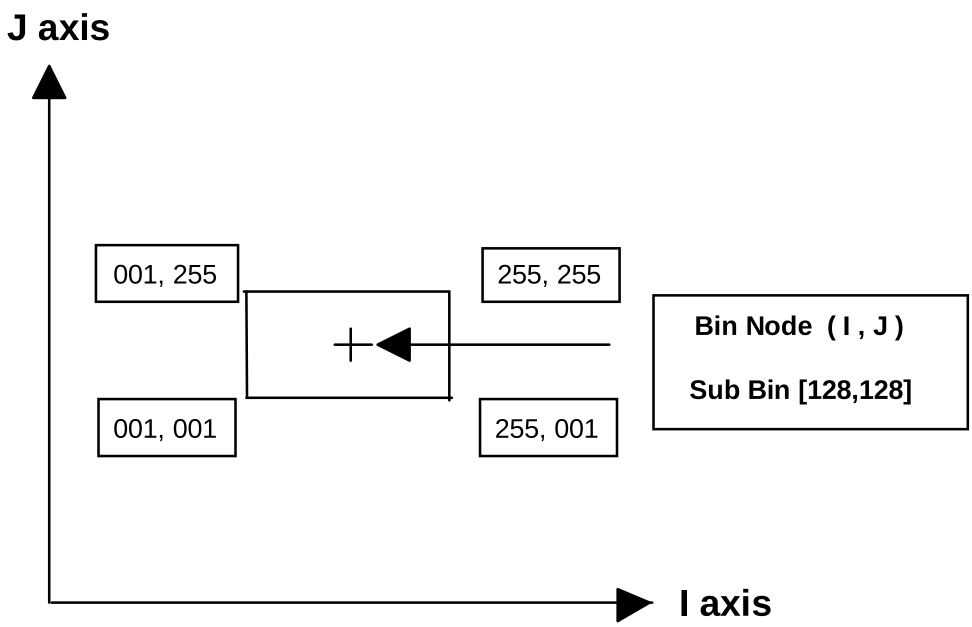


Figure 3: *Definition of sub-bin node*

TOTAL COVERAGE	**:**	The total area for which any coverage exists, full fold or low fold (including acquisition run-ins and run-outs).
NULL COVERAGE	**:**	An area within the TOTAL COVERAGE without any coverage (e.g. undershoot of platforms). In the context of GIS systems frequently denoted as an island.
FULL FOLD COVERAGE	**:**	The area for which the coverage is greater than or equal to nominal full fold (e.g. TOTAL COVERAGE area excluding acquisition line run-ins and run-outs).
NULL FULL FOLD COVERAGE	**:**	An area within the FULL FOLD COVERAGE area where the fold is less than nominal full fold. The combination of a NULL COVERAGE perimeter and a NULL FULL FOLD COVERAGE perimeter makes it possible to describe an acquisition hole caused by an undershoot of a platform, including possible run-ins and run-outs in conjunction with the undershoot.
DATA SET EXTENT	**:**	The extent of the associated seismic data set expressed as a minimum bounding rectangle. The extent can be expressed in bin grid, map grid or geographical coordinate values.

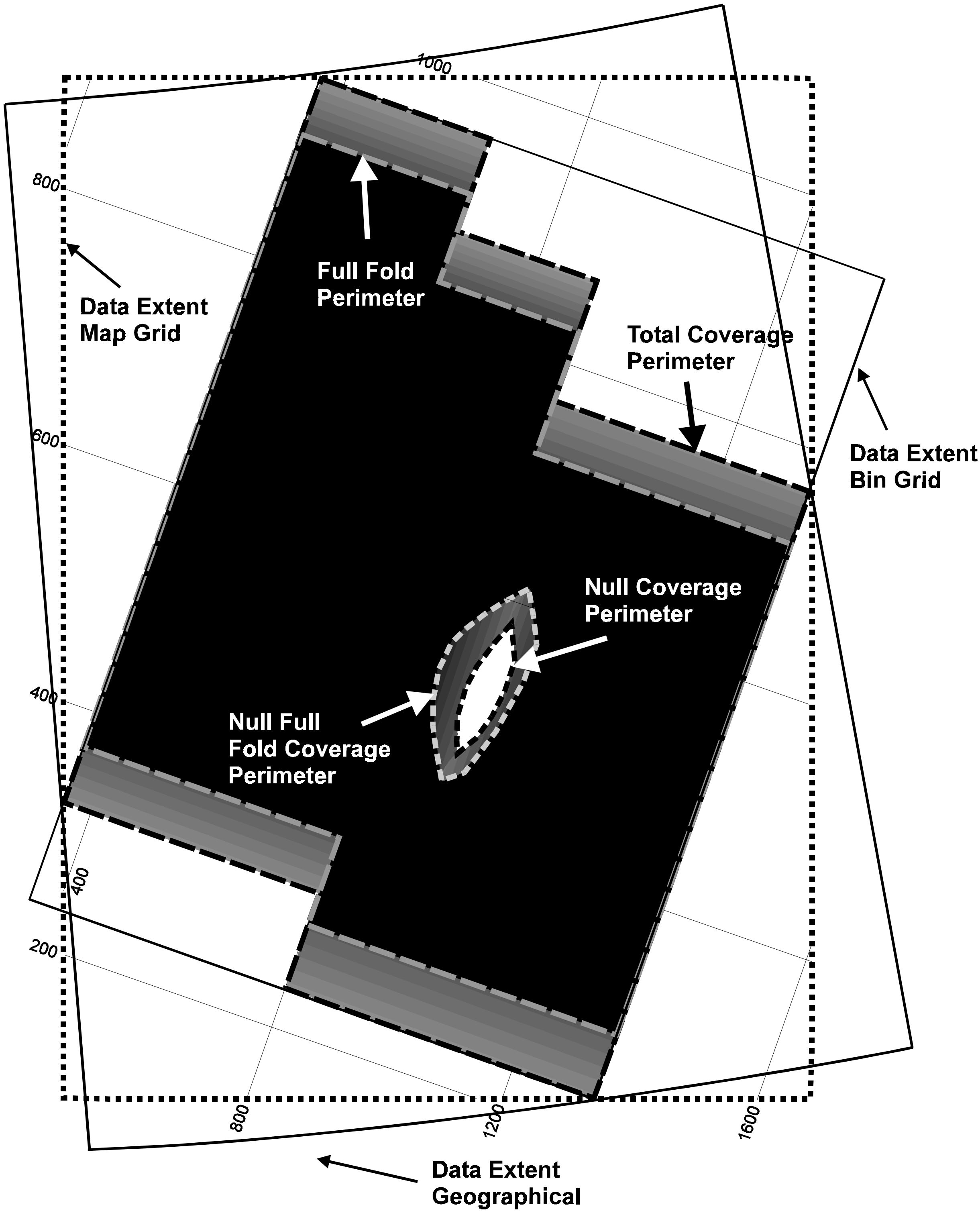


Figure 4: *Schematic diagram showing the various coverage perimeters for a seismic survey encompassing a platform undershoot*

5. DEFINING PARAMETERS:

1. H0100 3D Survey Name

The survey name should be some acronym of the company, year and acquisition or processing contractor. For merged surveys two or more acronyms can be concatenated subject to the limit of 14 characters. A further format field is available for an extended survey name, but the majority of software packages have a limited display field which would use the 14 character field.

2. H0200 Bin Grid Descriptor

This is a descriptive field to include details of the processing sequence or version number, or the details of merged surveys.

3. H0300 Geodetic Datum Name

Name of the Geodetic Datum used by the coordinate system. (See also H8000 series cards for EPSG coordinate system description).

4. H0400 Ellipsoid Name

Description of the Reference Ellipsoid used by the coordinate system. (See also H8000 series cards for EPSG coordinate system description).

5. H0500 - H0590 Projection

The defining parameters of various projection methods differ. Only the relevant parameters need to be completed for records H0500 to H0590. (See also H8000 series cards for EPSG coordinate system description).

The following projection type codes have been defined:

001	U.T.M. Northern Hemisphere
002	U.T.M. Southern Hemisphere
003	Transverse Mercator (North Oriented)
004	Transverse Mercator (South Oriented)
005	Lambert Conic Conformal, (one standard parallel)
006	Lambert Conic Conformal, (two standard parallels)
007	Mercator (2 SP)
008	Cassini-Soldner
009	Oblique Mercator (Skew Orthomorphic)
010	Stereographic
011	New Zealand Map Grid
999	Any other projection or non-standard variation of the above projections.

Requirements for projection definition parameters include the following format records:

Projection	Defining Parameters to be included in header
U.T.M.	H0530 (or 0540)
Transverse Mercator	H0530 (and/or 0540), 0550, 0560
Lambert Conic (1 SP)	H0520, 0530, 0540, 0530 (and/or 0540), 0550, 0560
Lambert Conic (2 SP)	H0520, 0530, 0540, 0550
Mercator (2SP)	H0520, 0530, 0540, 0550
Cassini-Soldner	H0540, 0550, 0560
Oblique Mercator	H0540, 0550, 0560, one of 0580 through 0584, 0590
Stereographic	H0540, 0550, 0560
New Zealand Map Grid	H0540, 0550

6. H0600 Description of Linear Units

The code and description of map grid coordinate system linear units is defined as:

H0600 Linear unit code is 1 for International metres, 2 for any other unit.

7. H0700 Description of Angular Units

The code and description of map grid coordinate system angular units is defined as:

H0700 Angular unit code is 1 for sexagesimal degrees, 2 for any other unit.

Example: The input format for degrees, minutes and seconds is I3, I2, F6.3, A1
123 deg 4 min 53.124E sec is input as 1230453.124E.

8. H0800 Bin Grid Origin (I_O , J_O)

9. H0900 Map Grid Coordinates (E_O , N_O) of Bin Grid Origin (I_O , J_O)

10. H1000 Scale Factor of Bin Grid at node reference (I , J)

The scale factor of the Bin Grid is defined under the terms in Section 5: Glossary

11. H1100 Nominal Bin Widths along I axis and J axis

The nominal bin width shall be given in map grid linear units and is defined under the terms in Section 5: Description of Terms.

12. H1200 Grid Bearing of Bin Grid J axis (clockwise from map grid North, θ)

The map grid bearing of the bin grid J axis shall be given in map grid angular units and is defined under the terms in Section 5: Description of Terms.

13 H1300 & H1350 Bin Node Increment on (I, J) axes.

This number may be positive or negative, and has a format of F9.3 to allow non-integer increments. The increments along each axis may be different.

14. H1400 to H1430 Check Parameters

For data exchange, check parameters are required to confirm that the grid parameters have been correctly set up. These are three defined locations quoting both the bin grid and the map grid coordinates. Two of these points must be on the J axis, from which the grid bearing of the J axis can be derived and checked, and the third point should be remote from the J axis so that the scale factor and bin parameters can be checked. Although these values will have been derived from the parameters themselves, they will provide a check against transcription errors in the parameters - for example typing errors or errors of sign.

Additionally, the H1401 and H1402 records are included to allow for a consistency check on the geodetic coordinate system definition. The geographic coordinates of the bin grid origin given in H1400 are given in these records.

15. H2100 Comments

General comments on grid definition (e.g. which axis has been used as 'inline' direction). Repeated as necessary.

16. H2300 to H3900 Bin Coverage Type, Perimeter and Comments

This format allows for the description of the following coverages:

a) The geographical extent of the data set through the maximum and minimum coordinates which bound the data. Provision is made for all three of bin grid, map grid and/or latitude/longitude values.
b) The total coverage of all data within the data set through the coordinates of a series of points describing the perimeter of the **total** coverage.
c) Full-fold coverage through the coordinates of a series of points describing outer perimeter of the **full fold** coverage.
d) Islands within the full-fold coverage with less than full fold through the coordinates of a series of points describing outer perimeter of the **null full fold** coverage.
e) Islands within the total coverage within which there is no coverage through the coordinates of a series of points describing outer perimeter of the **null fold** coverage.

See figure 4 for a diagram describing these concepts.

For processed data sets (near trace cubes, migrated volumes, etc.), the fold will be affected by various processing steps (trace summation, offset rejection, migration, etc.). These data sets can be represented by either a Total Coverage Perimeter or a Full Fold Perimeter. The type of processed data set should be stated in the respective comment cards.

As a minimum, the Data Set Extent should be included. If not known in detail, the Data Set Extent should still be described to provide the user with a simple representation of the area covered by the survey for mapping and data management purposes, rather than a precise representation of the fold of coverage of a binning system or process.

Wherever a detailed perimeter is known for a data set this should be included in the exchange file. Bin grid and/or map grid coordinates may be given for each node of each perimeter. The data set extent can then be easily derived from the detailed perimeter. However, given the practical importance of the data set extent (e.g. used for loading of data onto workstations), the extent should be defined explicitly in bin grid, map grid and/or latitude and longitude through records H23-25.

Data Set Extent:

H2300 Data Set Extent – Max J, Min J, Max I and Min I in Bin Grid Coordinates.
H2400 Data Set Extent – North, South, East and West limits in Map Grid Coordinates.
H2501 Data Set Extent – North and South limits in Geographical Coordinates (in degrees, minutes and seconds).
H2502 Data Set Extent – East and West limits in Geographical Coordinates (in dms).
H2503 Data Set Extent – North and South limits in Geographical Coordinates (in grads).
H2504 Data Set Extent – East and West limits in Geographical Coordinates (in grads).
H2600 Data Set Extent – Comments on data extent. May be repeated as necessary.

COVERAGE PERIMETERS

H2700 Number of perimeter outlines described in the data set
Number of perimeter outlines described in the data set. Up to 99 perimeters may be described. A sequential counter ## (01-99) is used to uniquely identify the perimeter within each category of perimeters. Each perimeter may have an unlimited number of nodes, given in bin grid and/or map grid coordinates. A single perimeter described with both bin grid and map grid coordinates counts as one (1).

Total Coverage:

H28## Total Coverage - Number of Perimeter Nodes
Number of perimeter nodes for boundary number ##, as listed in the H27 or H28 records. This includes a repeat of the first point at the end of the list, i.e. for an n-sided perimeter there should be n+1 points.

H29## Total Coverage - Perimeter Node Coordinates (i,j,E,N)
Bin grid and/or map grid coordinates of total coverage boundary number ##. Repeat record as necessary, with nodes in sequential order around the perimeter. The coordinates of the first node should be repeated at the end of the list as the (n+1)th node.

H30## Total Coverage - Comments
General comments on total coverage (e.g. fold range, type of data set). Record can be repeated as required.

Full Fold Coverage:

H31## Full Fold Coverage - Number of Perimeter Nodes
H32## Full Fold Coverage - Perimeter Node Coordinates (i,j,E,N)

H33## Full Fold Coverage - Comments
General comments on full fold coverage (e.g. value of nominal full fold, type of data set).

Null Full Fold Coverage:

H34## Null Full Fold Coverage - Number of Perimeter Nodes
H35## Null Full Fold Coverage - Perimeter Nodes Coordinates (i,j,E,N)

H36## Null Full Fold Coverage - Comments
General comments on null full fold perimeter number ## (e.g. reason for hole in coverage).

Null Coverage:

H37## Null Coverage - Number of Perimeter Nodes
H38## Null Coverage - Perimeter Nodes Coordinates (i,j,E,N)

H39## Null Coverage - Comments
General comments on null coverage (e.g. reason for hole in coverage).

Perimeter records need to be specified in order, either clockwise or anticlockwise from any starting point. The total number of nodes must be specified as a check that the full perimeter list has been recorded. As a second check, the first point should be re-entered as the last point, to close the polygon. As an example, a rectangular boundary therefore will be described by **4+1** nodes.

17. H8000 to H8006 EPSG Coordinate System Description

For improved machine readability and/or to enable integrity checking of coordinate system definitions, a set of EPSG records has been adopted for all UKOOA Positioning (P) formats. This allows an industry-standard name to be quoted where the geodetic coordinate system used for the 3D survey is a common system. Records H8000 and H8001 describe geographic coordinate system; records H8002 and H8003 describe projected coordinate system; records H8004 and H8005 describe vertical coordinate system and the H8006 record gives the EPSG database version number. For the P6/98 format, only the H8002, H8003 and H8006 records are required.

Defining parameters and units are then as given by EPSG and are not strictly required to be explicitly given in the H0300 through H0700 records. However, as an integrity check, it is considered good practice also to include the explicit definition.

6. AFFINE TRANSFORMATION DEFINITION:

From the defining parameters the relationship between the bin grid and the map grid coordinates can be derived.

In the general case where the bin node separations are not equal along the I and J axes, the transformations are defined by the affine transformation coefficients k to w in the equations:

$$E = r \cdot I + s \cdot J + t \qquad I = k \cdot E + l \cdot N + m$$
$$N = u \cdot I + v \cdot J + w \qquad J = n \cdot E + p \cdot N + q$$

Where the bin node separations are equal and the bin and increment values are equal this simplifies to a similarity transform, with parameters *k,l,m,q,r,s,t,w* only, since for this special case $u = -s$, $v = r$, $n = -l$ and $p = k$.

Theta (θ) is the orientation of the bin grid.

Coefficients:

k	=	I_bin_inc · cos(θ) / (I_bin_width · S.F._Bin_Origin)
l	=	-1.0 · I_bin_inc · sin(θ) / (I_bin_width · S.F._Bin_Origin)
m	=	I_Origin - (coeff_*k* · Easting_origin) - (coeff_*l* · Northing_origin)
n	=	J_bin_inc · sin(θ) / (J_bin_width · S.F._Bin_Origin)
p	=	J_bin_inc · cos(θ) / (J_bin_width · S.F._Bin_Origin)
q	=	J_Origin - (coeff_*n* · Easting_origin) - (coeff_*p* · Northing_origin)
r	=	I_bin_width · S.F._Bin_Origin · cos(θ) / I_bin_inc
s	=	J_bin_width · S.F._Bin_Origin · sin(θ) / J_bin_inc
t	=	Easting_origin - (coeff_*s* · J_Origin) - (coeff_*r* · I_Origin)
u	=	-1.0 · I_bin_width · S.F._Bin_Origin · sin(θ) / I_bin_inc
v	=	J_bin_width · S.F._Bin_Origin · cos(θ) / J_bin_inc
w	=	Northing_origin - (coeff_*v* · J_Origin) - (coeff_*u* · I_Origin)

7. DATA EXCHANGE FORMAT:

The TYPE card covers column 1-6, the ITEM description columns 7-32, and all FORMAT statements begin in column 33 and end in column 80.

Format description is given in Fortran style (i.e. F-float, A-character, I-integer, X-space).
Example: 2 (A4, 2X, F6.3, X) = ‘ABCD__ 00.000_ ABCD__ 00.000_’

TYPE	ITEM	FORMAT
1-6	7-32	33-80
H0100	3D Survey Name	A14, 2X, A32
H0200	Bin Grid Descriptor	A40
H0300	Geodetic Datum Name	A12
H0400	Ellipsoid-Axis-Inv Flat	A12, F12.3, F12.7
H0450	Prime Meridian Name	A48
H0460	Prime Mer. Offset (dms)	1X, I3, I2, F6.3, A1
H0461	Prime Mer. Offset (grad)	F11.7, A1
H0500	Projection Method	A4, 2X, A42
H0510	Projection Zone Name	A48
H0520	Lat of Std Par (dms)	2(1X, I3, I2, F6.3, A1, 1X)
H0521	Lat of Std Par (grad)	2(F11.7, A1, 1X)
H0530	Lon of CM (dms E/W)	1X, I3, I2, F6.3, A1
H0531	Lon of CM (grads E/W)	F11.7, A1
H0540	Map Grid Origin (dms N/E)	2(1X, I3, I2, F6.3, A1, 1X)
H0541	Map Grid Origin (grad N/E)	2(F11.7, A1, 1X)
H0550	Map Grid Origin (E,N)	2(F12.2, A1, 1X)
H0560	Map Grid Scale Factor	F12.10
H0570	Lat/Lon of Sc Fact (dms)	2(1X, I3, I2, F6.3, A1, 1X)
H0571	Lat/Lon of Sc Fact (grad)	2(F11.7, A1, 1X)
H0580	Lat/Lon of Ini Line(dms)	2(1X, I3, I2, F6.3, A1, 1X)
H0581	Lat/Lon of Ini Line(grad)	2(F11.7, A1, 1X)
H0582	Bearing of Ini Line(dms)	1X, I3, I2, F6.3, A1
H0583	Bearing of Ini Line(grad)	F11.7
H0584	Quad Bear (N/S dms E/W)	A1, 2X, 2I2, F6.3, A1
H0585	Quad Bear (N/S grads E/W)	A1, F11.7, A1
H0590	Skew to Rectified (dms)	I3, I2, F7.4
H0600	Descr of Linear Units	I1, 1X, A24, F15.12
H0700	Descr of Angular Units	I1, 2X, A24
H0800	Bin Grid Origin (Io,Jo)	2(F11.4, 1X)
H0900	Bin Grid Origin (E,N)	2(F12.2, A1, 1X)
H1000	Scale Factor at (I,J)	F12.10, 1X, 2(F11.4, 1X)
H1100	Nom Bin Width on I axis	F8.4
H1150	Nom Bin Width on J axis	F8.4
H1200	Grid Bear J axis (dms)	1X, I3, I2, F6.3
H1201	Grid Bear J axis (grad)	F11.7
H1300	Bin Node Increment I axis	F9.3
H1350	Bin Node Increment J axis	F9.3
H1400	Coords (I,J,E,N) Fst Node	2(F11.4, 1X), 2(F12.2)
H1401	Lat,Lon (dms) First Node	2(1X, I3, I2, F6.3, A1, 1X)
H1402	Lat,Lon (grad) First Node	2(F11.7, A1)
H1410	Coords (I,J,E,N) Sec Node	2(F11.4, 1X), 2(F12.2)
H1420	Coords (I,J,E,N) Gen Pnt	2(F11.4, 1X), 2(F12.2)
H2300	Data Extent Bin Grid	4(F11.4,X)
H2400	Data Extent Map Grid	4(F12.2)
H2501	Data Extent Geog (N/S dms)	2(1X, I3, I2, F6.3, A1, 1X)
H2502	Data Extent Geog (E/W dms)	2(1X, I3, I2, F6.3, A1, 1X)
H2503	Data Extnt Geog (N/S grad)	2(F11.7, A1)
H2504	Data Extnt Geog (E/W grad)	2(F11.7, A1)
H2600	Data Set Extent comments	A48
H2700	Number of perimeters	I2
H28##	Total Coverage # of Nodes	I4
H29##	Total Coverage (i,j,E,N)	2(F11.4, 1X), 2(F12.2)
H30##	Total Coverage Comments	A48

```
H31## Full Fold Cov # of Nodes  I4
H32## Full Fold Cov (i,j,E,N)   2(F11.4, 1X), 2(F12.2)
H33## Full Fold Cov Comments    A48
H34## Null Full Fold # of Nodes I4
H35## Null Full Fold (i,j,E,N)  2(F11.4, 1X), 2(F12.2)
H36## Null Full Fold Comments   A48
H37## Null Coverage # of Nodes  I4
H38## Null Coverage (i,j,E,N)   2(F11.4, 1X), 2(F12.2)
H39## Null Coverage Comments    A48
H8002 EPSG Projected CS Name    A40
H8003 EPSG Projected CS Code    I5
H8006 EPSG Database Version     F4.1
```

Sequential counter 1-99 for perimeter within each perimeter type.

APPENDIX A – PRACTICAL EXAMPLE:

Numerical Example Based on survey area in figure 4

```
H0100 3D Survey Name            MARINE X
H0200 Bin Grid Descriptor       ACQUISITION
H0300 Geodetic Datum Name       WGS 84
H0400 Ellipsoid-Axis-Inv Flat   WGS 84       6378137.000 298.2572236
H0500 Projection Method          001  UNIVERSAL TRANSVERSE MERCATOR
H0510 Projection Zone Name      ZONE 31   NORTHERN HEMISPHERE
H0530 Lon of CM (dms E/W)         3 0 0.000E
H0600 Descr of Linear Units     1 INTERNATIONAL METRES     1.000000000000
H0700 Descr of Angular Units    1  DEGREES
H0800 Bin Grid Origin (Io,Jo)        1.0000      1.0000
H0900 Bin Grid Origin (E,N)        456781.00E   5836723.00N
H1000 Scale Factor at (I,J)     0.9998400000      1.0000      1.0000
H1100 Nom Bin Width on I axis    25.0000
H1150 Nom Bin Width on J axis    12.5000
H1200 Grid Bear J axis (dms)      200000.000
H1300 Bin Node Increment I axis     1.000
H1350 Bin Node Increment J axis     1.000
H1400 Coords (I,J,E,N) Fst Node    334.0000    235.0000    465602.94  5836624.30
H1401 Coords (Lat,Lon) Fst Node   524042.457N    22928.411E
H1410 Coords (I,J,E,N) Sec Node   1352.0000    955.0000    492591.98  5836377.16
H1420 Coords (I,J,E,N) Gen Pnt     605.0000    955.0000    475046.03  5842763.36
H2300 Data Extent Bin Grid          955.0000    235.0000   1352.0000    334.0000
H2400 Data Extent Map Grid        5845080.18  5827921.28   491792.63   465966.28
H2501 Data Extent Geog (N/S)      524516.782N   523604.359N
H2502 Data Extent Geog (E/W)       25243.181E    23209.385E
H2700 Number of perimeters       4
H2801 Total Coverage # of Nodes   10
H2901 Total Coverage (i,j,E,N)     334.0000    955.0000    468680.63  5845080.18
H2901 Total Coverage (i,j,E,N)     654.0000    955.0000    476196.97  5842344.46
H2901 Total Coverage (i,j,E,N)     654.0000    875.0000    475855.00  5841404.91
H2901 Total Coverage (i,j,E,N)     900.0000    875.0000    481633.18  5839301.83
H2901 Total Coverage (i,j,E,N)     900.0000    768.0000    481175.81  5838045.19
H2901 Total Coverage (i,j,E,N)    1352.0000    768.0000    491792.63  5834180.98
H2901 Total Coverage (i,j,E,N)    1352.0000    235.0000    489514.29  5827921.28
H2901 Total Coverage (i,j,E,N)     802.0000    235.0000    476595.58  5832623.30
H2901 Total Coverage (i,j,E,N)     802.0000    320.0000    476958.92  5833621.57
H2901 Total Coverage (i,j,E,N)     334.0000    320.0000    465966.28  5837622.56
H2901 Total Coverage (i,j,E,N)     334.0000    955.0000    468680.63  5845080.18
H3102 Full Fold Cov # of Nodes    10
H3202 Full Fold Cov (i,j,E,N)      334.0000    908.0000    468479.72  5844528.20
H3202 Full Fold Cov (i,j,E,N)      654.0000    908.0000    475996.06  5841792.48
H3202 Full Fold Cov (i,j,E,N)      654.0000    833.0000    475675.47  5840911.65
H3202 Full Fold Cov (i,j,E,N)      900.0000    833.0000    481453.65  5838808.57
H3202 Full Fold Cov (i,j,E,N)      900.0000    721.0000    480974.90  5837493.21
H3202 Full Fold Cov (i,j,E,N)     1352.0000    721.0000    491591.73  5833629.00
H3202 Full Fold Cov (i,j,E,N)     1352.0000    289.0000    489745.12  5828555.47
H3202 Full Fold Cov (i,j,E,N)      802.0000    289.0000    476826.41  5833257.49
H3202 Full Fold Cov (i,j,E,N)      802.0000    368.0000    477164.10  5834185.29
H3202 Full Fold Cov (i,j,E,N)      334.0000    368.0000    466171.46  5838186.29
H3202 Full Fold Cov (i,j,E,N)      334.0000    908.0000    468479.72  5844528.20
H3302 Full Fold Cov Comments    48 Fold Data
H3403 Null Full Fold # of Nodes    9
H3503 Null Full Fold (i,j,E,N)     968.0000    611.0000    482101.92  5835620.00
H3503 Null Full Fold (i,j,E,N)    1008.0000    572.0000    482874.75  5834820.00
H3503 Null Full Fold (i,j,E,N)     988.0000    493.0000    482067.29  5834063.19
H3503 Null Full Fold (i,j,E,N)     966.0000    455.0000    481388.11  5833804.99
H3503 Null Full Fold (i,j,E,N)     934.0000    440.0000    480572.36  5833902.39
H3503 Null Full Fold (i,j,E,N)     890.0000    479.0000    479705.57  5834736.58
H3503 Null Full Fold (i,j,E,N)     864.0000    521.0000    479274.40  5835452.12
H3503 Null Full Fold (i,j,E,N)     874.0000    550.0000    479633.25  5835707.21
H3503 Null Full Fold (i,j,E,N)     914.0000    589.0000    480739.50  5835823.27
H3503 Null Full Fold (i,j,E,N)     968.0000    611.0000    482101.92  5835620.00
```

```
H3704 Null Coverage # of Nodes      8
H3804 Null Coverage (i,j,E,N)       958.0000     579.0000     481730.25  5835329.67
H3804 Null Coverage (i,j,E,N)       978.0000     552.0000     482084.61  5834841.59
H3804 Null Coverage (i,j,E,N)       980.0000     512.0000     481960.60  5834354.72
H3804 Null Coverage (i,j,E,N)       958.0000     481.0000     481311.34  5834178.73
H3804 Null Coverage (i,j,E,N)       946.0000     468.0000     480973.91  5834128.64
H3804 Null Coverage (i,j,E,N)       900.0000     498.0000     480021.67  5834874.23
H3804 Null Coverage (i,j,E,N)       920.0000     522.0000     480594.03  5834985.11
H3804 Null Coverage (i,j,E,N)       958.0000     582.0000     481743.07  5835364.90
H3804 Null Coverage (i,j,E,N)       958.0000     579.0000     481730.25  5835329.67
H8002 EPSG Projected CS Name     WGS 84 / UTM zone 31N
H8003 EPSG Projected CS Code     32631
H8006 EPSG Database Version      4.3
```

APPENDIX B – TEST CONVERSIONS:

SYSTEM DEFINITION:

Orientation (deg)	=	20.00000
Bin Width I (m)	=	25.00
Bin Width J (m)	=	12.50
Increment I	=	1.00
Increment J	=	1.00
Scale factor at origin	=	0.99984
Origin - E (m)	=	456781.00
Origin – N (m)	=	5836723.00
Origin – I	=	1.00
Origin – J	=	1.00

CALCULATED PARAMETRES:

***k* =**	0.03759372	***r* =**	23.48855675
***l* =**	-0.013683	***s* =**	4.274567751
***m* =**	62692.755	***t* =**	456753.237
***n* =**	0.02736599	***u* =**	-8.5491355
***p* =**	0.07518744	***v* =**	11.74427837
***q* =**	-451347.523	***w* =**	5836719.805

CONVERT FROM BIN GRID (I,J) TO MAP GRID (E,N):

Bin Value (I)	:	300	Sub-Bin Node [i]:	:	39
Bin Value (J)	:	247	Sub-Bin Node [j]:	:	70
Easting	:	464855.62	Easting (E)	:	464846.45
Northing	:	5837055.90	Northing (N)	:	5837056.21

CONVERT FROM MAP GRID (E,N) TO BIN GRID (I,J):

Easting:	:	464855.62	Easting (E)	:	464846.45
Northing:	:	5837055.90	Northing (N)	:	5837056.21
Bin Value (I)	:	300	Sub-Bin Node [i]	:	39
Bin Value (J)	:	247	Sub-Bin Node [j]	:	70