Moderator and Presenters

- **Walter Jardine:** Moderator (IOGP Geomatics Committee acting Vice Chair)

- **Tony Blackburn**: Consultant to IOGP on P-Formats, Member of IOGP Geophysical Operations Sub-Committee

- **Tom Owen**, Mid Point Geo Limited. Member of the Px/11 Revision Taskforces and Member of IOGP Geophysical Operations Subcommittee.

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Agenda

- A Short Introduction to Bin Grids

- An Overview of the P6/11 Format

- Use of P6/11 during the Seismic Data Lifecycle
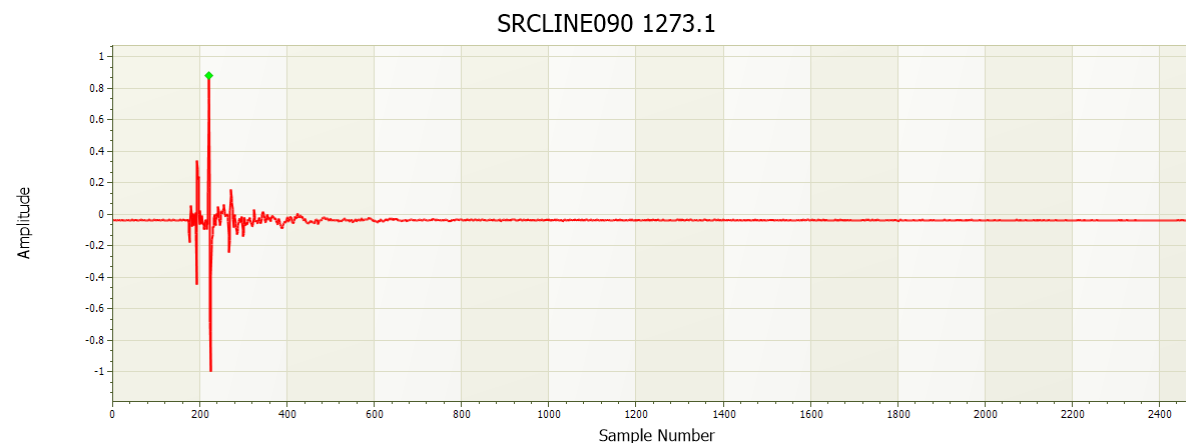
A Short Introduction to Bin Grids

Seismic Data Acquisition

• Collecting Seismic Data requires an energy source and a receiving sensor.

Seismic Data Acquisition

• Each time the sensor receives a source event, a data trace is recorded
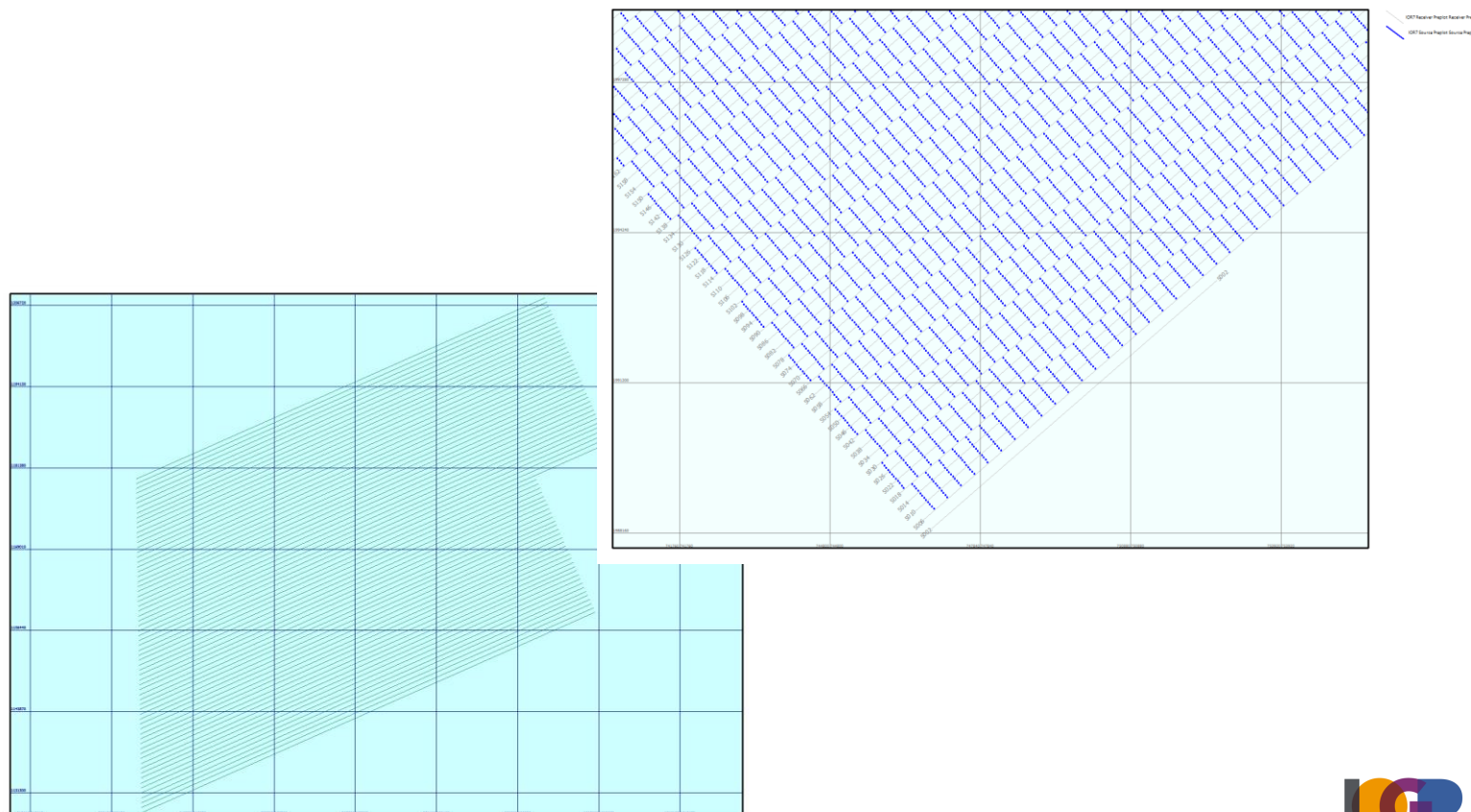

SRCLINE090 1273.1

Seismic Data Acquisition

- Each trace is referenced to a position, usually the midpoint between the source and the receiver

Receiving Sensor   **Common Mid Point (CMP)**   **Energy Source**
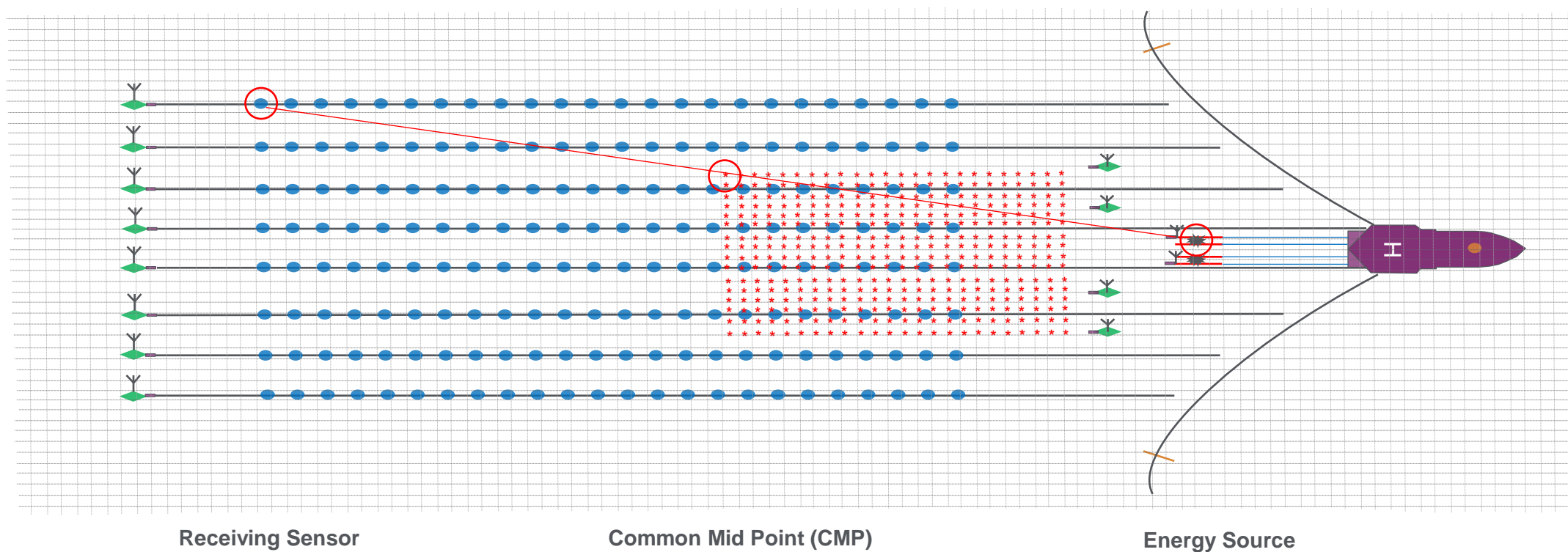
Seismic Data Acquisition

- Data is commonly acquired using a grid of source and receiver points to cover the area being investigated.
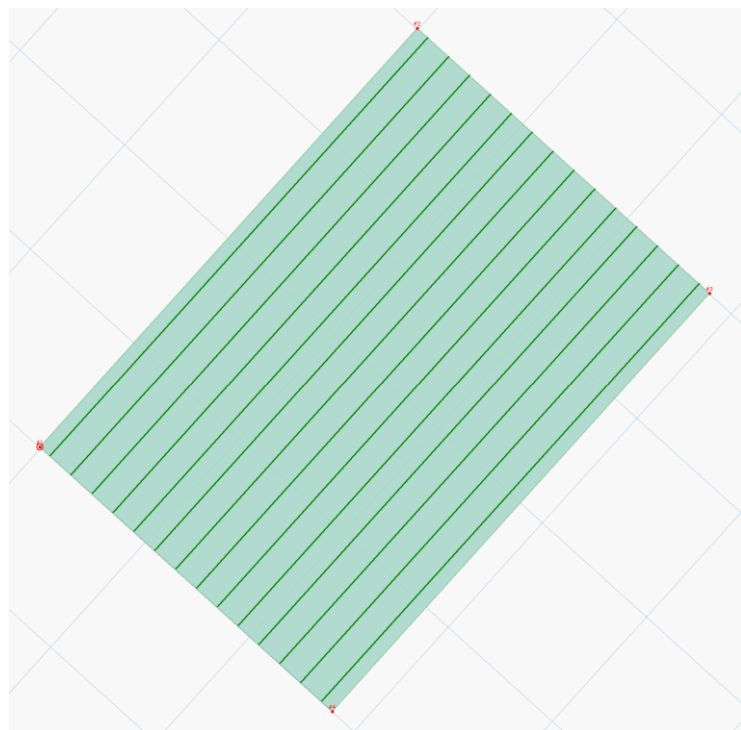
Seismic Data Acquisition

- Multiple data is thus acquired in (roughly) the same location
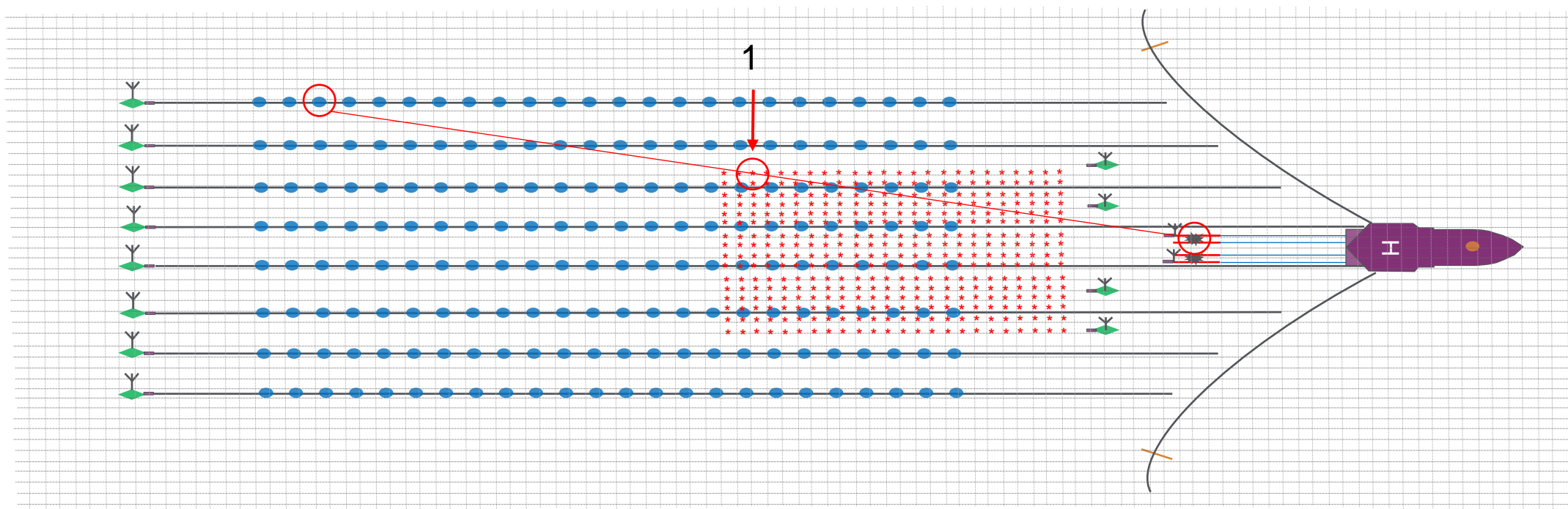
Seismic Data Acquisition
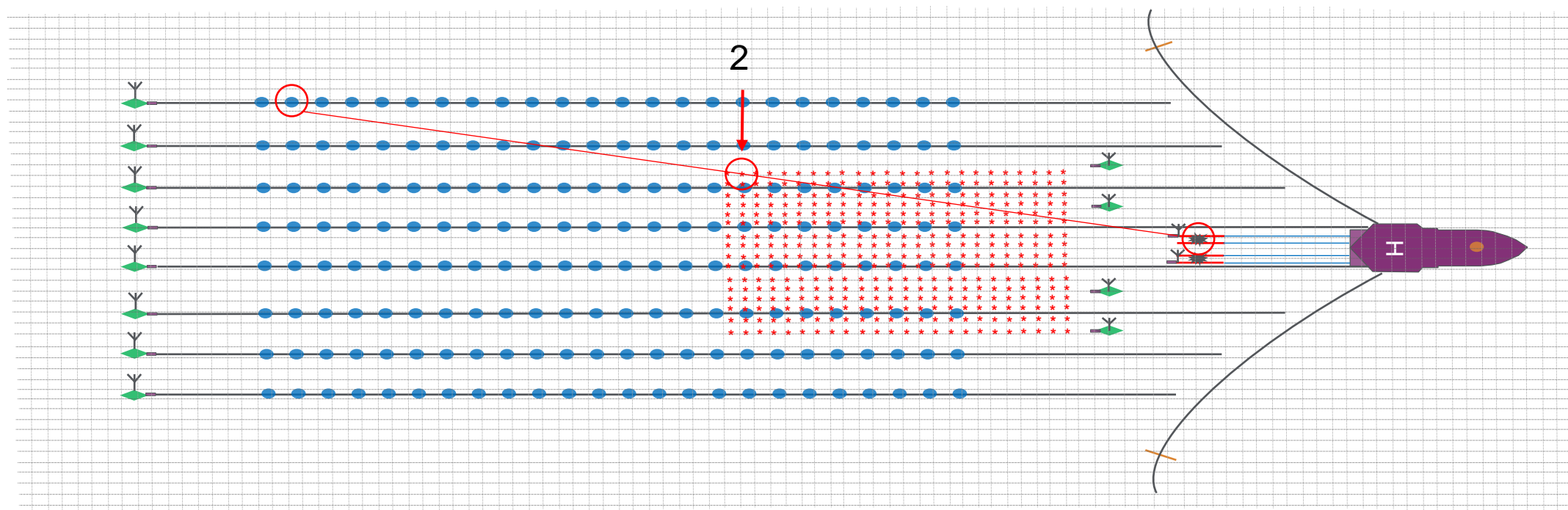
Seismic Data Acquisition
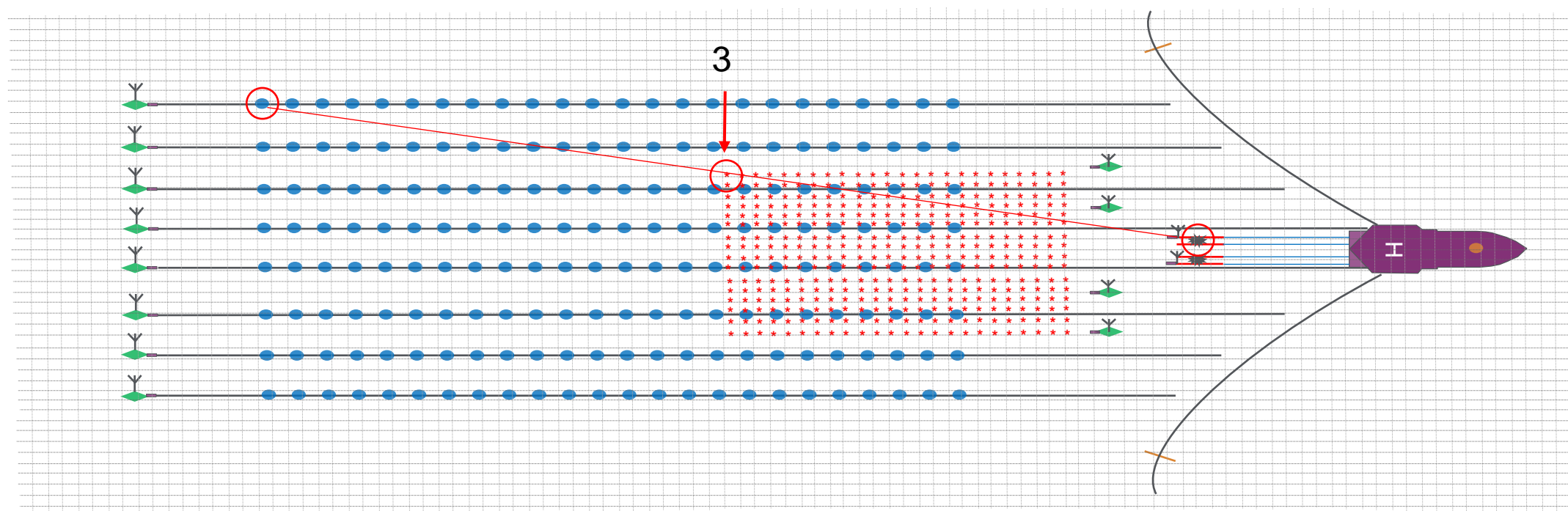
Seismic Data Processing

• During data processing, seismic traces are grouped into a regularly spaced bin grid covering the survey area

ΔX, ΔY Stacking-bin dimensions   □ Bin midpoint

Image Curtesy of PetroWiki
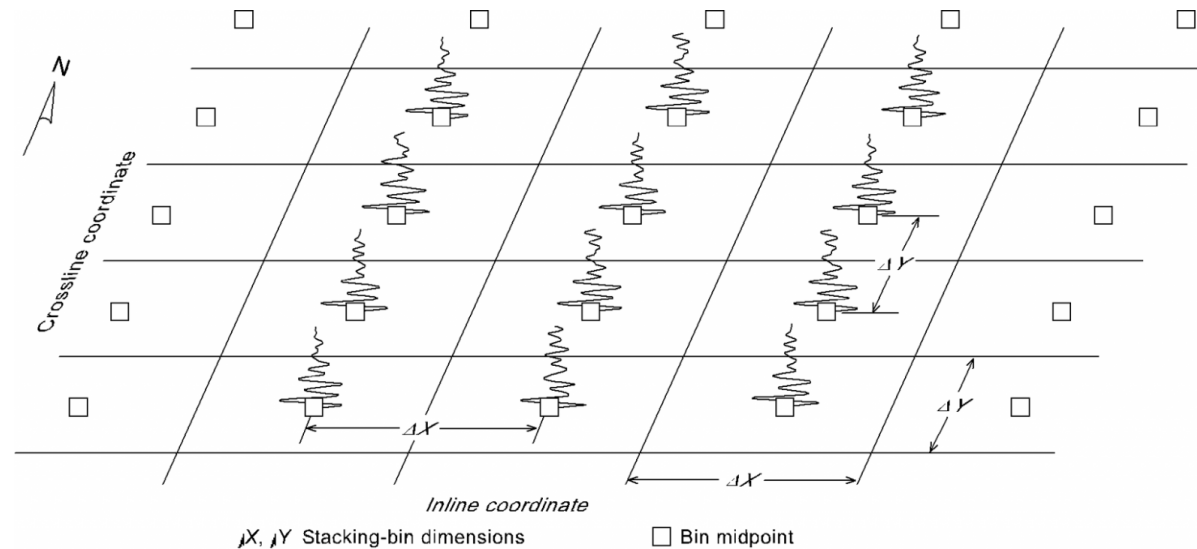
Binning During Acquisition

- To quantify the data that has been acquired during a survey, the data is typically binned during the survey to ensure the required coverage in the area surveyed.
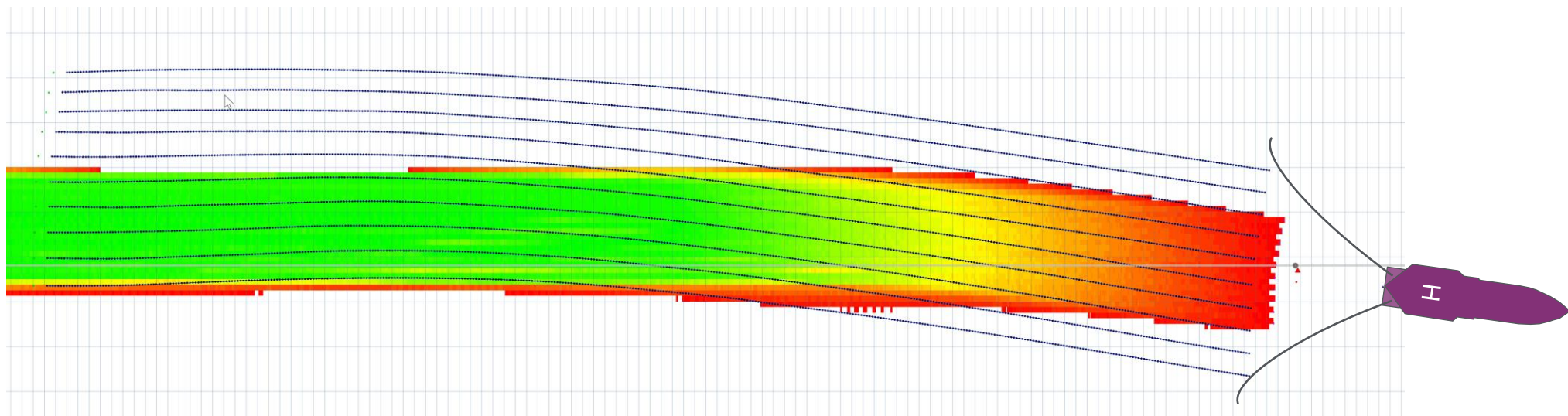
Getting from the Real World to the Bin Grid

GEODETIC COORDINATE REFERENCE SYSTEM
(Coordinates: Latitude, Longitude)

Getting from the Real World to the Bin Grid
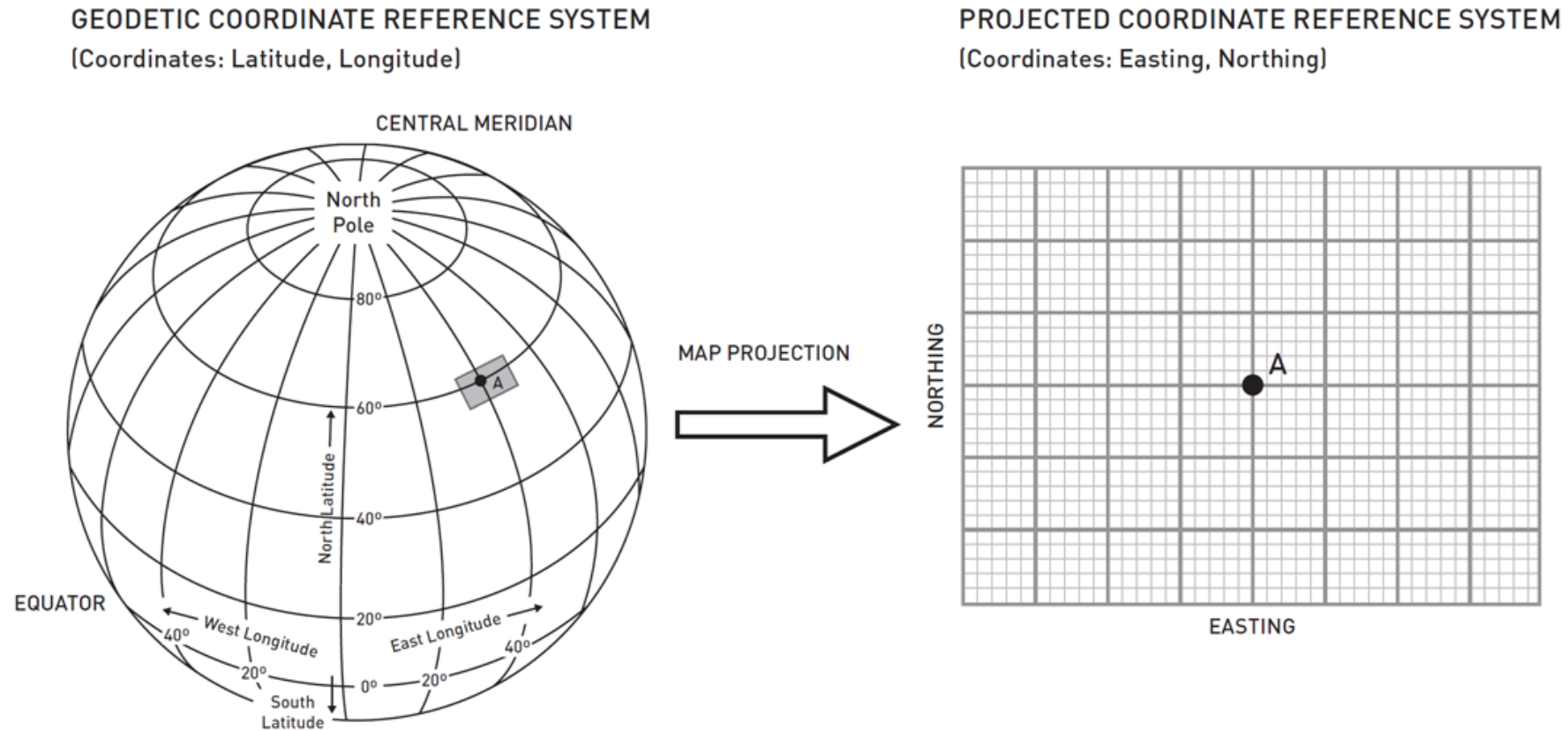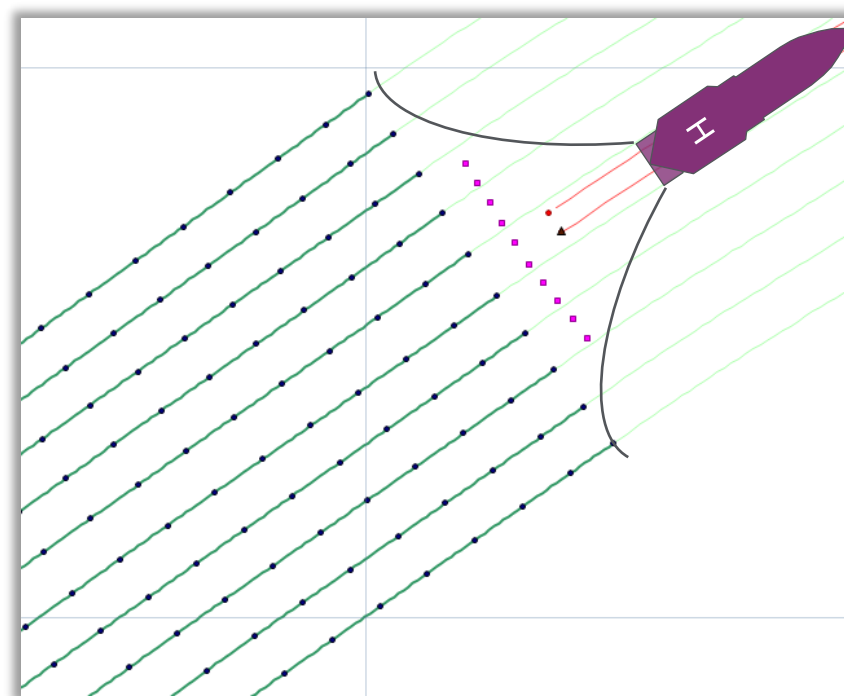
GEODETIC COORDINATE REFERENCE SYSTEM
(Coordinates: Latitude, Longitude)

PROJECTED COORDINATE REFERENCE SYSTEM
(Coordinates: Easting, Northing)

Getting from the Real World to the Bin Grid

Getting from the Real World to the Bin Grid
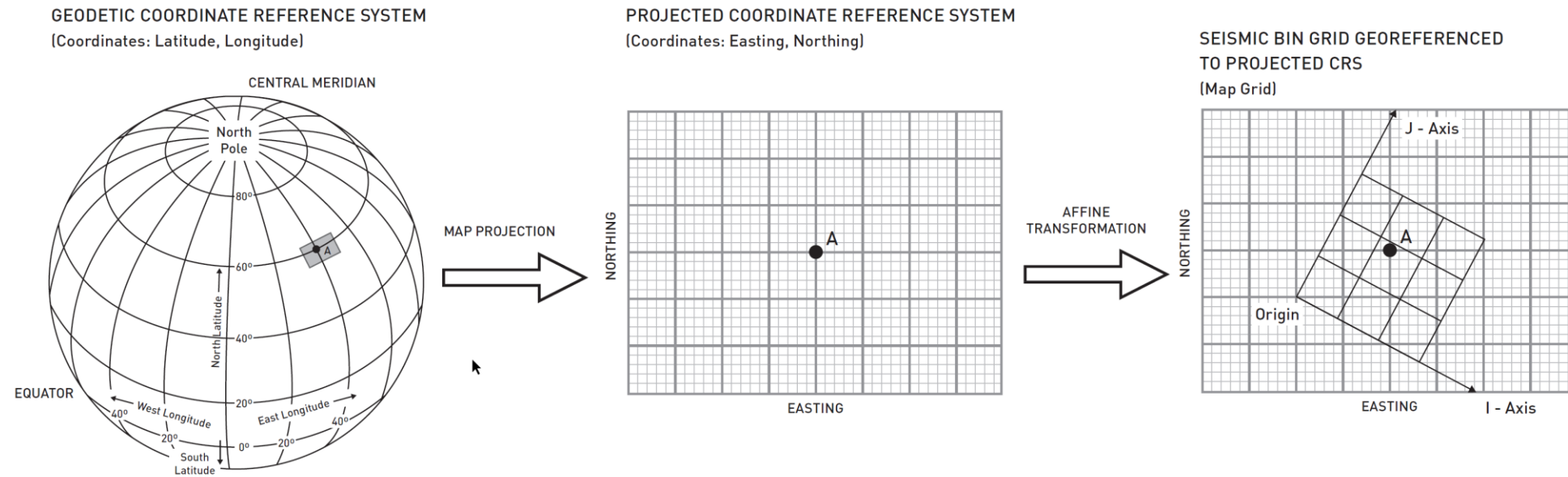
Getting from the Real World to the Bin Grid
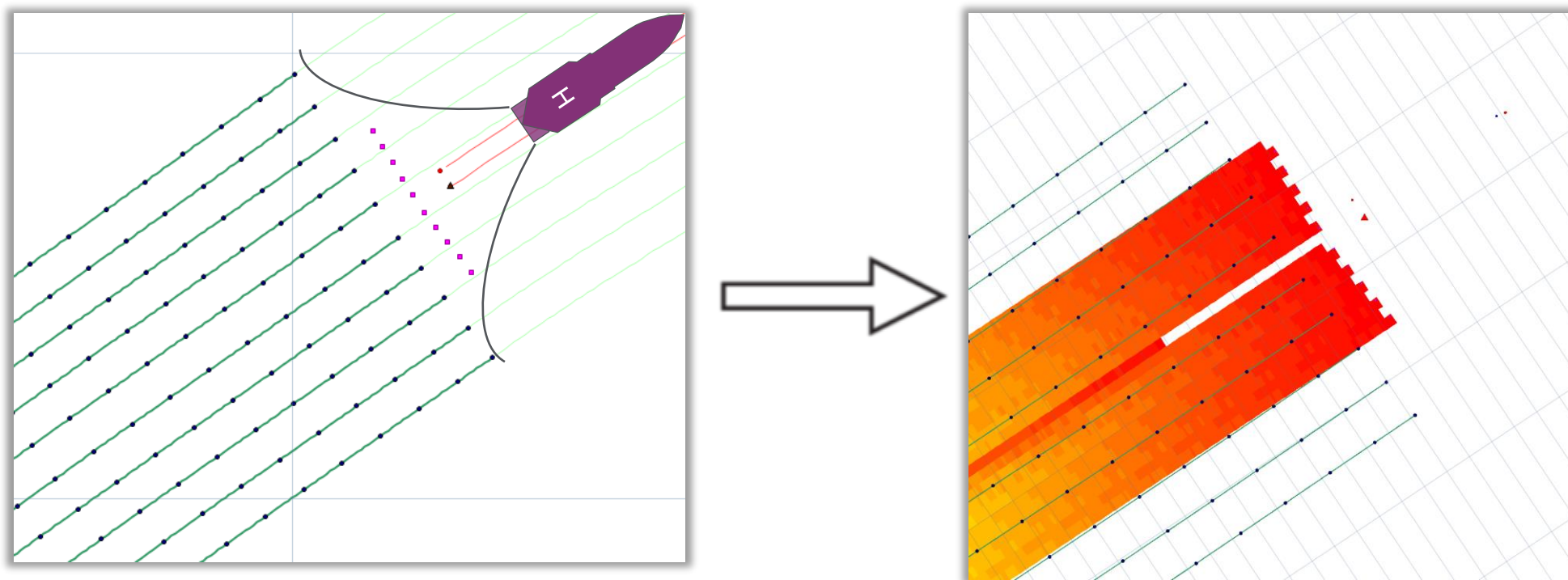
Getting from the Real World to the Bin Grid
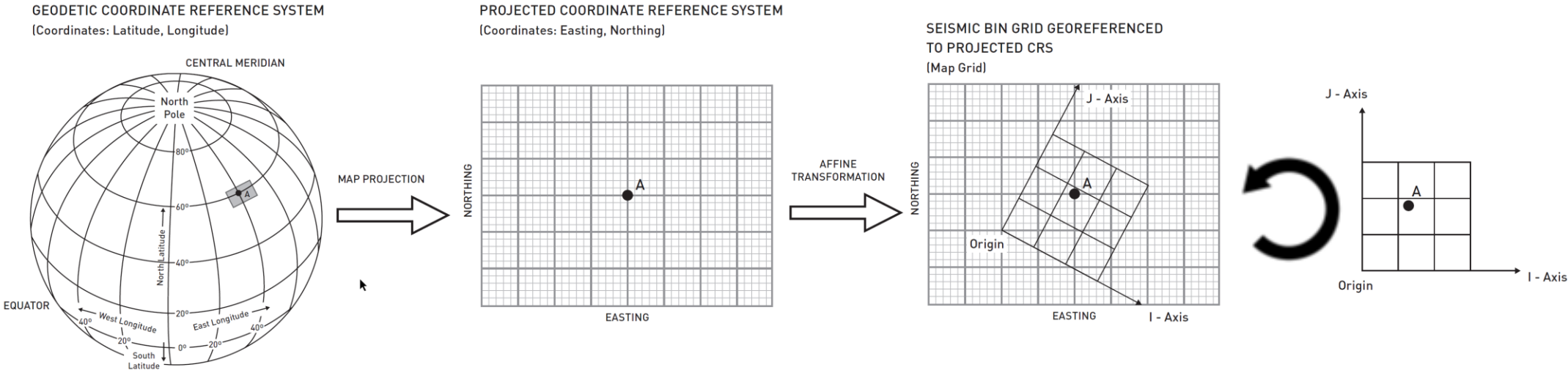
Getting from the Real World to the Bin Grid
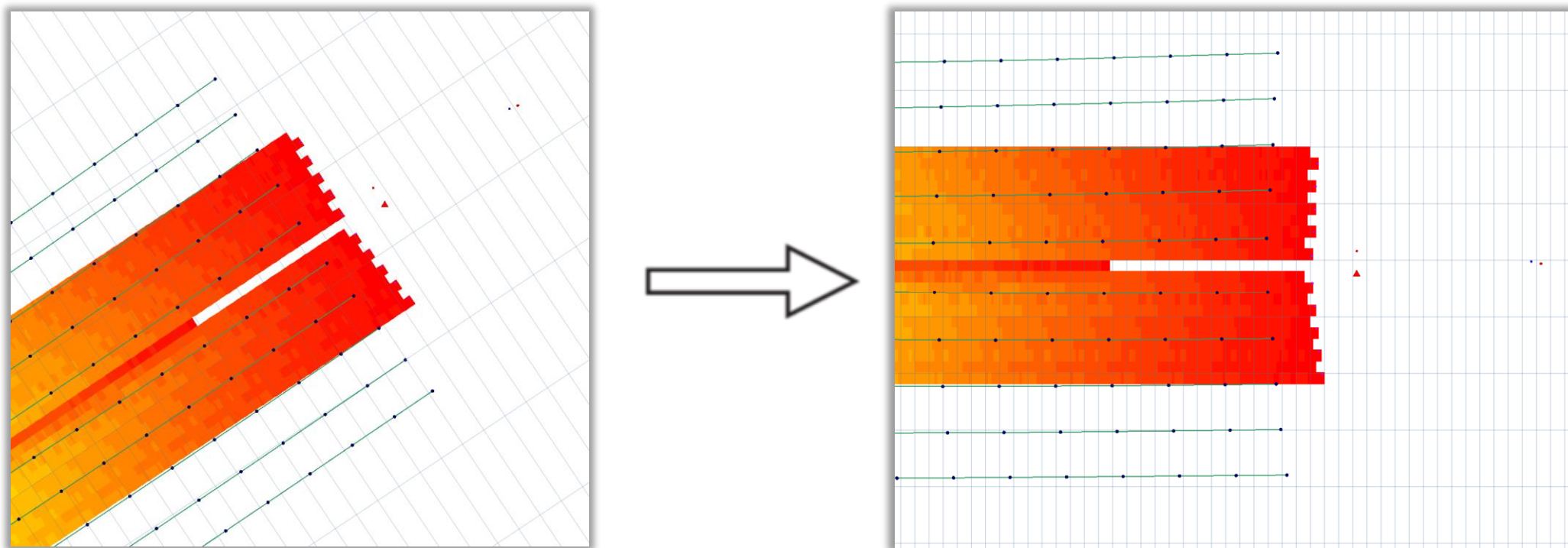
Rotation can be in either sense

An Overview of the P6/11 Format

define

location

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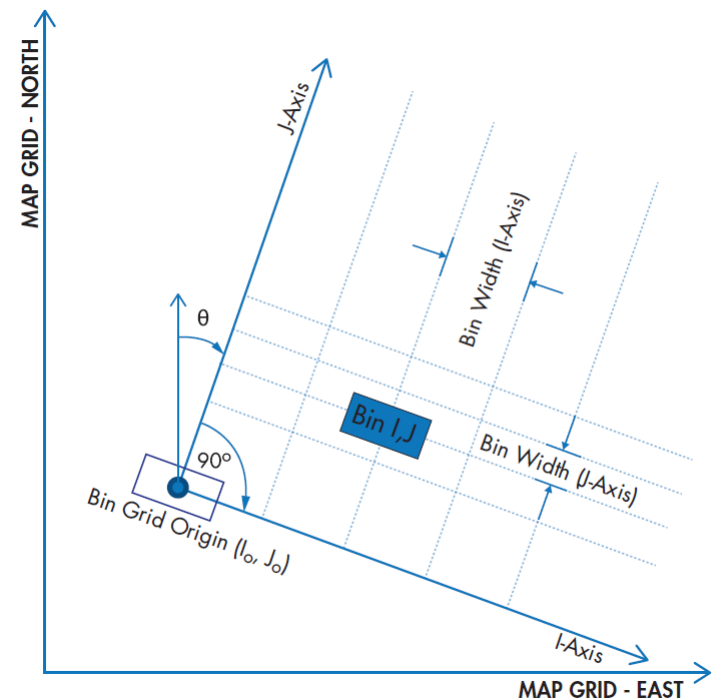
Purpose of the P6/11 Format

- Exchange information about the bin grid acquired during a geophysical survey.

- Provide a standard format for data exchange

- Tie the bin grid back to the original acquisition geodesy.

- Record the history of any changes made to the bin grid during reprocessing or merging of surveys.

- Store and exchange additional information relating to a bin, such as water depth, fold, amplitude attributes, 4D attributes or time to a horizon.

History of the P6/11 Format

- P6/11 was developed to replace the old P6/98 format

- It replaces both the legacy P6/98 bin grid data exchange format and also the UKOOA P1/90 data exchange format (when used as a bin centre data exchange format).

- Aligned with Px/11 family of products

- Development took over 3 years, with publication in 2012

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Documents

- Format Definition
  - IOGP Ref: 483-6/1
  - Version 1.1 (June 2017)

OGP P6/11 Seismic bin grid data exchange format

positioning   integrity

Documents

- ## User Guide
  - IOGP Ref: 483-6u
  - Version 1.0 (Sept 2019)
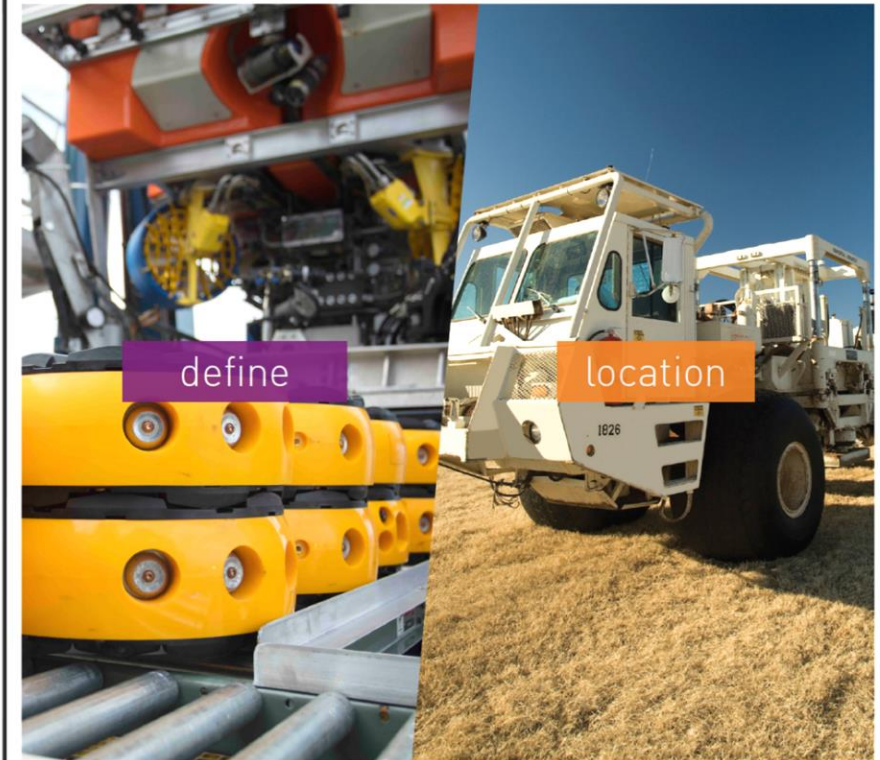
Documents

- GIS Data Model
  - IOGP Ref: 483-6g
  - Version 1.0 (July 2013)
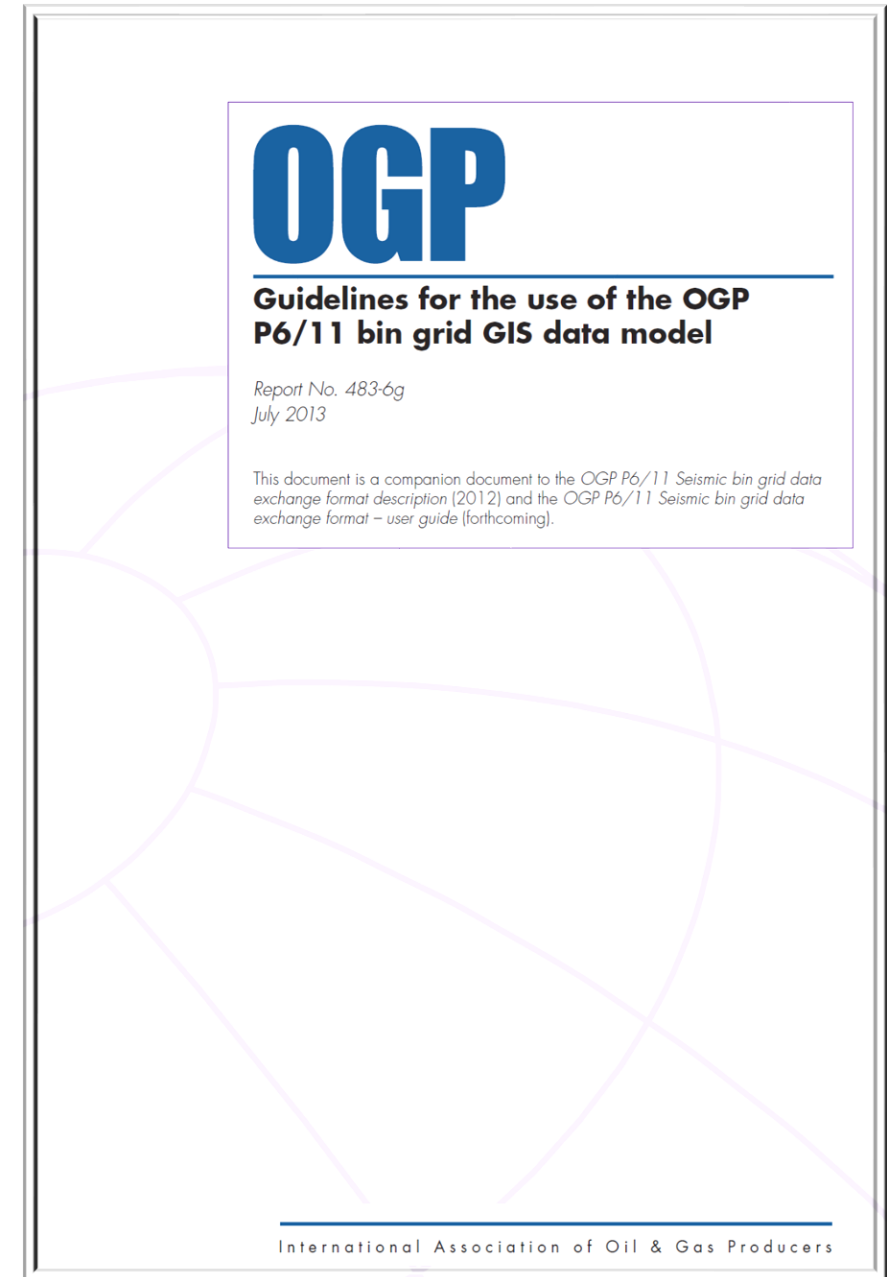
Uses of the P6/11 Format

- The planning and execution of seismic data acquisition operations

- From seismic data processing, loading and interpretation steps, where the resulting deliverable is intended to be exchanged for further use, or visualised, such as:
  - Data processing
  - Data management (reprocessing, loading, merging surveys, etc.)
  - Interpretation

- Used in data management systems alongside the seismic data

- Used in GIS to manage and map seismic position data and bin grids

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High Level Overview of the Format

File Identification Record

Survey Summary Info

Units of Measure

Time Reference Systems

Coordinate Reference Systems

File Contents Definition

Perimeters

Bin Node Positions (B6)

Geospatial Integrity

- Header Integrity: Ensuring the header on the P6/11 file contains the correct information to reference the data contained in the file back to the real world.

- Data Integrity: Using Parameter Check Points to ensure the format is correctly set up

- Non-linear Grids: Ensure all grid locations can be specified if required.

- Retain Configuration History

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Header Integrity

- P6/11, in common with all the Px/11 formats, uses the concept of a fully described definition of the geodetic parameters, including all referenced unit-of-measure definitions.

- The format uses the structure of the EPSG Dataset, but requires all geodetic parameters to be listed, along with the reference to the data source.

HC,1,3,0: Coordinate Reference System Implicit Identification

Field	Description	Data Type	Reference Code	Value
5	"CRS Number/EPSG Code/Name/Source"	Description		CRS Number/EPSG Code/Name/Source
6	CRS Number	Integer	CRSREF	1
7	EPSG CRS Code	Integer		32628
8	CRS Name	Text		WGS 84 / UTM zone 28N
9	Version of EPSG Database referenced	Text		7.6
10	Date of EPSG Database referenced	Date		2010:11:02
11	Source of EPSG Database referenced	Text		EPSG
12	Any Other Details	Text		

HC,1,1,0: Units of Measure Definition

Field	Description	Data Type	Reference Code	Value
5	"Unit of Measure"	Description		Unit of Measure
6	Unit Number	Integer	UNITREF	5
7	Unit Name	Text		second
8	Quantity Type Name	Text		time
9	Format Reference	Integer	DATATYPEREF	12
10	Base Unit Number	Integer	UNITREF	
11	Conversion Factor A	Float		
12	Conversion Factor B	Float		
13	Conversion Factor C	Float		
14	Conversion Factor D	Float		
15	Description	Text		second
16	EPSG Unit Code	Integer		
17	Source Description	Text		POSC UOM Dictionary
18	Source Version Details	Text		2.2
19	Source Unit Code	Text		s

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Data Integrity

- The P6/11 format has a number of check values that can be included to ensure software reading the files can validate that the parameters have been correctly written into the format.

HC,1,9,0: Example Point Conversion

Field	Description	Data Type	Reference Code	Value
5	"Example Point Conversion"	Description		Example Point Conversion
6	Point number	Integer		1
7	Point Name	Description		Satellite to Survey Test Point
8	CRS Number	Integer	CRSREF	1
9	Coordinate 1	Variant		0.79037639
10	Coordinate 2	Variant		6.83307611
11	Coordinate 3	Variant		
12	CRS Number	Integer	CRSREF	2
13	Coordinate 1	Variant		0.79037639
14	Coordinate 2	Variant		6.83307611
15	Coordinate 3	Variant		
16	CRS Number	Integer	CRSREF	3
17	Coordinate 1	Variant		258840.55
18	Coordinate 2	Variant		87423.34
19	Coordinate 3	Variant		

Good Practice (17): Provide example conversions for all defined conversions and transformations in [HC,1,9,0] records.

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Data Integrity (cont)

- The ability to check data is also carried through into the data records, where information is written in a number of different geodetic systems to allow for integrity checking

M6: Survey Perimeter Positions

Field	Description	Data Type	Reference Code	Value
3	Perimeter Number	Integer	PERIMREF	1
4	Point Group Number	Integer		1
5	Point Number	Integer		1
6	Segment Computation Method	Integer		1
7	CRS 1 Coordinate 1	Variant		1398.50000000
8	CRS 1 Coordinate 2	Variant		1028.16656605
9	CRS 1 Coordinate 3	Variant		
10	CRS 2 Coordinate 1	Variant		405032.56
11	CRS 2 Coordinate 2	Variant		9206333.85
12	CRS 2 Coordinate 3	Variant		
13	Record Extension Fields	Additional Field List		

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Record Good Practice

File Identification Record

Survey Summary Info

Units of Measure

Time Reference Systems

Coordinate Reference Systems

File Contents Definition

Perimeters

Bin Node Positions (B6)

Good Practice (15): Use the defined P6/11 header records to document the purpose, status and applicability of the file.
- OGP File Identification Record
- H6,0,0,0 File Contents Description
- H6,0,1,0 File Processing Details
- H6,0,2,0 File Contents Attribute.

Good Practice: Include all available optional record and field types

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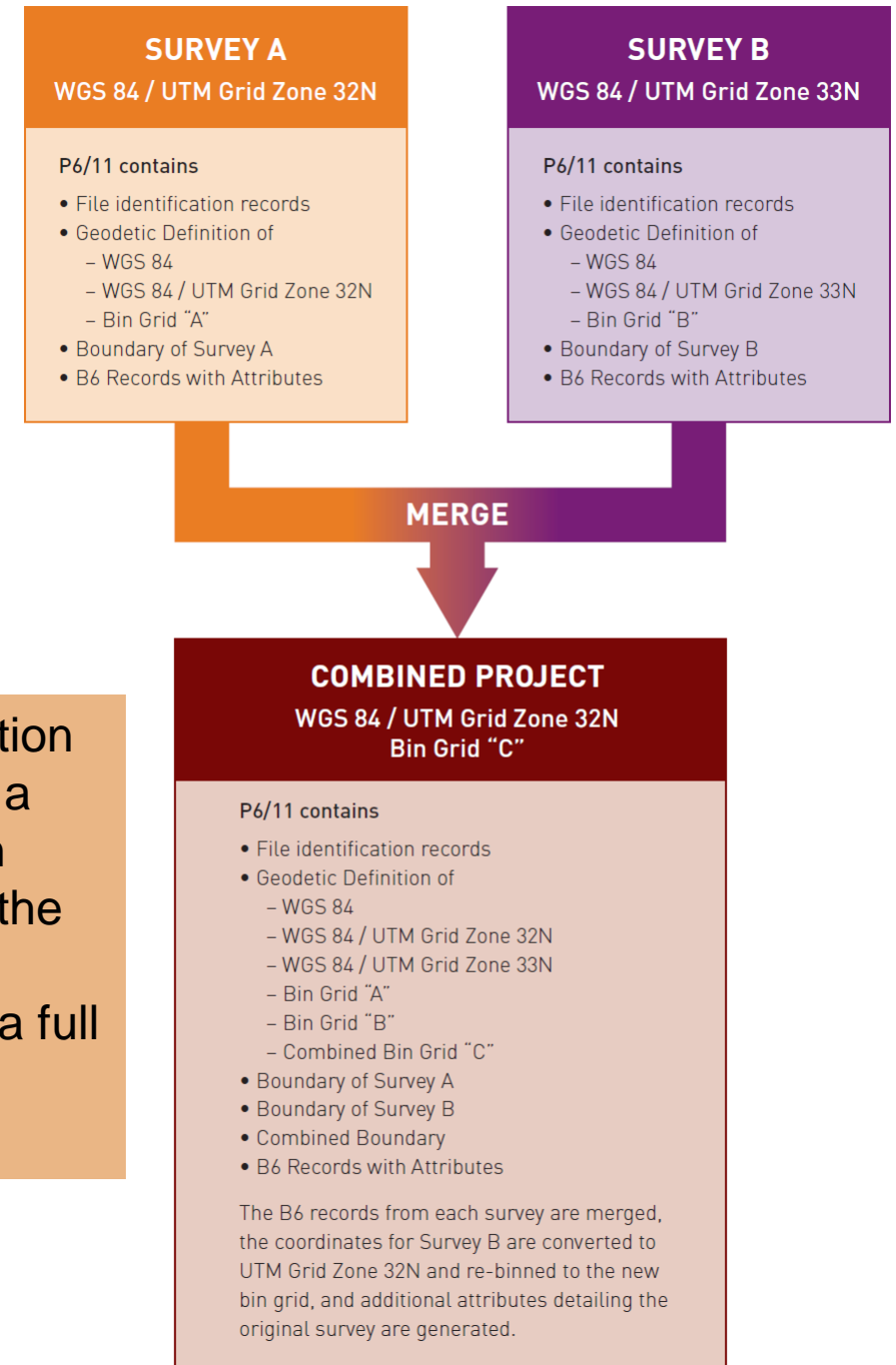
Audit Trail

- Keeping the information from previous surveys allows for a full audit trail and avoids information being lost
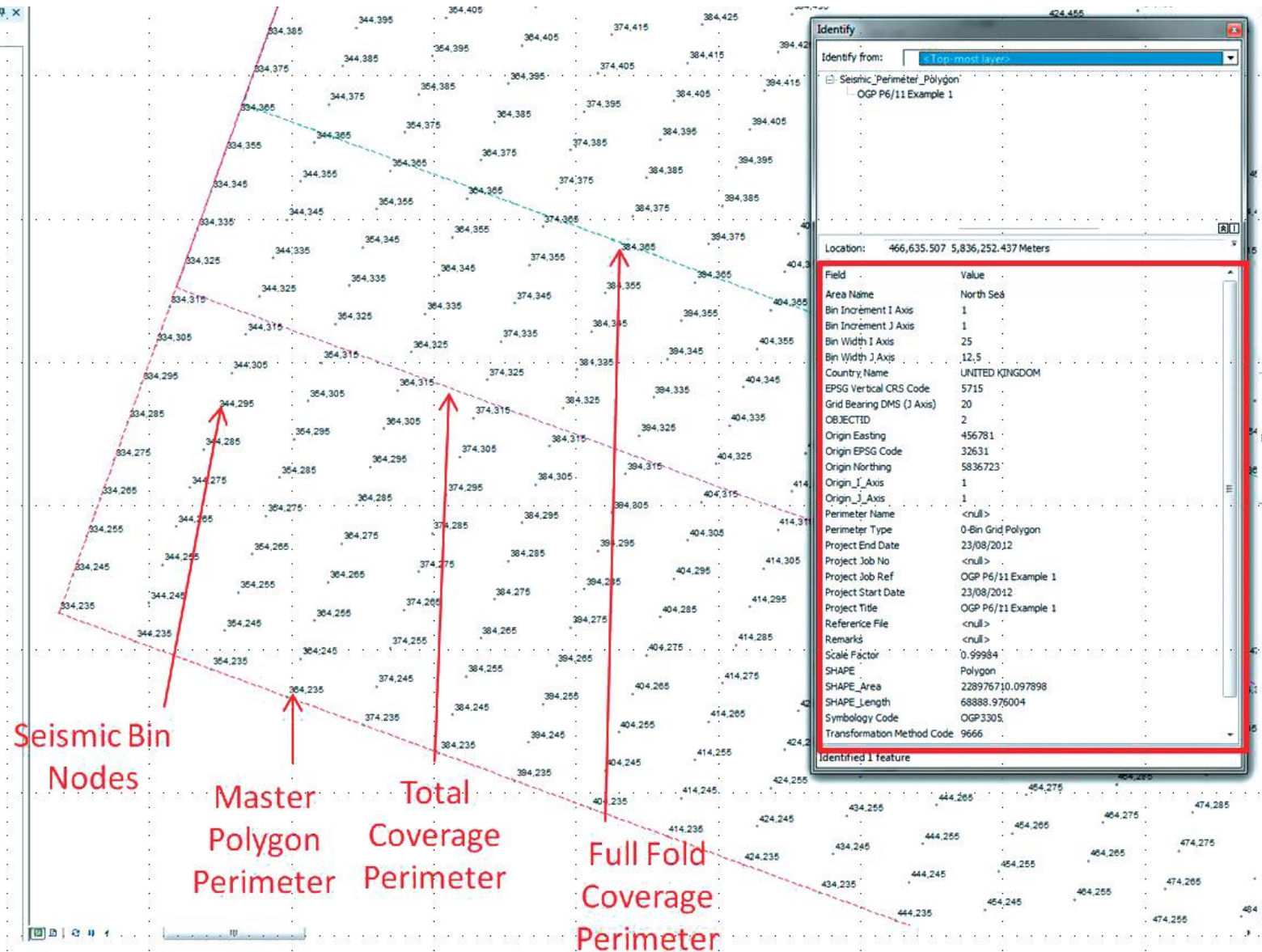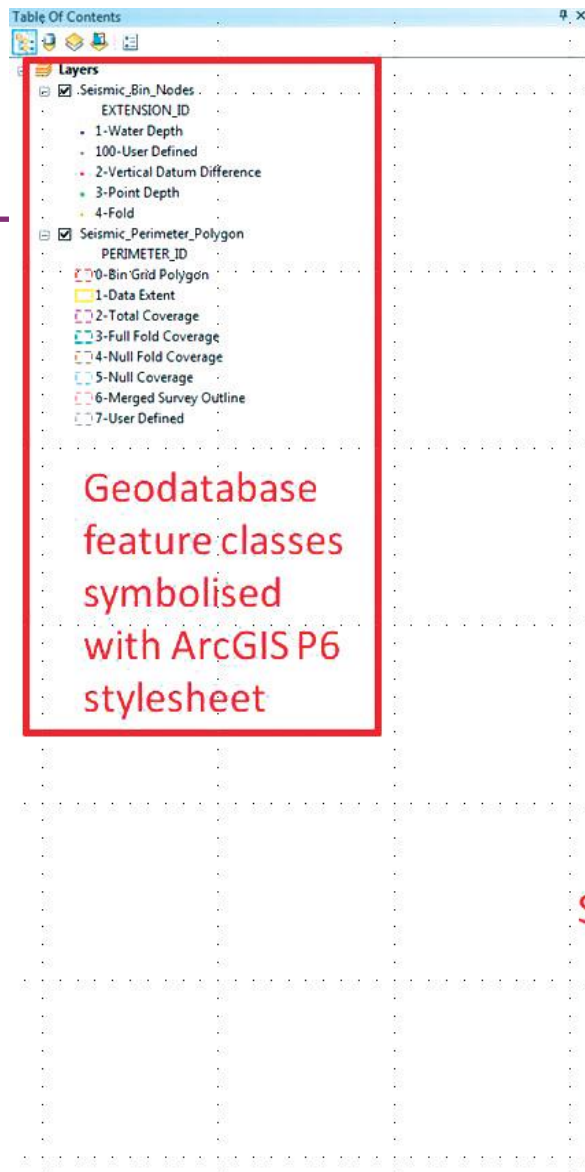
Good Practice: Knowledge of how the in-house geoscience application handles reprojection of seismic bin grids is critical when attempting a conversion of a bin grid. Since most applications can only work with rectilinear gridded data, they will use an implicit method to perform the reprojection. The resulting effect on the spatial integrity of the data should be understood. To avoid irreversible loss of spatial integrity, a full bin centres file should be produced, for archiving as the reference dataset and for any further exchange of data.

SURVEY A
WGS 84 / UTM Grid Zone 32N

P6/11 contains
- File identification records
- Geodetic Definition of
  – WGS 84
  – WGS 84 / UTM Grid Zone 32N
  – Bin Grid "A"
- Boundary of Survey A
- B6 Records with Attributes

SURVEY B
WGS 84 / UTM Grid Zone 33N

P6/11 contains
- File identification records
- Geodetic Definition of
  – WGS 84
  – WGS 84 / UTM Grid Zone 33N
  – Bin Grid "B"
- Boundary of Survey B
- B6 Records with Attributes

MERGE

COMBINED PROJECT
WGS 84 / UTM Grid Zone 32N
Bin Grid "C"

P6/11 contains
- File identification records
- Geodetic Definition of
  – WGS 84
  – WGS 84 / UTM Grid Zone 32N
  – WGS 84 / UTM Grid Zone 33N
  – Bin Grid "A"
  – Bin Grid "B"
  – Combined Bin Grid "C"
- Boundary of Survey A
- Boundary of Survey B
- Combined Boundary
- B6 Records with Attributes

The B6 records from each survey are merged, the coordinates for Survey B are converted to UTM Grid Zone 32N and re-binned to the new bin grid, and additional attributes detailing the original survey are generated.

Usage in GIS

- A GIS data model has been developed and published by IOGP to visualise the contents of the P6/11 file in a GIS environment. This P6 GIS Data Model (P6DM) consists of 2 feature classes, one to store the various survey outline and coverage perimeters (polygons) and one for the bin nodes (points). Attributes associated with these features may be used to store and retrieve information and data related to the perimeters and bin nodes .

Good Practice: Checking the correct location of the seismic data during data loading should include use of GIS to map and visualise the seismic bin grid and survey and coverage perimeters; any discrepancies found should be resolved before any further data analysis is undertaken.

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Geodatabase feature classes symbolised with ArcGIS P6 stylesheet

Seismic Bin Nodes

Master Polygon Perimeter

Total Coverage Perimeter

Full Fold Coverage Perimeter

P6/11 during the Seismic Data Lifecycle

P6/11 during the Seismic Data Lifecycle

- Planning

- Data Acquisition

- Data Processing

- Loading and Interpretation

- Merging and Reprocessing

- Archival and Storage, including any later cycles of further data re-processing, loading, interpretation and merging

Planning

- During the planning phase an initial P6/11 file should be produced to define unambiguously where data will be acquired.

- This should include a complete explicit geodetic definition, definition of the proposed bin grid, and identification of full fold area, operational area, restricted/obstructed areas, exclusion zones, etc.

- This planning file is the basis of the bin grid audit trail. It can be visualised within a GIS and can be used in setting up the field equipment.

Good Practice: The initial P6/11 file should be produced as a prerequisite for the acquisition stage of a project, potentially through use of seismic survey planning software.

Seismic Data Acquisition

- During the data acquisition phase, subsequent operational changes to the planned survey should be *appended* to the P6/11 file to record the audit trail, document the geographic location of the final field data and associated products, and maintain the geospatial integrity of the data. Typically, these changes will be confined to the bin grid geometry and should not involve modifications to the geodetic parameters.

Good Practice: The final field data deliverables should include the updated acquisition P6/11 file.

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Seismic Data Processing

- If processing is undertaken at a separate location to the field data acquisition, the acquisition P6/11 file should accompany the delivery of field data to the processing centre. Its function as a data exchange format is to define unambiguously the geographic location of the binned seismic data and the geometry of the bin grid.

Good Practice: P6/11 files accompanying the field data should be checked as part of the processing centre's verification process

Good Practice: A P6/11 file, with a complete audit trail and all bin grids defined, should be delivered with any relevant dataset, e.g. seismic, bathymetry, velocity, fold, etc., to document the file contents, purpose, bin grid audit trail, and related datasets.

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Seismic Data Loading & Interpretation

- Initial loading of seismic data into a geoscience workstation environment, for subsequent interpretation, comparison or merging with associated data, requires knowledge of the potential pitfalls, and a good process, to ensure that its geospatial integrity is preserved.

- Many proprietary seismic data loading forms are used. These are typically simple, manually compiled forms, and prone to errors, responsible for loss of geodetic integrity in loaded datasets.

- A verified P6/11 file provides robust data loading QC - a standard format with all information necessary to reliably transfer the data to the workstation at its true real world positions.

Good Practice: A P6/11 file should be used to define the geographic location and geometry of the bin grid when loading 3D seismic data.

Good Practice: The input P6/11 file should be verified to ensure that the data is traceable to its origins whenever data is loaded.

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Merging and Reprocessing of Seismic Data

- It is common practice to merge individual 3D surveys to create larger or regional mega-surveys. This may involve re-binning of some datasets to make them compatible with the end product. When seismic data are combined from different sources, data managers and users need to be aware of the potential corruption to the spatial integrity of the end product if insufficient attention is paid to the geodetic properties of the constituent datasets. The audit trail in the P6/11 accompanying each dataset will help to manage this and can be used to prevent the inadvertent merging of incompatible datasets, or the loss of spatial integrity of one or more of the datasets being merged.

Good Practice: On completion of the merging operation, produce a P6/11 file, containing an audit trail to document the origin and location of all constituent surveys, as well as a CRS and bin grid for the resulting end product.

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Survey Reprojection

- Care must be taken when a survey is reprojected.

- Reprojection will introduce distortion as points on a regularly spaced grid in one projection will not be regular or orthogonal in another
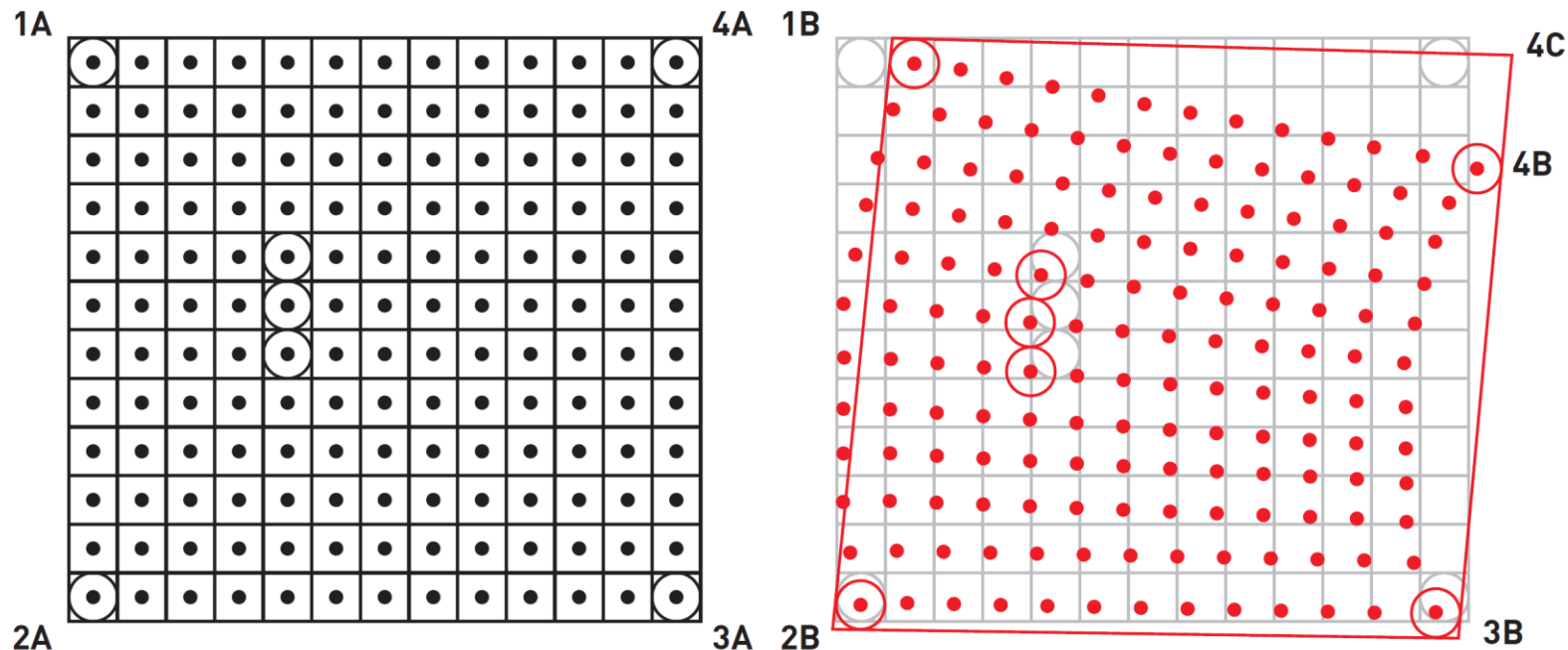
Survey Reprojection (cont)

- The scale and extent of distortion varies depending on number of factors, and can be significant in severe examples. The resultant degradation of spatial integrity should be modelled/visualised to establish whether or not it could impact the project
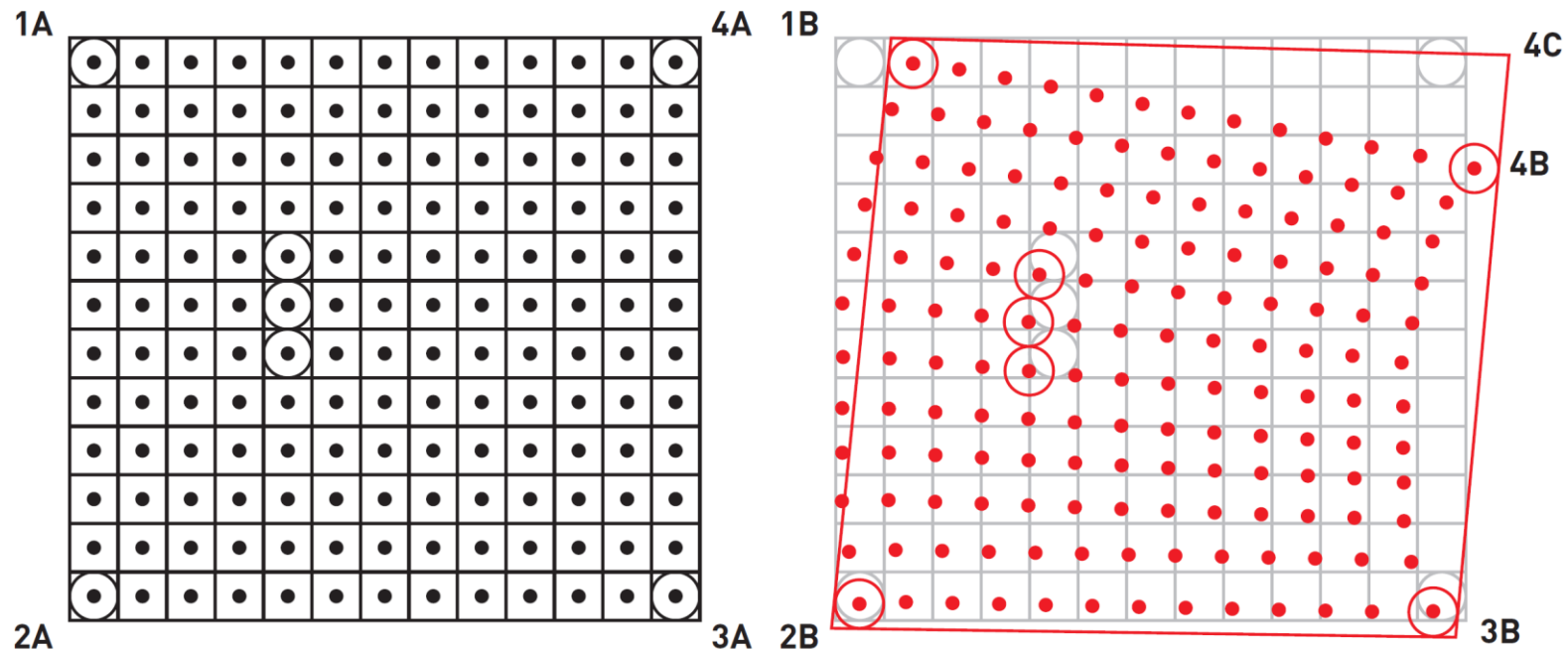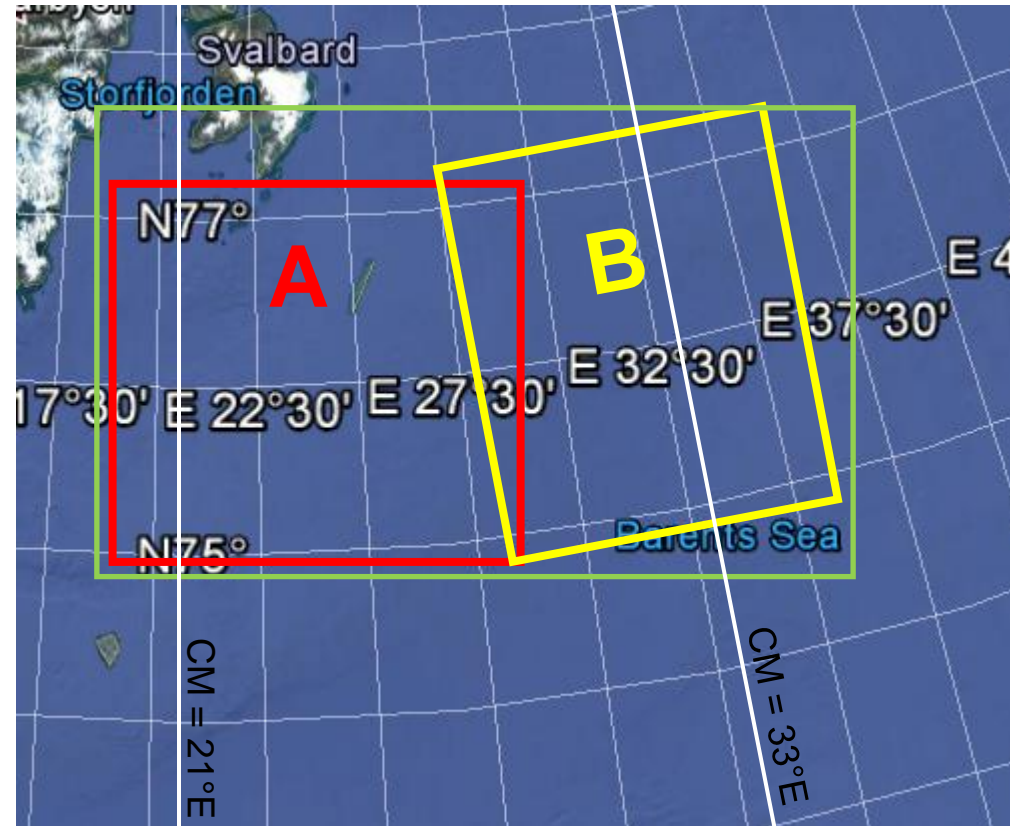
Bin Grid Reprojection Example

Reprojection Example - Two 3D Surveys

New bin grid resulting from merge of Surveys A & B

Survey A: Acquired (and binned) on WGS 84/UTM 34N (CM = 21°E)
Survey B: Acquired (and binned) on WGS 84/UTM 36N (CM = 33°E)

Merge Surveys

- The best result would be achieved by re-binning original field data from Surveys A & B in a common CRS to produce a merged dataset

However...

- Workstations offer the option to 'reproject' a bin grid
  - These come at a price – the geospatial integrity of the data

- In the workstation, surveys A & B are to be merged by converting Survey B to the same projection as Survey A

  - UTM 36N converted to UTM 34N
  - No change of datum (WGS 84)
  - Bin grid reprojection and merge procedures default to methods particular to the workstation
  - What are those methods and how do they impact the geospatial integrity of the seismic data?

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Survey B Original Bin Grid

- Regularly spaced rectilinear bin grid:
  - In-line direction 90° = I axis (I=J+90°)
  - In-line length 188.225 kms (grid distance)

  - X-line direction 0° = J axis
  - X-line length 223.225 kms (grid distance)
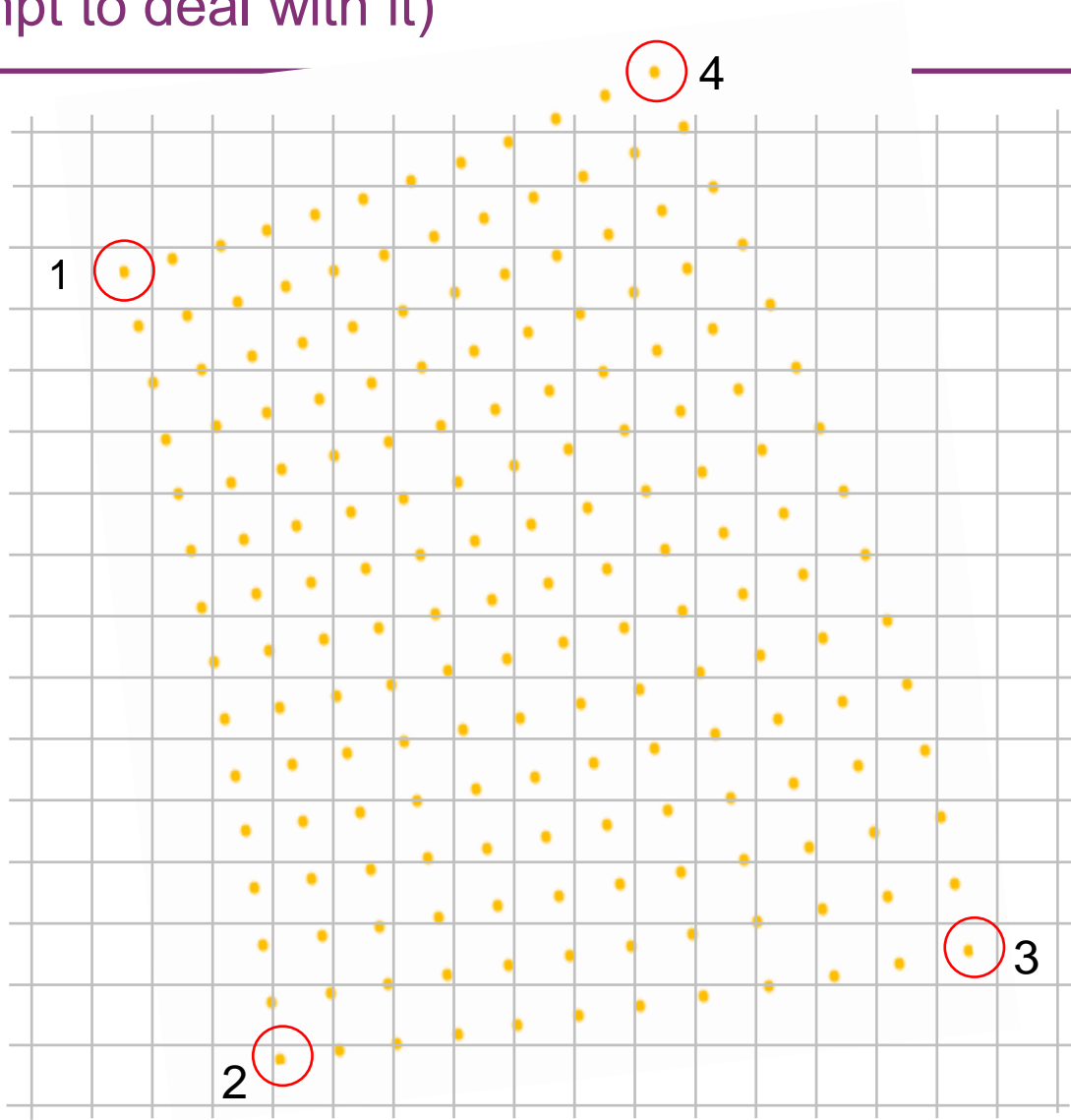
  - Bin dimension 25m x 25m

WGS 84/UTM 36N
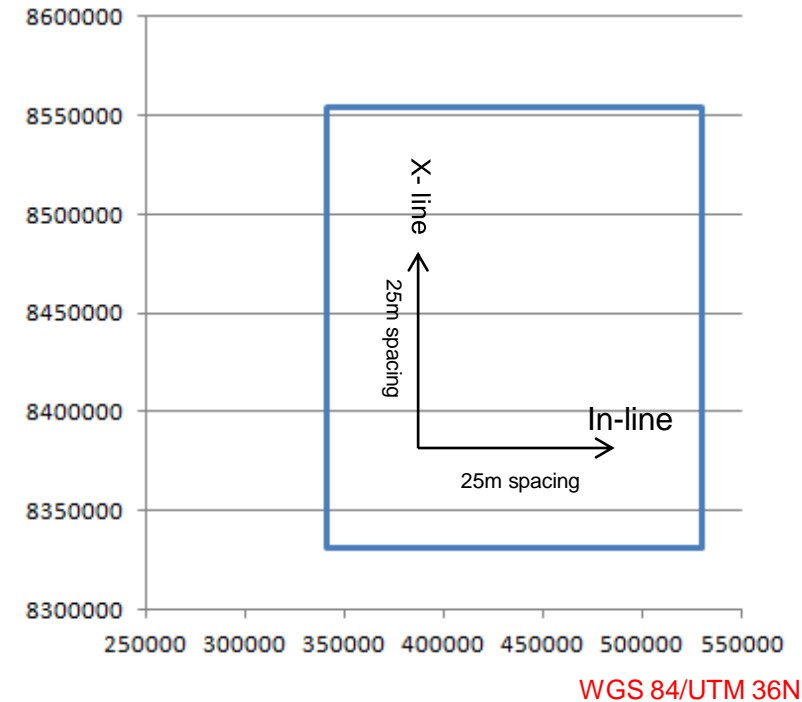
Geoscience applications require bin grids to be rectangular (have orthogonal axes)
Binning the data on the acquisition projection is compliant with this

Distortion effect after Conversion
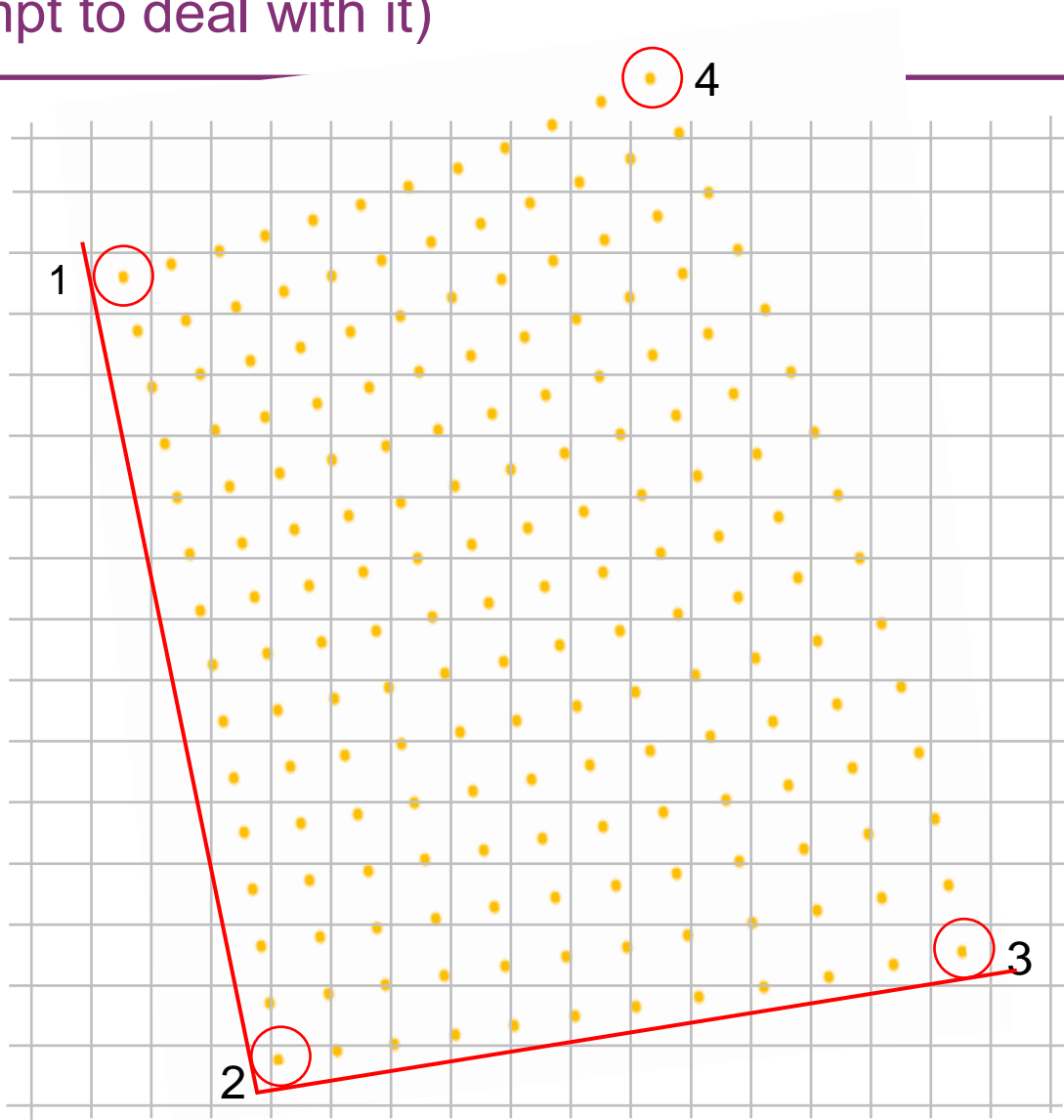## (and 'skew parallelogram' method attempt to deal with it)

- Bin centres on the target CRS (UTM 34N) if individually reprojected

- 4 — True position of corner 4

- Target bin grid

(Distortion exaggerated for effect)

Distortion effect after Conversion
(and 'skew parallelogram' method attempt to deal with it)

Legend:
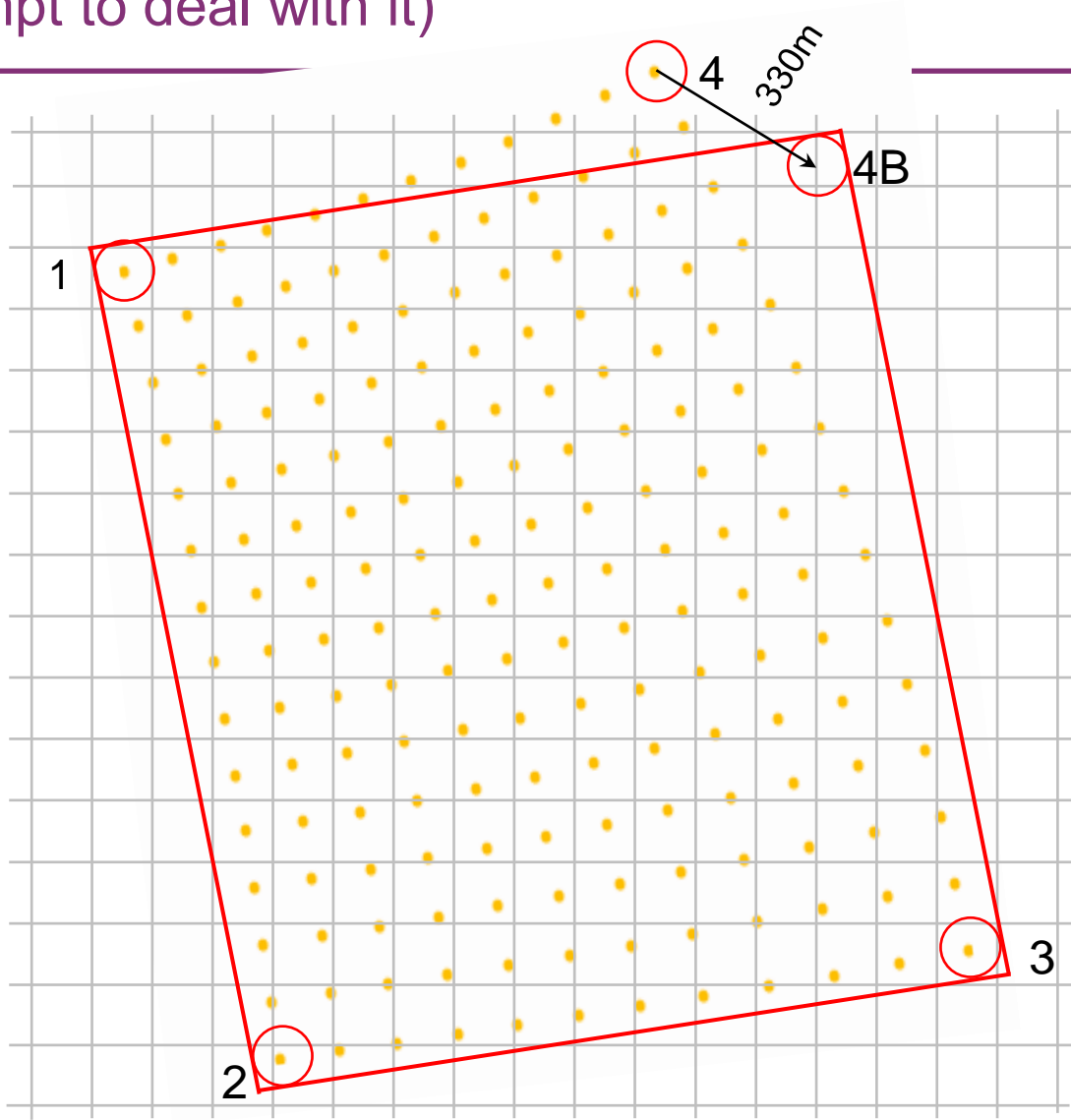- Bin centres on the target CRS (UTM 34N) if individually reprojected
- True position of corner 4
- Target bin grid
- Parallelogram constructed from corners 1,2 & 3 to locate the 4th corner

(Distortion exaggerated for effect)

Distortion effect after Conversion
(and 'skew parallelogram' method attempt to deal with it)

Bin centres on the target CRS (UTM 34N) if individually reprojected

True position of corner 4

Target bin grid

Parallelogram constructed from corners 1,2 & 3 to locate the 4th corner

4B Computed position of corner 4

53 *(Distortion exaggerated for effect)*

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Distortion effect after Conversion
(and 'skew parallelogram' method attempt to deal with it)

Bin centres on the target CRS (UTM 34N) if individually reprojected

True position of corner 4

Target bin grid

Parallelogram constructed from corners 1,2 & 3 to locate the 4th corner

4B Computed position of corner 4

Matrix of bin centres on the target map grid after alignment to the parallelogram

An affine transformation converts the matrix of bin centres to the target bin grid (UTM 34N E/N > bin grid i/j conversion operation) for merging with Survey A

This implicit method should be used with caution and awareness of its effects. Commonly used in geoscience applications.
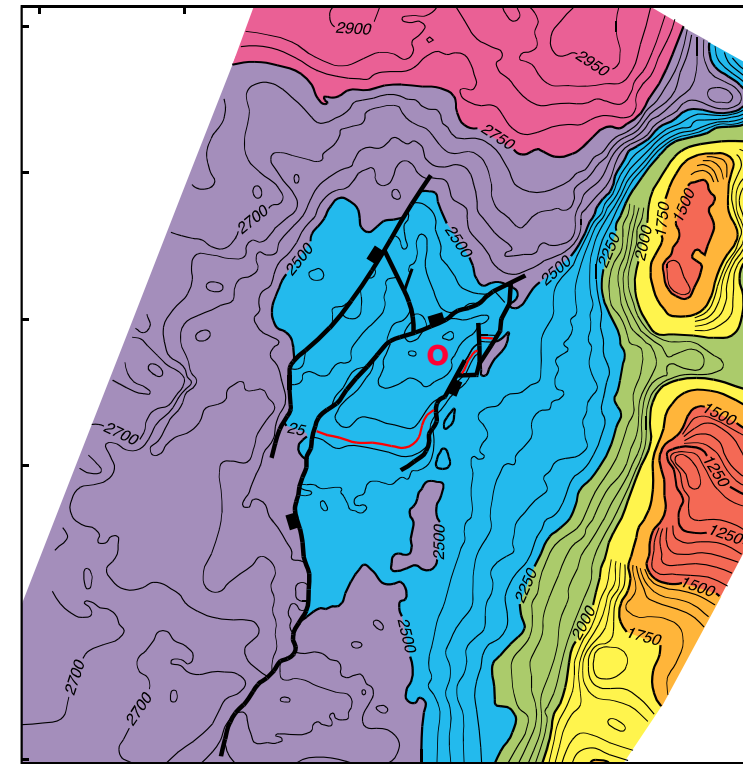
(Distortion exaggerated for effect)

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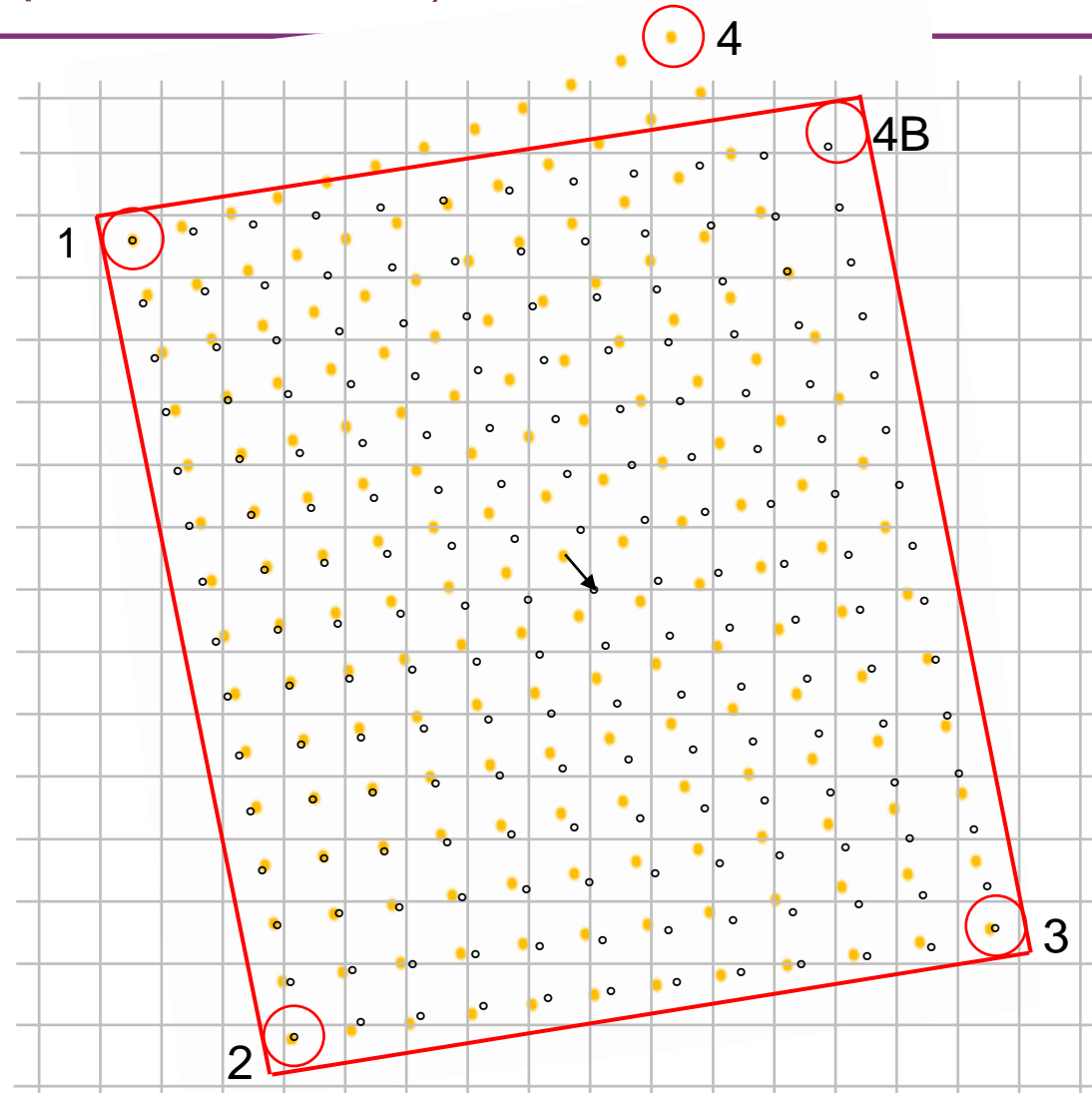
A consequence of a seismic data loading error

Partner B map
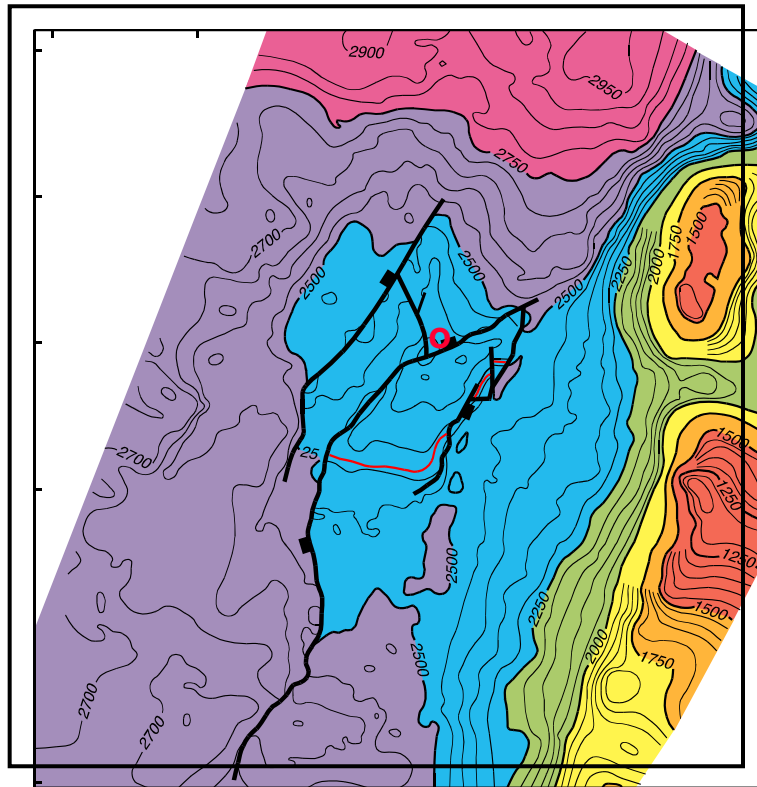
Grid north (UTM zone 36N)

Data interpreted on original CRS, well location picked at structural high.
Lat/long of proposed well passed to Partner A

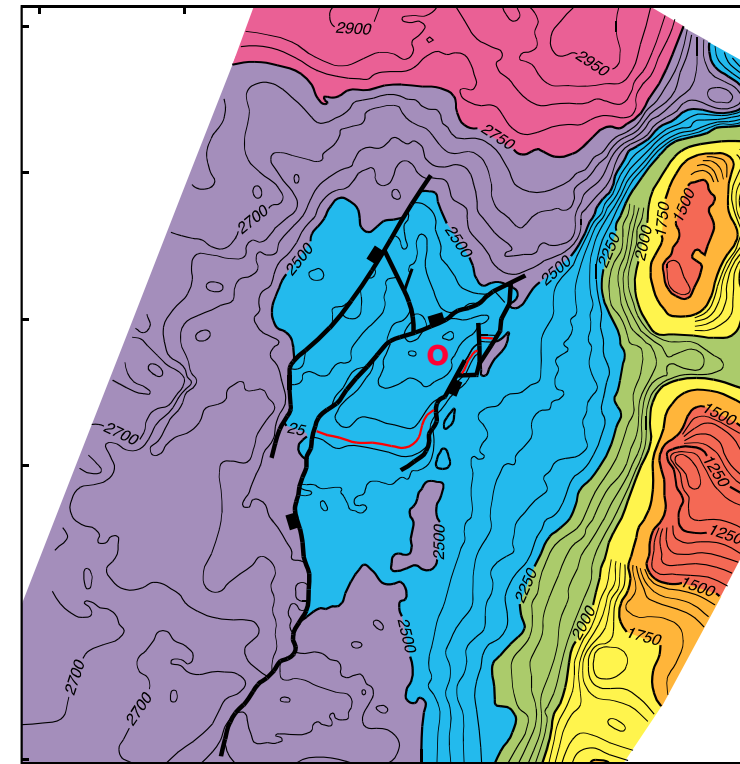# A consequence of a seismic data loading error

Partner A map

Grid north (UTM zone 34N)

Bin grid reprojected to UTM 34N map grid. Structure now mislocated to SE. Well loc'n converted directly from lat/long coordinates

Partner B map

Grid north (UTM zone 36N)

Data interpreted on original CRS, well location picked at structural high. Lat/long of proposed well passed to Partner A

A Better Implicit Adjustment (1)

4 corner points converted to target projection. This results in:

- Survey rotated by c. -11.65° with respect to GN on target map grid

- Bin grid axes no longer orthogonal or straight lines

- Bin cell dimensions no longer regular or constant
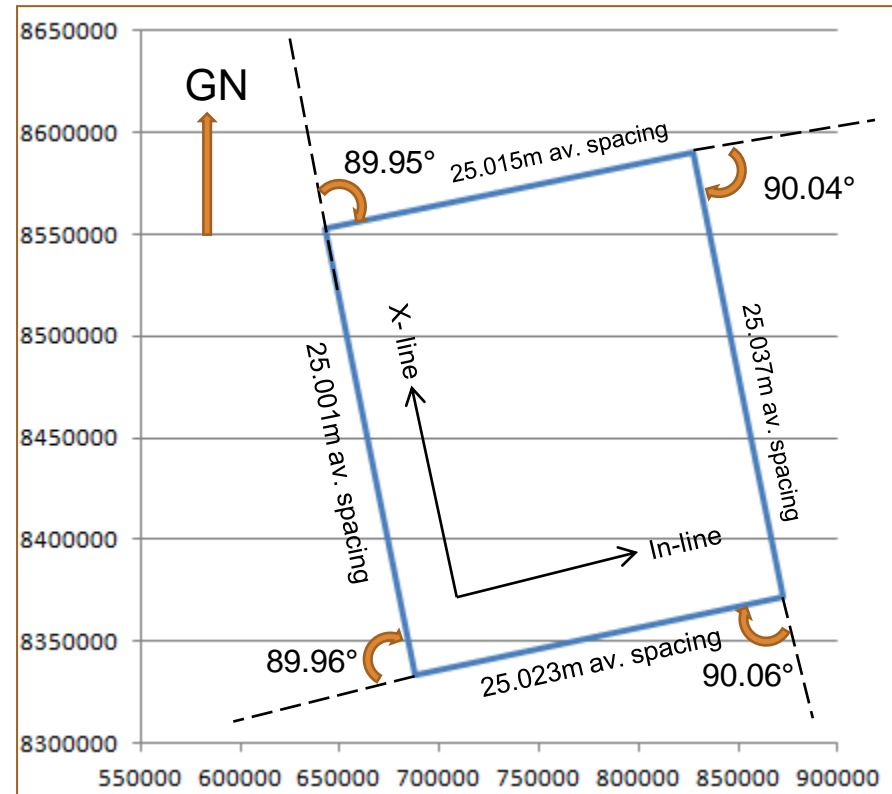
WGS 84/UTM 34N

A Better Implicit Adjustment (2)

- Geoscience applications require a bin grid to be rectangular (have orthogonal axes)

- Adjustment method applied: "4 point optimized best fit grid"

  - *4 corner points converted to target projection UTM 34N (as seen on last slide)*

  - Bearings between corner points averaged and adjusted to orthogonal

    - *Ideally using least squares method to minimise residuals of corner coordinates*

  - This also regularises bin cell dimensions to rectangular

  - Centre of adjusted polygon fixed at CoG of unadjusted polygon to minimise mislocation at centre of bin grid

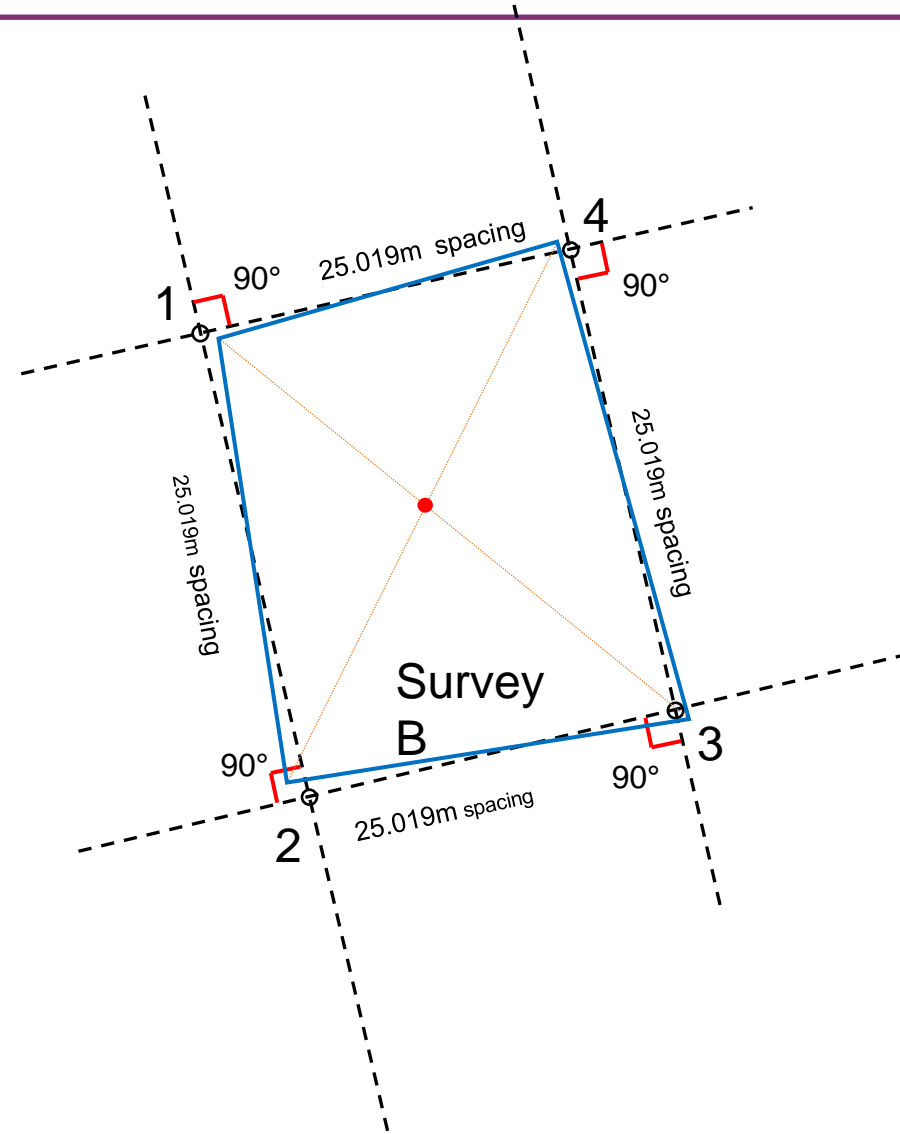   - *This shifts greatest mislocation towards the corners*

This is demonstrated in next diagram...

Axes Adjusted to Orthogonal

- Bearings between corner points averaged and adjusted to orthogonal

- Centre of adjusted polygon fixed at CoG of unadjusted polygon (●)

- New regularised bin cell dimensions generated as a result of this process

	Changes		
Corner	ΔN	ΔE	ΔD
1	82	-13	83
2	-74	42	85
3	82	-19	84
4	-70	43	83

A matrix of bin centres is calculated within the adjusted polygon.

Note: This implicit adjustment method is more robust than some in common use

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	ΔN	ΔE	ΔD
1	82	-13	83
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3	82	-19	84
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A matrix of bin centres is calculated within the adjusted polygon.

Mislocation may be significant but is minimised at centre of bin grid by aligning polygons at their CoGs

Note: This implicit adjustment method is more robust than some in common use
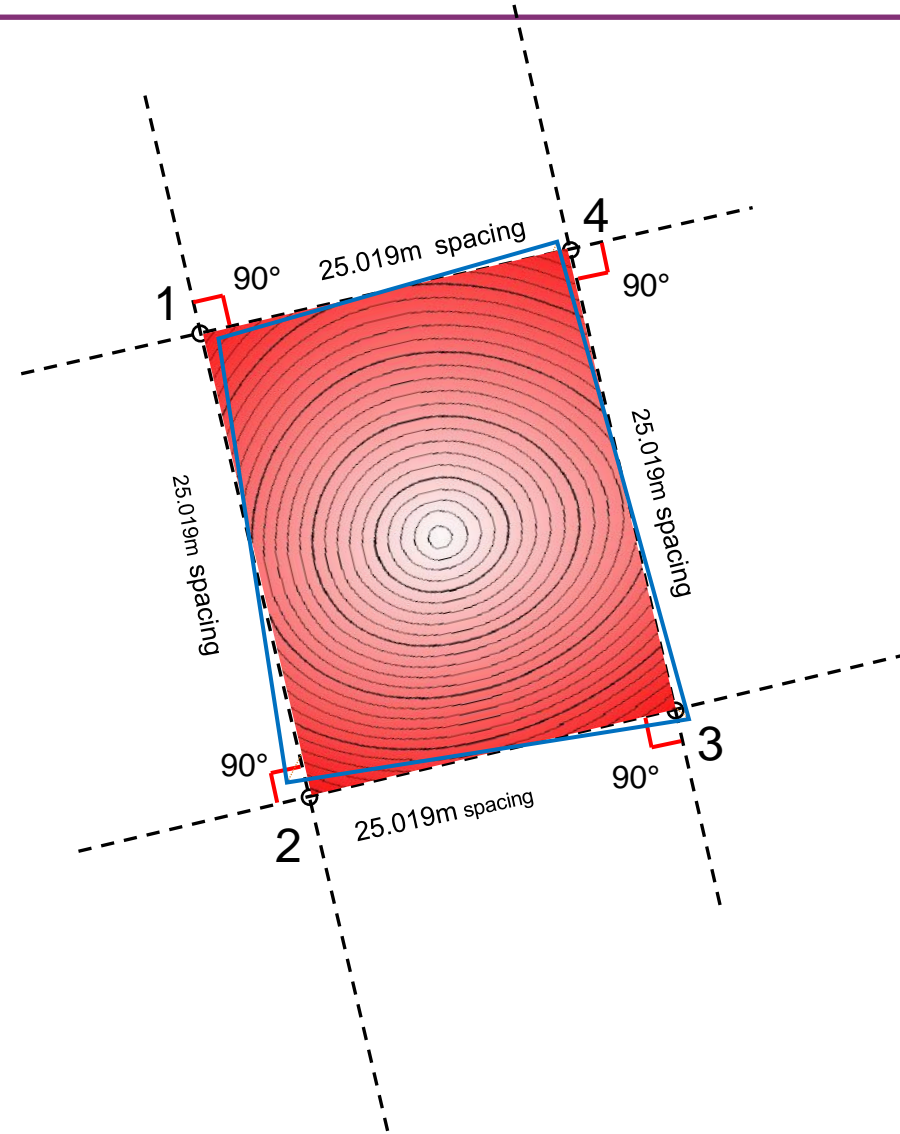
Further Refinement

- Latest versions of leading geoscience applications attempt to minimise the movement of bin centres during reprojection

- Done by generating a sparse grid of tiles at a regular density set by a requirement that no bin centre shall move during reprojection by more than a threshold amount

- The tiles will be reduced in size until this is the case

- The threshold may be hard-wired by software (e.g. 0.01 of bin length)

- All the bin centres in the same tile move by the same amount during reprojection (presumably the amount the tile centre moves by) which cannot exceed the threshold set

- Some workstation applications use on-the-fly reprojection so do not store the bin grid in its reprojected form

Good practice steps when reprojecting bin grids in the workstation

- Bin the 3D seismic data in the CRS to be used for loading and interpretation if possible.

- If necessary to reproject a bin grid to a different CRS, *append* the target CRS details to a new P6/11 file containing the bin centres individually reprojected (a 'bin centres P6/11' file), for archiving as the reference dataset, to avoid irreversible loss of geospatial integrity and for any further exchange of the data.

- On completion of the merging operation, produce a P6/11 file, containing an audit trail to document the origin and location of all constituent surveys, and CRS and bin grid for the resulting end product, providing a verifiable audit trail back to the original data. Make use of P6/11 records intended for this purpose *(File Identification Record, File Contents Description, File Processing Details, File Contents Attributes).*

- Understand the method used by the workstation to reproject the bin grid.

- Measure the impact on the geospatial integrity of the data by comparing the coordinates of bin centres held by the workstation with the bin centres P6/11 file (representative sample).

- It is particularly important to understand the geospatial integrity of the workstation data at proposed drilling locations.

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Final Recommendations

- Request P6/11 as a deliverable from all surveys and all reprocessed volumes.

- Check how any geoscience applications handle the loading of data. Request vendors support P6/11 if they don't already and start to use P6/11 as part of the loading process.

- Check how any geoscience applications handle the reprojection of seismic bin grids.

- Support the use of P6/11 as an integral part of the data lifecycle.

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