2007 ESRI Petroleum User's Group Workshop

# Positioning Issues Related to Seismic Data


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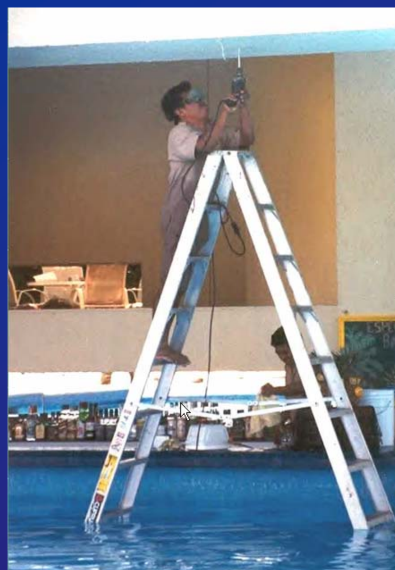
## *Applying the right tools and knowledge to complete a complex task with a predictable result!*



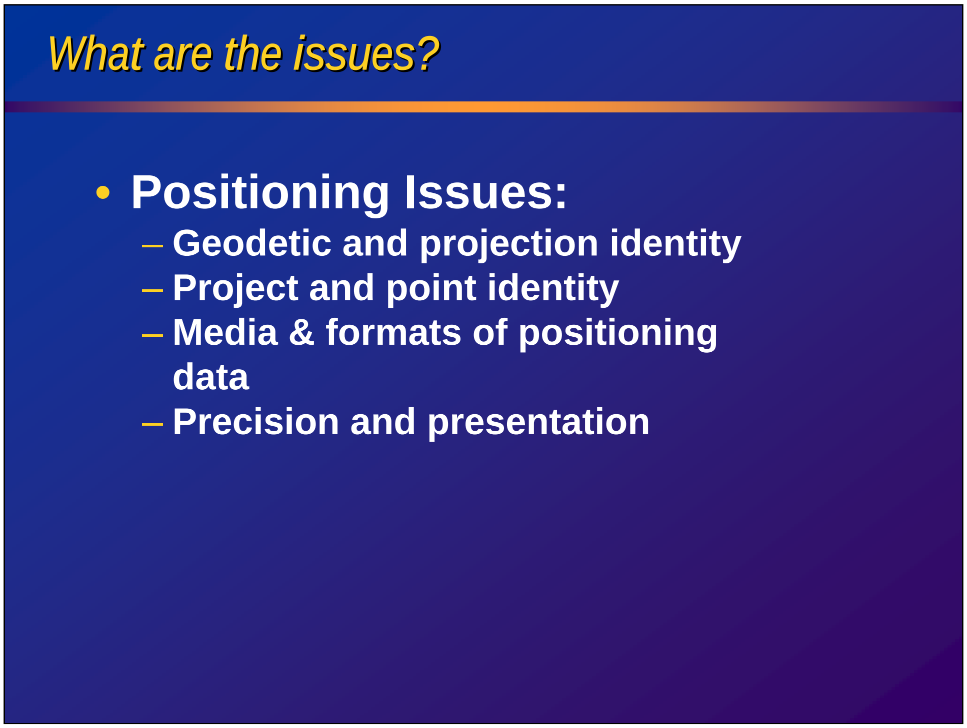
**Any position data loading is an exercise in this!**

**And remembering there is more than just X & Y***

Note: Geodetically this s/b Easting & Northing

This talk addresses the exchange and use of coordinates for seismic requirements.

There are good and not so good ways to do these tasks.




**Abstract: <u>Positioning Issues Relating to Seismic Data Loading</u>**

This talk relates to various issues encountered in seismic positioning data, which create problems in the loading and usage of the data in coordinate databases and workstations.

In particular the presentation discusses 4 topics:

1. Geodetic and projection identity
2. Project and point identity
3. Correlation with seismic data
4. Media and formats of positioning data

Geodetic and projection identity focuses on the root cause of most positioning problems, which is miss-identified or miss-matched CRS data during the loading processes. Several slides are shown which point out the type and magnitude of positioning errors due to these problems.

Projection and point identity provides some examples of problems encountered by not understanding the identity of seismic coordinates. Slides show the many types of coordinates, which can relate to the same shot point number, what impact shooting direction, re-shoots, re-lays and re-naming can play in creating errors. It also discusses additional requirements for merging coordinate data with seismic.

Correlation with seismic data talks about direct loading of 3D bin data and issues relating to loading sheets, skew and distortion. The reduction of acquisition coordinates to row and columns identity and the need to audit this type of data.

Media and formats of positioning data. A discussion on the various media on which coordinate data is recorded and exchanges, issues relating to encoding, blocking, compression and machine dependencies. I also talk about the standard (UKOOA, SEG and SPS) formats as well as the many non-standard formats for exchanging positioning data and the types of problems this causes.

For the HIS presentation of 20 minutes, there are approximately 40 slides in Microsoft 2000 PowerPoint format, with notes pages.

## *If the geodesy doesn't fit, you must a quit!*

| Latitude | Longitude | X | Y |
|---|---|---|---|
| 29 25 00.00 N | 89 56 30.00 W | 2,443,081.1 | 275,426.9 |
| 29 25 00.79 N | 89 56 30.25 W | 3,723,882.6 | 336,132.4 |
| 29 25 00.65 N | 89 56 30.80 W | 214,552.1 | 3,257,770.7 |
| 29 24 59.77 N | 89 56 29.99 W | 744,653.0 | 83,943.2 |

- **All these coordinates represent the exact same physical point on the Earth.**
- **They are all correct coordinates.**
- **Individually, they could also represent another point somewhere else on the Earth and still be correct.**

**Intermixing misidentified coordinates can create positional errors ranging from a few feet or meters to miles or kilometers.**

**This is the number 1 reason for positioning differences!**

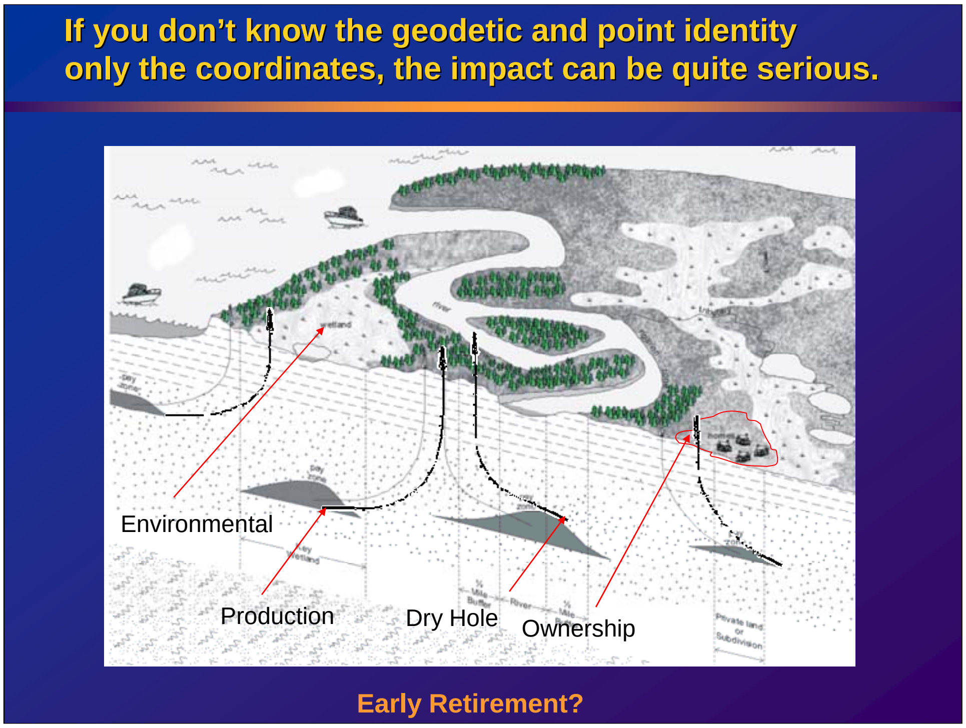
Same position, but represented by different datums, projections and units.

The key point is to demonstrate that there are more than 1 latitude,longitude representations of the earth and that the majority of projections are referenced to an ellipsoid.

(Can point out difference between a sphere and an ellipse).

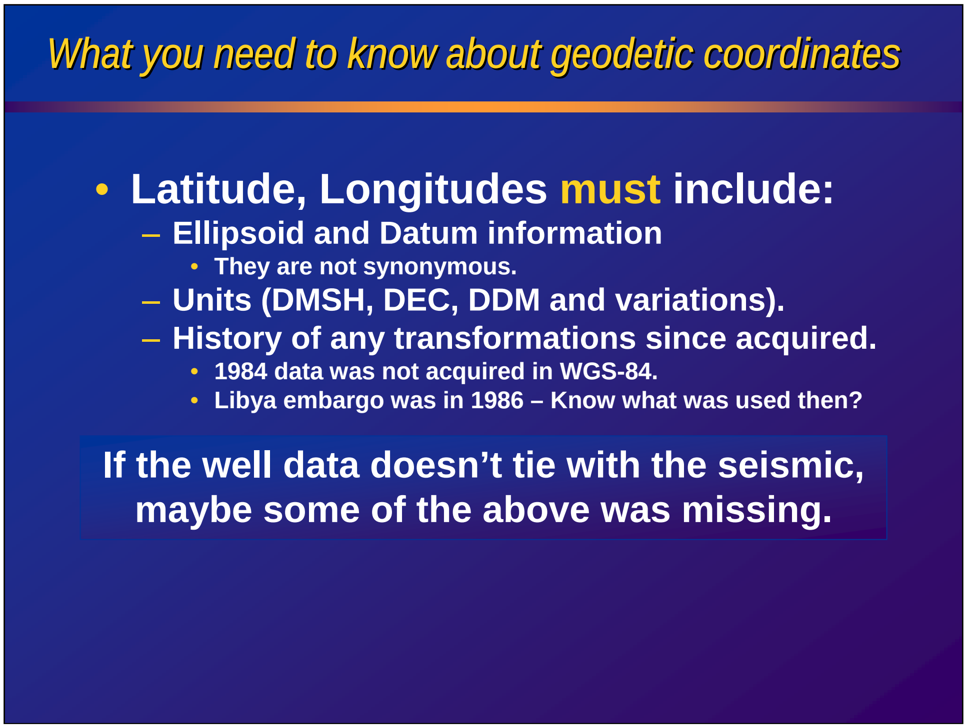
Reference Jim Cain's talk on Geodesy at IHS.

CLICK to point out this is the number one reason for positioning difference.




Often well coordinates are provided with no information. If assumptions are made as to their geodetic or point identity

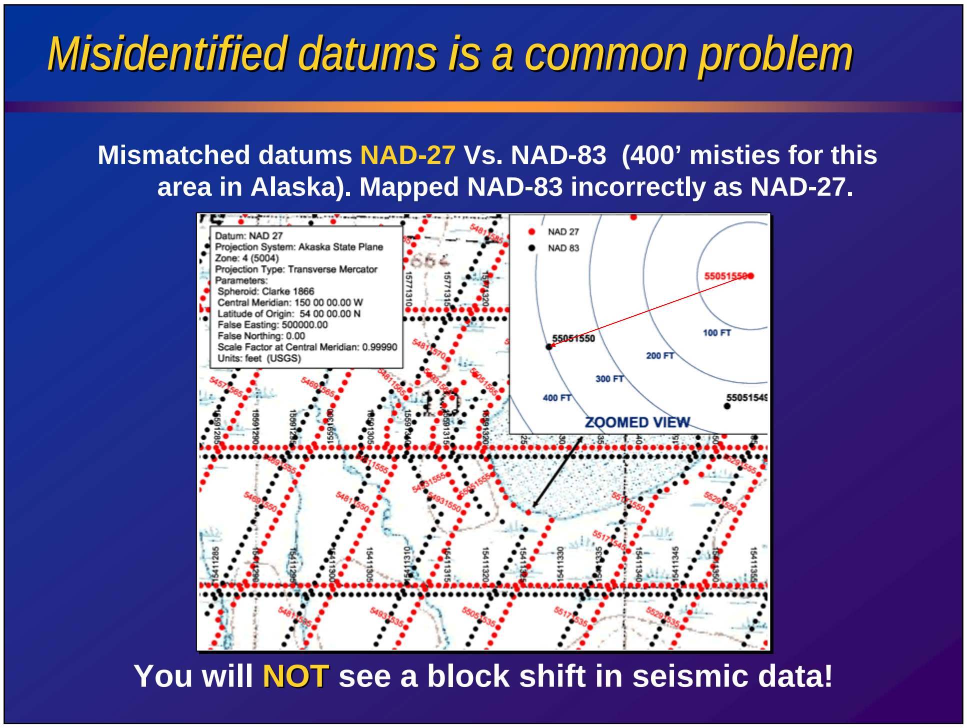
Mistakes can be serious, even deadly. Incorrectly miss-identifying the datum can cause large positional shifts, perhaps impacting the environmental, legal (boundary / ownership) and safety factors when drilling. Simply assuming what a coordinate is might impact interpretation leading to an economic loss due to a dry or poorly producing target.




These are the basic requirements to identify which datum and ellipsoid a set of latitude and longitude coordinates belong to. Without this identity information, the potential for misuse, misidentification and error is maximized.

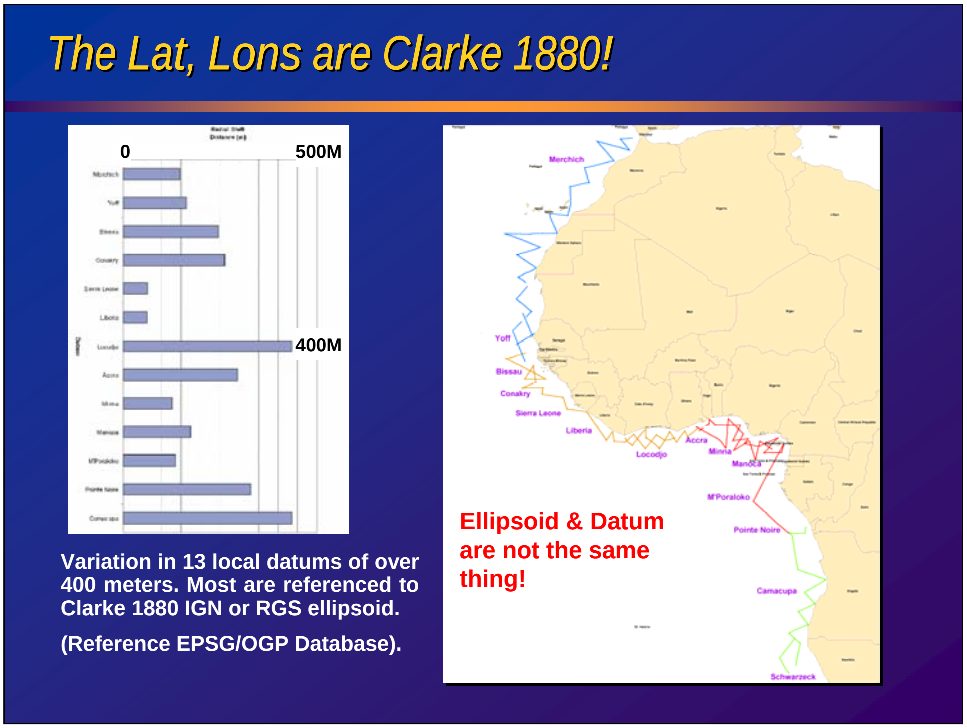
Included should be a historical archive of how these coordinates were originally obtained and what processes may have been performed to produce the current coordinates.

Generally, acquisition is/was performed using the current satellite datum (e.g. WGS-84 (AKA GPS)). To arrive at something different a translation or transformation is performed. Without that knowledge there is a risk of conflict with other data sets and it may be difficult to resolve.



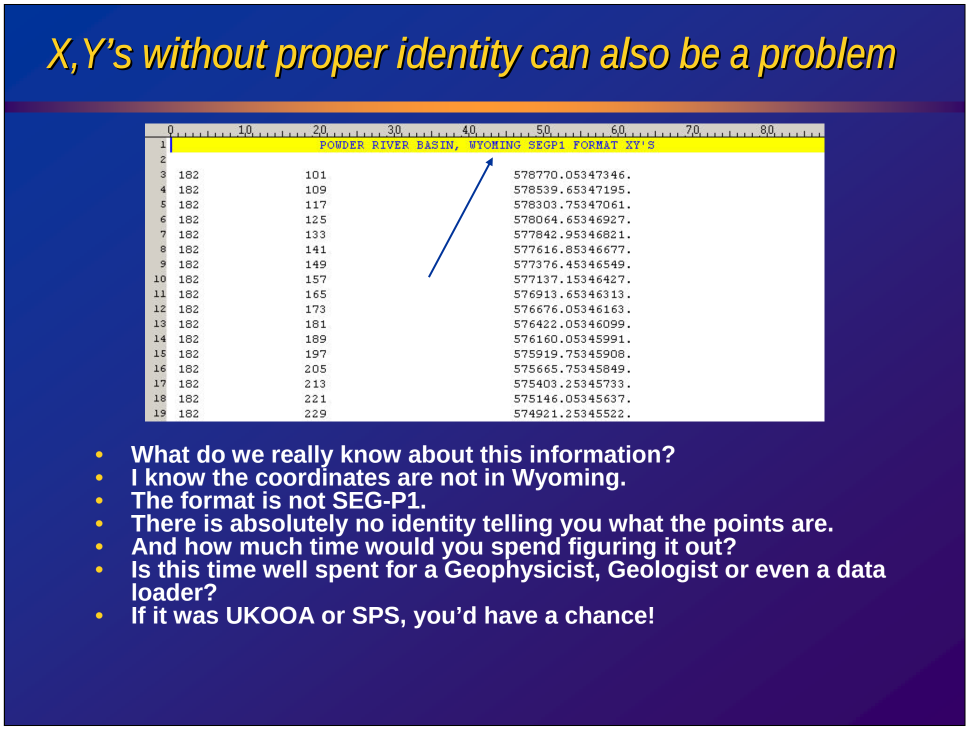

This is an example of incorrectly mapping lat,lon coordinates. The project has been defined as Alaska State Plane Zone 4, which is a Transverse Mercator projection. For this project that projection is referenced to the North American Datum of 1927, which is further referenced to the Clark 1866 Ellipsoid.

A set of latitude, longitude coordinates which were acquired in satellite datum (WGS-84 / NAD-83 datum) have been mistakenly read into the project as NAD-27. As can be seen when plotted along side the same coordinates properly shifted to NAD-27, the unit difference is approximately 400 feet.




In this slide we see what misidentifying datums in West Africa can potentially cause. Here are 13 commonly used datums, most of which are referenced to a similar or only slightly different ellipsoid. The reality is many datums share common ellipsoids and can have quite different geodetic coordinates. Converting an X,Y to a Latitude Longitude correctly and not knowing the datum might lead to an error in positioning.

The chart on the left shows the range of unit difference that can be created. It varies between 10 and 450 meters. The maximum difference between the semi-major axis of ellipsoids is about 1500 meters, so the potential for positional error through misidentification ranges from a few meters to that sort of magnitude. Add in blunders, misuse of transformation algorithms etc. and the potential grows.

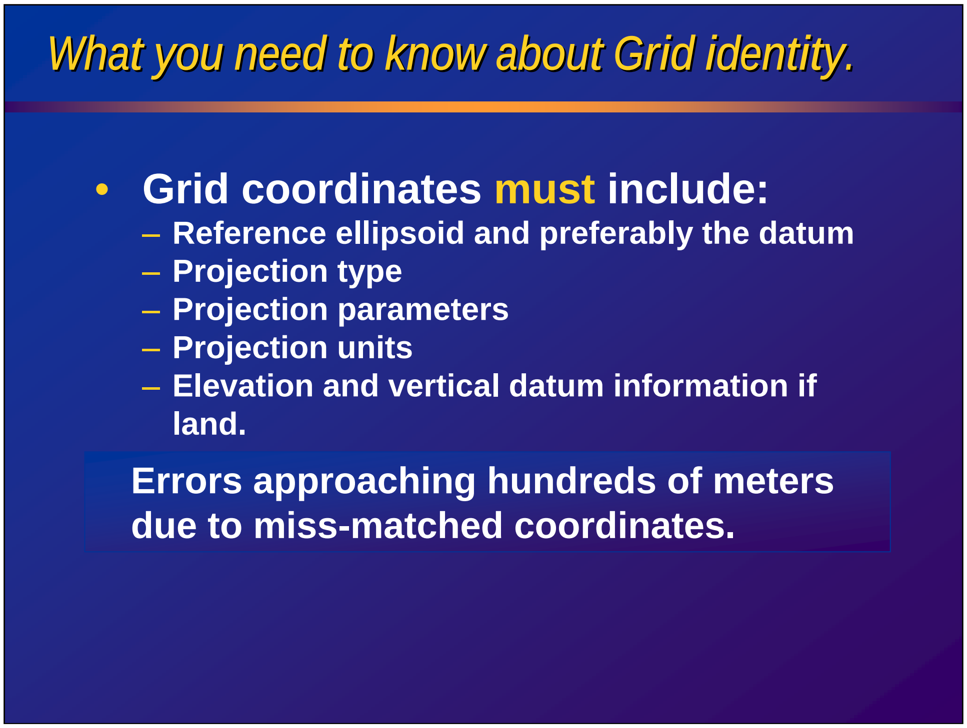



Often the seismic data loader is provided with minimal coordinate information.

It is common, to receive the line name, a shot point number and the X,Y or Eastings and Northings.

For this data, you are only told it is Powder River Basin in Wyoming.

CLICK to point out that this data is in fact not in Wyoming.  It was actually in Montana.




Like Latitude, longitude coordinates, projection data also require identity.

As mentioned earlier, most projections are referenced to the Earth in the form of the ellipsoidal shape onto which the X,Y grid is being projected.
(Note: In Jim Cain's talk, this is explained).

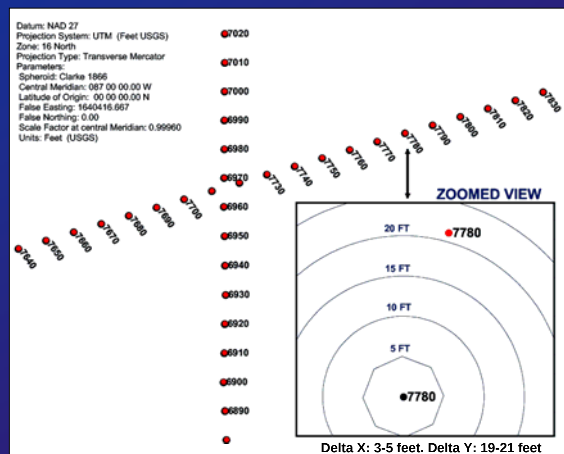
So in order to know the coordinates being provided, you must know something about the projection.
You need its reference ellipsoid and perhaps the datum.
You must know the projection name or type and more importantly its defining parameters. These often include parameters, which properly adjust a general projection to handle a very specific geographic area. An example of this would be the Lambert State Plane projections. Most of which utilize the same basic parameters except for the defining boundaries that are local to each state or zone within a state.

In the previous example the coordinates were Montana South State Plane as opposed to Wyoming North. In that case the prospect (though called Powder River), which is mostly in Wyoming, was actually predominantly in Montana.

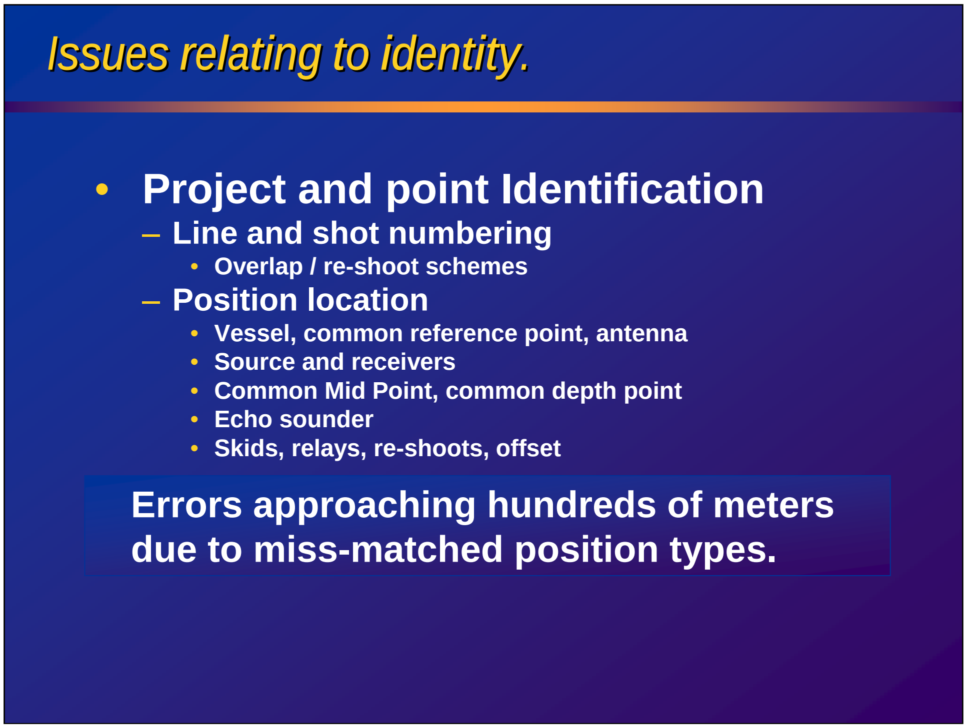
Units are a big issue. Not only are there difference types of units, but there are different measures or lengths within the same types.

## *Open mouth insert U.S. Survey foot!*

- **Mismatched units US Survey Ft. Vs. Intn'l Ft. (20' misties). 3.280833333 (39.37/12), not 3.28 or 1/.3048 etc. It's a scaling error. This is GOM data UTM Zone 16.**




Here is an example of using the wrong value for feet. This is a very common error in the Gulf of Mexico as the Outer Continental Shelf blocks (OCS) are defined in feet. The projection however is UTM, which is defined in meters. Many people convert the latitude,longitudes to Northings and Eastings (X,Y's), which yield meters. They then scale the resulting units to feet to match the block boundaries. Because they do not know there are different kinds of feet to meters conversions, they use a simple conversion such as what you find in the back of a day planner (3.28 feet per meter). Or they choose a conversion from a list of factors in their software (normally the one that says feet). Because these are multipliers, the magnitude of the error will vary depending on the projection type and in both northings and eastings depending on the magnitude of the coordinates. In Alaska the same mistake can yield an 80' error.



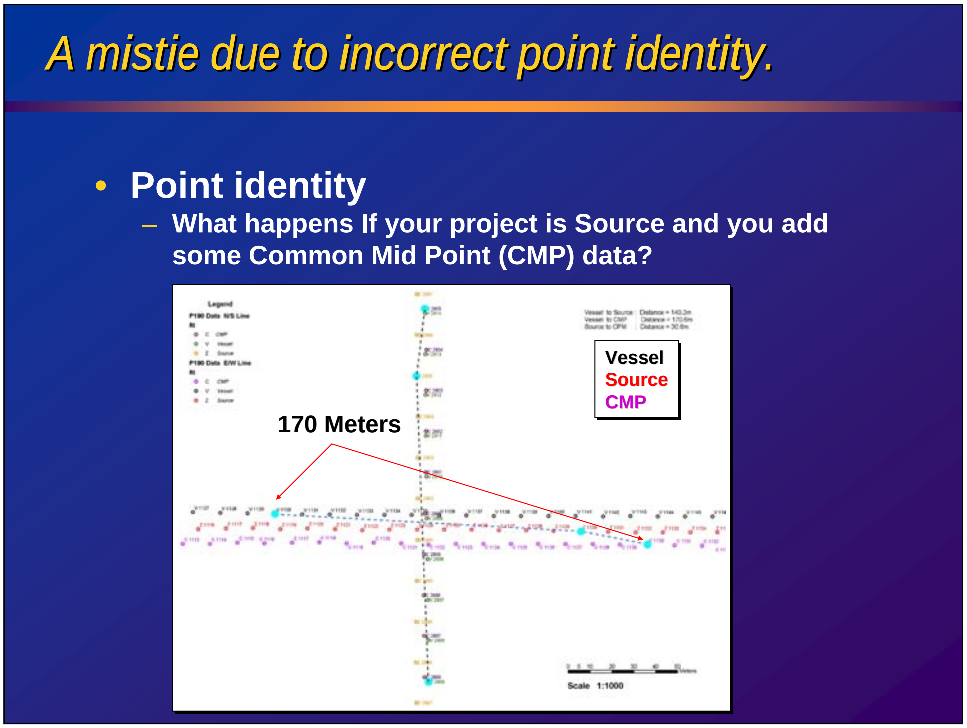

Apart from knowing where the coordinates are, you often also need to know what they are.

Receiving a file with line number, shot number and coordinates may not be enough, especially if you are merging data into an existing project with other data.  Line and shot number are often assumed to mean a particular point or place or data type.  They may in fact mean something entirely different.

In marine surveys, all the acquired positioning and ancillary information are often identified by the shot number.

Various acquisition techniques will employ unique numbering and naming conventions to identify the type of data or information being logged.

Problems in acquisition often require replacement or re-shoot data to be acquired.  Sometimes these data re re-named using other fields and those fields become the only way to properly identify the data.




This is an example of three sets of coordinate information from a typical 3D marine survey.

The black coordinates are the location of the vessel (which could be one of several identity types). The Red shows where the geometric center of the energy source is and the purple is what is called the Common Mid Point, which is half way between the source and the near trace. Each of these points shares the same identity, that of line and shot point.

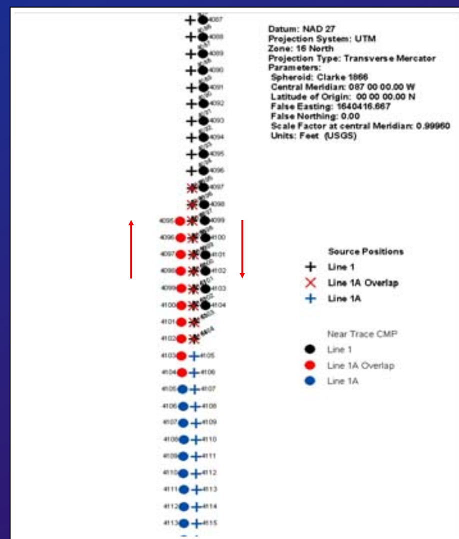
If you have a project, which is supposed to be source locations and your business or operating partner sends you some data to be included into your project that is at CMP and you assume it is source, then the potential for a mistie with your existing project is great and could approach several hundred meters.

## *The line was shot in two directions*

- **Point identity**
  - **Circles,**
  - **re-shoots,**
  - **Skids/offsets**
  - **Shooting direction**

**This line was shot in opposite directions. It was spliced and "A" overlaps dropped.**

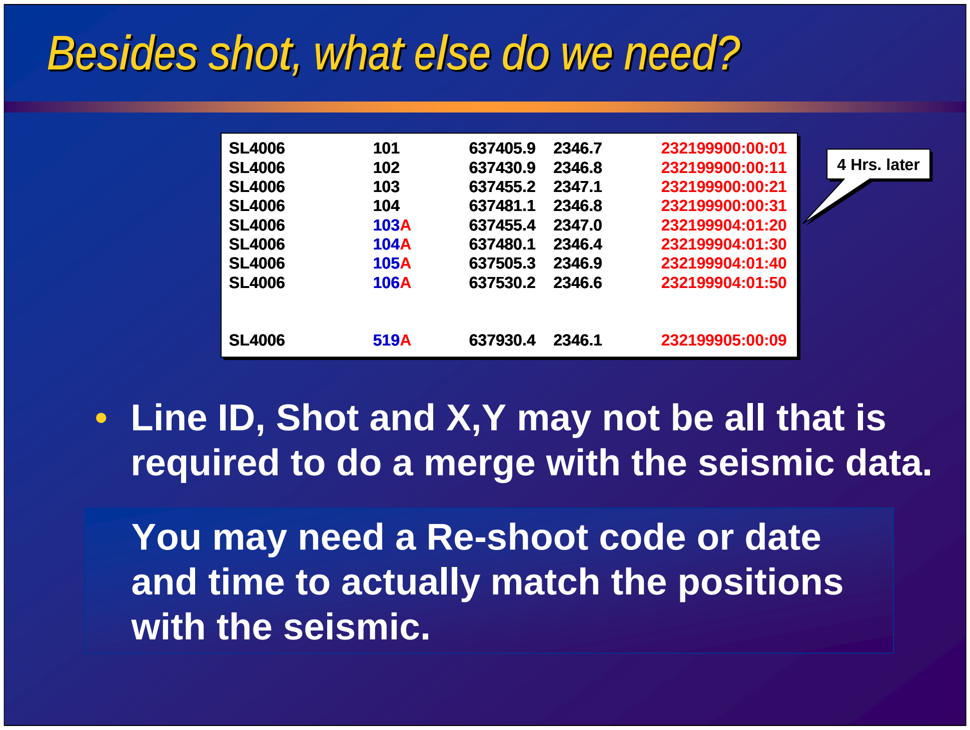
**An in workstation layback (150 mts.) could / did create a problem.**




Here is an example where the shooting direction was changed between the first attempt at acquiring some data and when it was re-shot to complete the coverage.

Without knowing the direction (as the shot numbering does not indicate the direction), then applying a layback in the work station to get from say antenna to source could in fact be done incorrectly.

The additional identity information provided by re-shoot codes, position type, line direction etc. become crucial to using, even correctly positioned data.

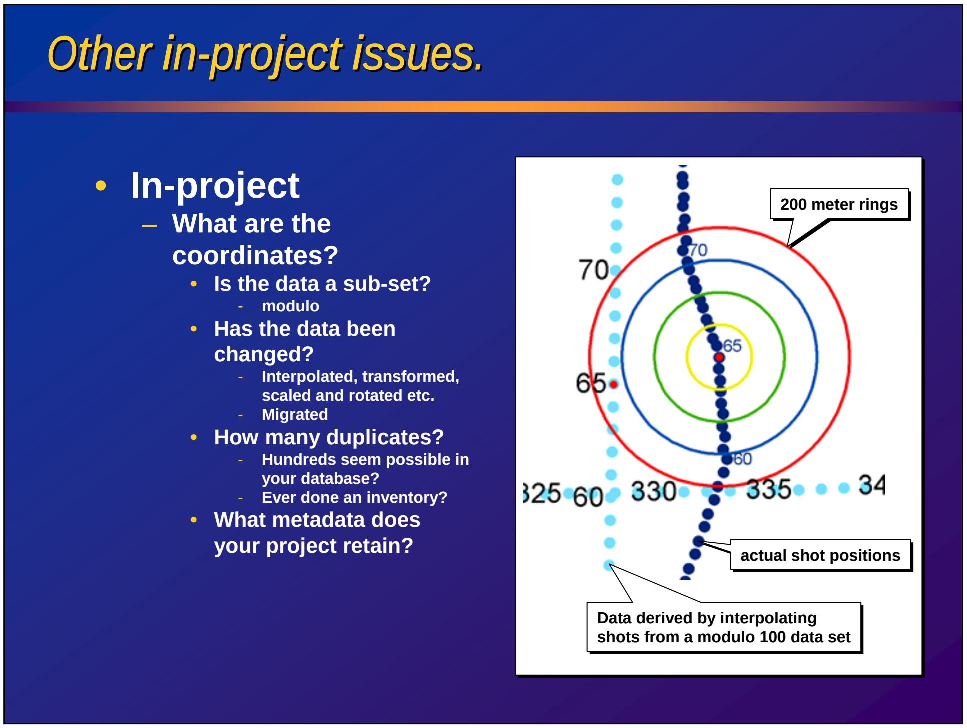



| | | | | |
|---|---|---|---|---|
| SL4006 | 101 | 637405.9 | 2346.7 | 232199900:00:01 |
| SL4006 | 102 | 637430.9 | 2346.8 | 232199900:00:11 |
| SL4006 | 103 | 637455.2 | 2347.1 | 232199900:00:21 |
| SL4006 | 104 | 637481.1 | 2346.8 | 232199900:00:31 |
| SL4006 | 103A | 637455.4 | 2347.0 | 232199904:01:20 |
| SL4006 | 104A | 637480.1 | 2346.4 | 232199904:01:30 |
| SL4006 | 105A | 637505.3 | 2346.9 | 232199904:01:40 |
| SL4006 | 106A | 637530.2 | 2346.6 | 232199904:01:50 |
| SL4006 | 519A | 637930.4 | 2346.1 | 232199905:00:09 |

Here we have an example showing some data with line, shot and eastings and northings, There is a range of shots running from 101 to 104 and then another from 103 to 519. On the surface this would indicate a re-shoot and in most cases, the seismic data will be spliced. Without any additional information it becomes difficult to make a decision on where the splice actually takes place.

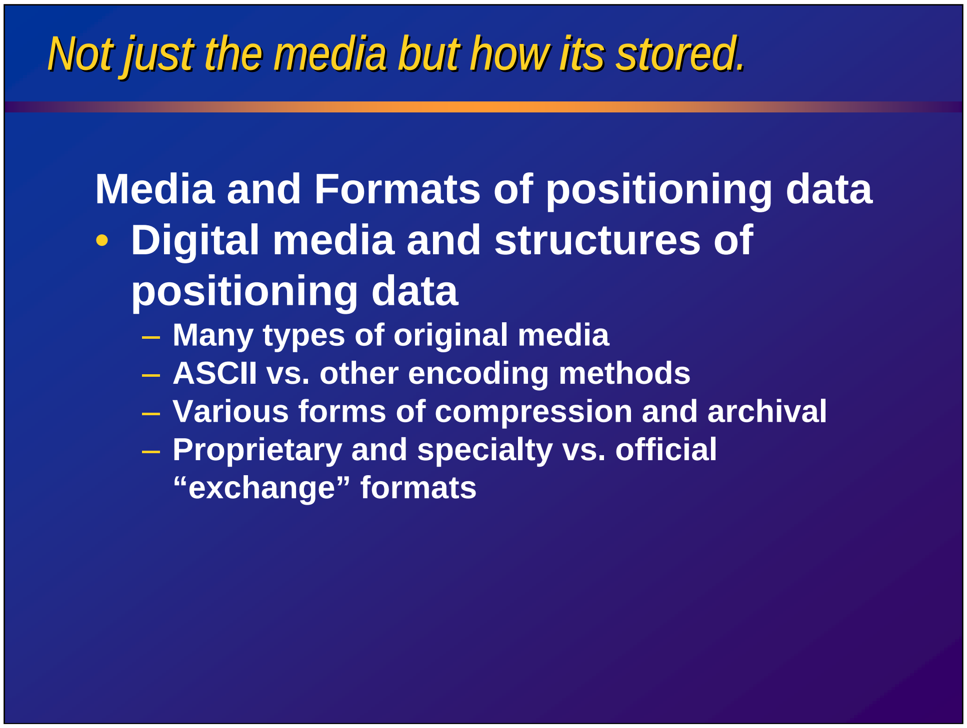
CLICK to show the ancillary information in Red.

By having the re-shoot codes (the A's), we can see that the line was stopped at 104, and then re-shot from 103 to the end. With day and time (also in red), we can even confirm with the seismic data where the splice occurred. They may have kept the original 103 & 104, or they may have kept the re-shoot of 103 & 104.




Something as simple as accepting a sub-set of an original data set can create problems.

Here a data set was provided as a modulo or the original data. Every 100$^{th}$ shot was used to create an assessment. It was decided that a more frequent data sample was needed, so rather than requesting the original data, the needed shots were interpolated in the workstation. Unfortunately the data was highly deviated and in this example, the difference between the real data and the interpolated data approached 600 meters.



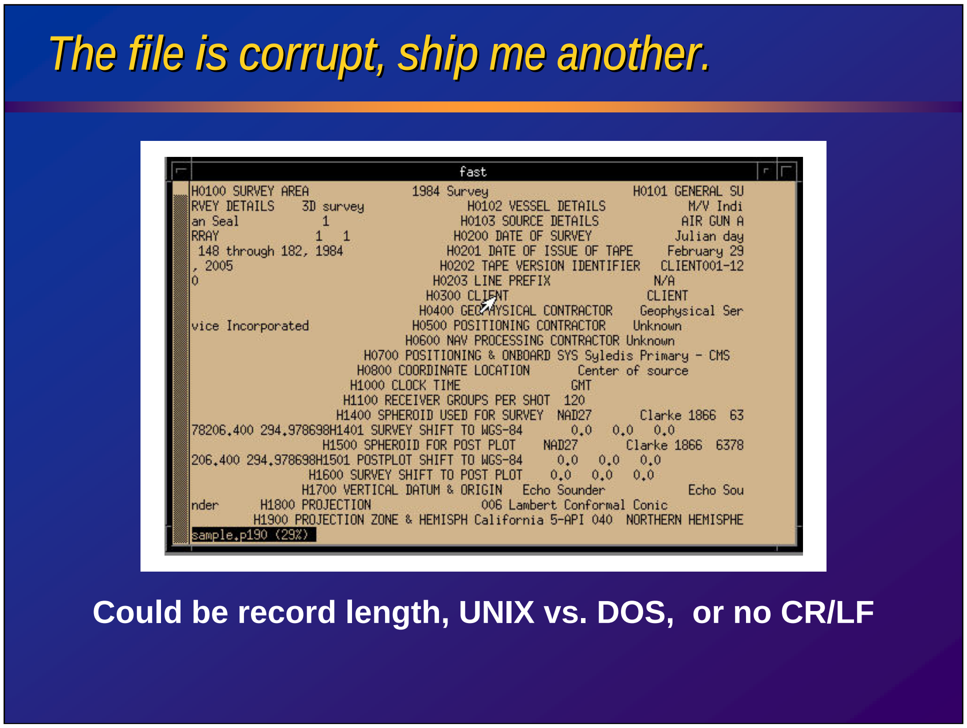

Many delays and problems are encountered with positioning data because of media, encoding and variations in formats.

Legacy positioning data is often archived on 9Trk tape in both raw and processed form.

The older the data the more likely it may have media quality issues resulting from improper storage methods, which may entail recovery procedures.  Some of these processes may involved special processes which can take weeks.

To eliminate these issues, many data holders often transcribe the data to newer media such as DLT, DVD and 3590.  Because of the unique formats of positioning data, involving a large variety of sensor and diverse data, the formats are often proprietary. Whereas seismic data has 3 or 4 formats, positioning data has many formats, which are binary, machine dependent and proprietary.

Many of the exchange formats are floppy based and are often encoded using compression and archival software.  Common forms are DOS formatted, UNIX compressed and archived using Tar.  They can be zipped, bzipped, gzipped and RARS compressed.  Even the character formats can be encoded as either EBCDIC or as ASCII.

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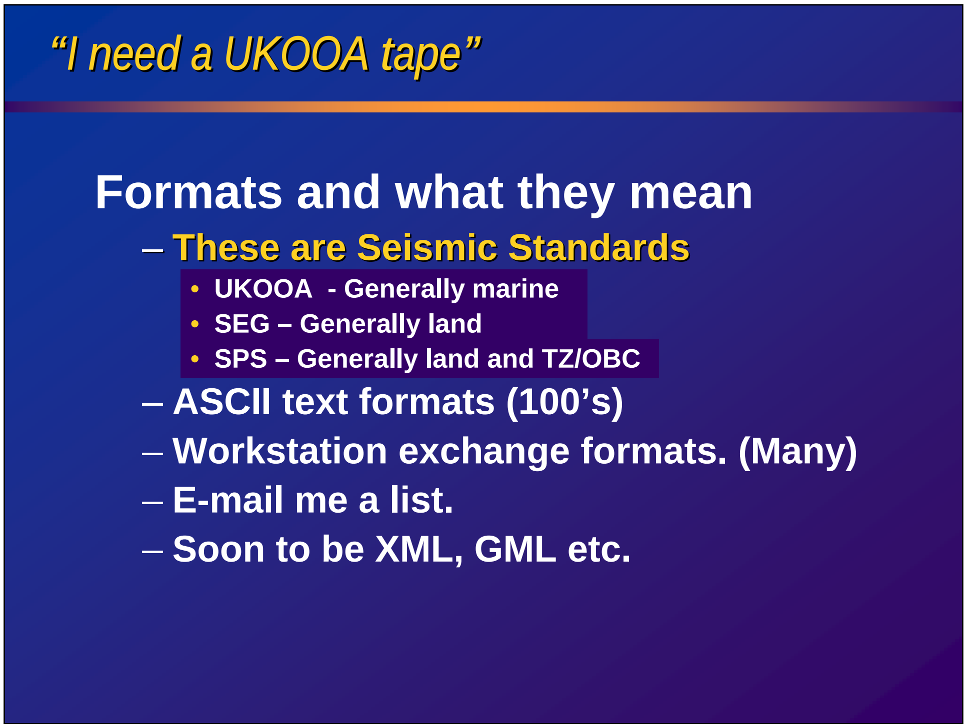



Positioning data is exchanged in multiple formats. There are standard exchange formats designed for seismic positioning data. The common names are UKOOS, SEG and SPS.

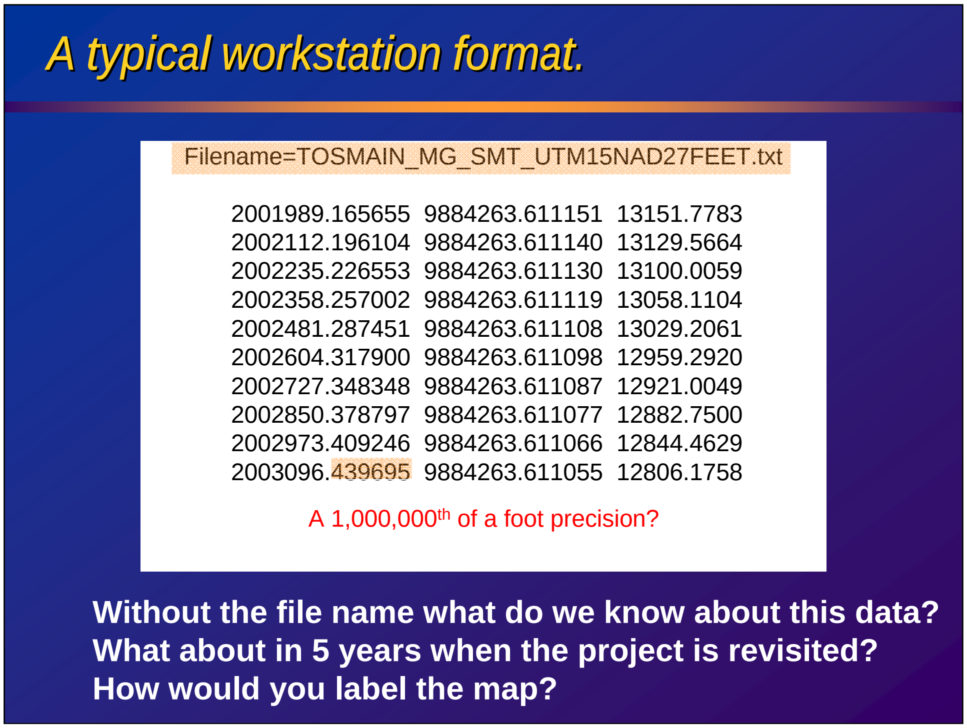
Positioning data is also exchanged in user and software defined ASCII formats. Spreadsheets are another routine way of exchanging positioning data.

You also have import and export capabilities in most workstation and geophysical database software.

We also routinely e-mail digital data as lists and tables in documents like Word or Wordperfect etc.

Each format should provide geodetic and point identity, which we've discussed.

Specific to each format is the precision of the coordinates.

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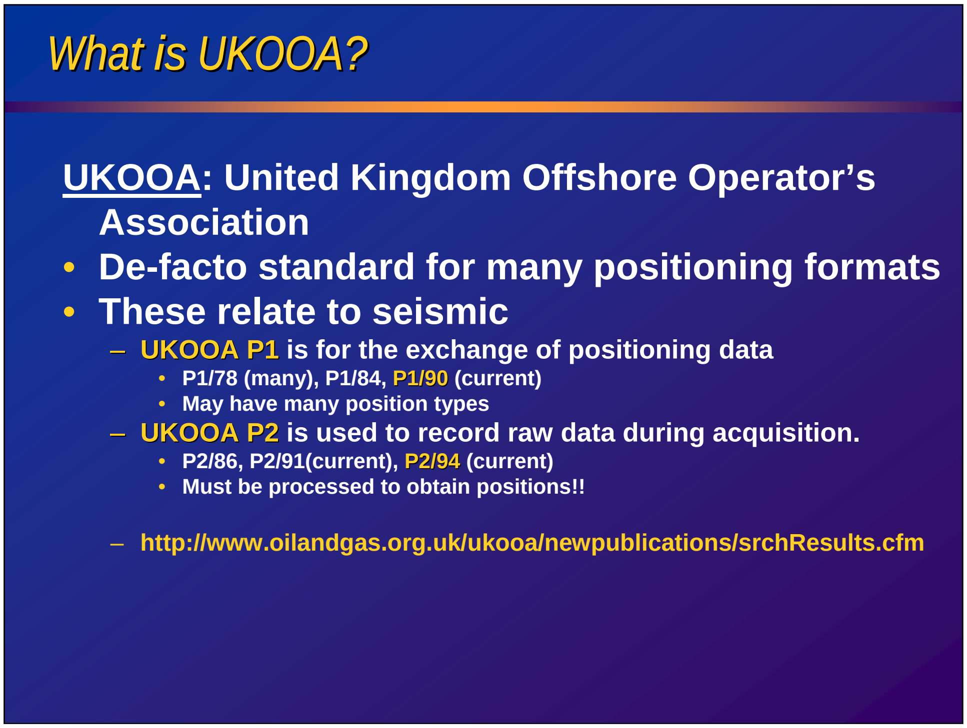
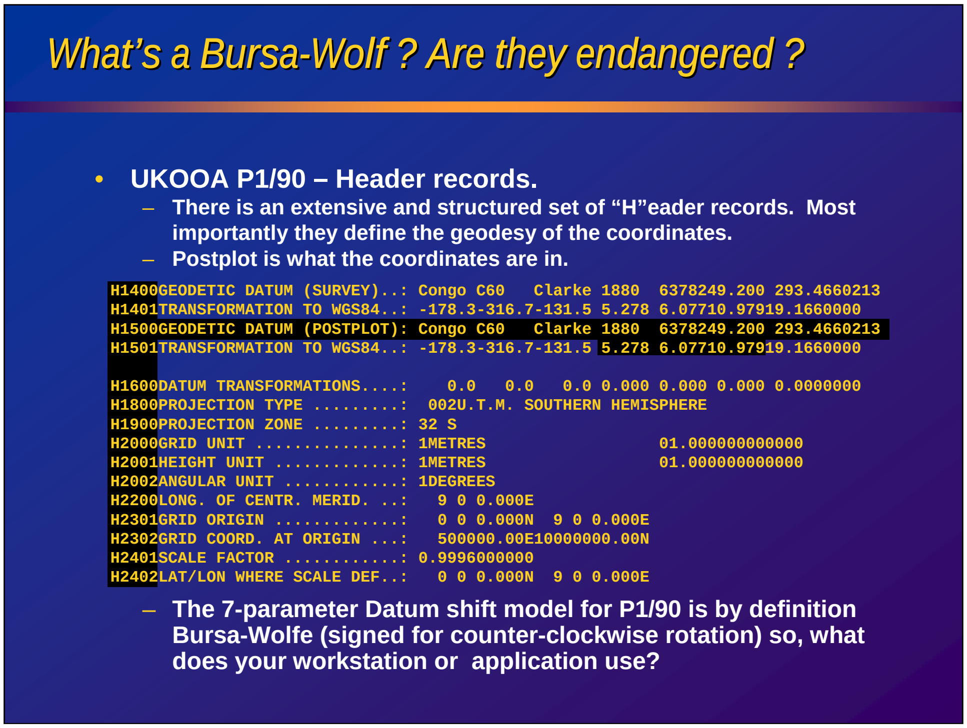



The first of the seismic standards for positioning data is UKOOA.
UKOOA stands for the United Kingdom Offshore Operator's Association. As you might expect the name implies offshore rather than land.
UKOOA in fact has many formats, which are used to exchange positioning data, but we are concerned with those that relate to seismic.
There are principally two basic structures.
One is for the exchange of positional data and is called the P1 format. It originated as UKOOA P1/78 (78 being the year) and preceded 3D operations. As 3D came into usage, the format was continuously modified until UKOOA P1/84 was adopted to handle streamer positions. That too was modified (beyond the standard) until UKOOA P1/90, which is the current. This format too has reached its limits and we should see some movement towards a new standard in the coming years.
UKOOA P2 is unique as a positioning standard if only because the initial version UKOOA P2/86 was intended to move the contractors away from proprietary recording formats for raw data. Raw data recording is the acquired information necessary to produce final positioning data. UKOOA p2/91 and UKOOA P2/94 are the current standards in recording raw marine data. P2/94 is an extension of P2/91 allowing for the recording of raw GPS data.
It is important to know the difference between UKOOA P1 and UKOOA P2. As a data loader, you want P1 data not P2 data. If you only have P2 data, it must be processed (weeks of work) to obtain the desired coordinates stored in UKOOA P1.

The UKOOA format contains extensive header information (a requirement of both formats). The headers are fixed format, meaning each record is identified as to type and content.

The link shown provides access to these formats and other UKOOA positioning formats.

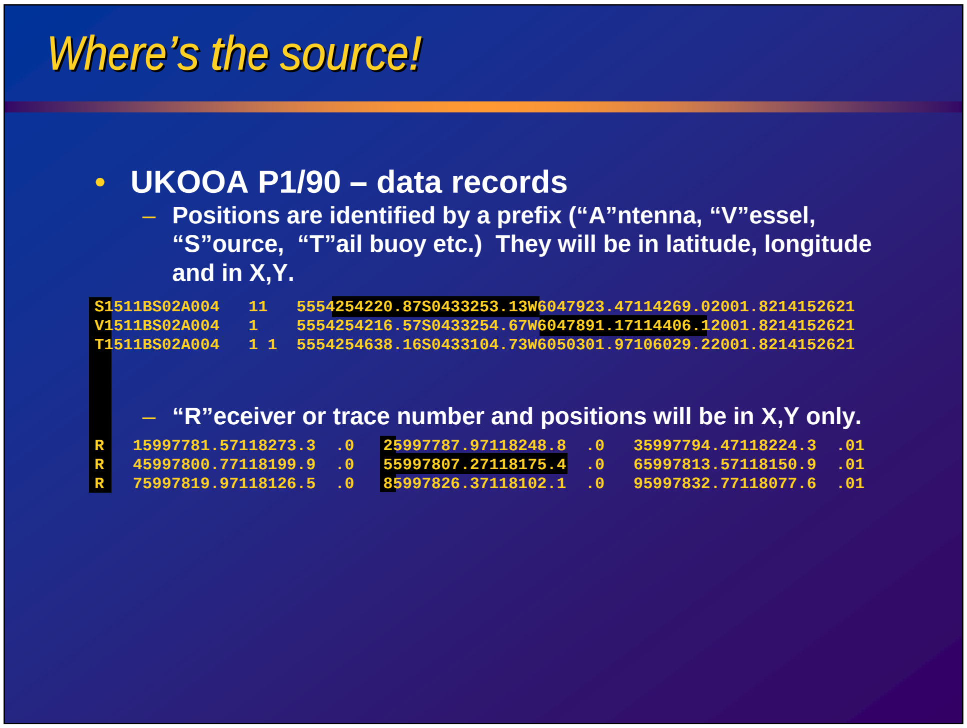



Here is an example of a set of UKOOA headers.

In general they contain all the information necessary to both geodetically and point identify the positioning data contained in the structure.

One tip that will help many readers of this format is that the "postplot" identity refers to the coordinates recorded. The "survey" identity was intended to provide some insight as to the original datum and ellipsoid of acquisition or what system the points were surveyed in. As the data progresses through different datums and projections, this information may often be the same or used to identify a translation. The key is to remember that the points relate to the Postplot datum as does the projection.

Datums and shifting between them was covered by Jim Cain's talk. Be aware that the convention for storing shift values in UKOOA is set, so the signs may need to be reviewed to ensure they match any intended use in the workstation. Reversing signs and using an incorrect shift method cause many positional disagreements.




For data loaders, the interest is in the UKOOA P1/90 format.

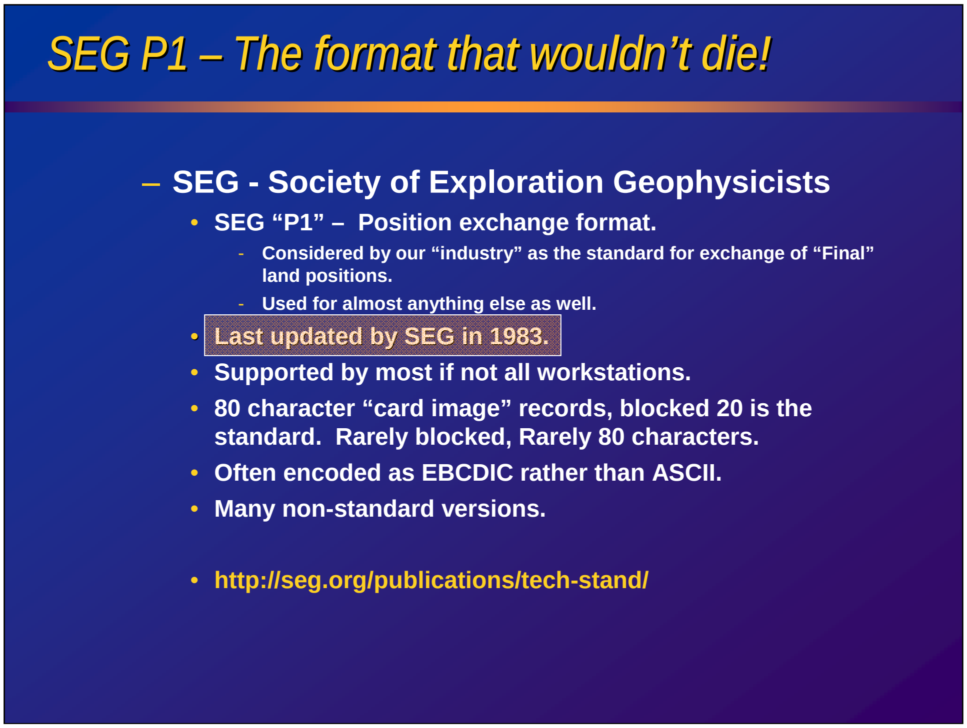
Within the positional formats are the ability to record multiple position types (remember the talk about identity?) for each shot.

In this example we are looking at data from a single shot (5554). Shown in black are the record prefixes which identify the coordinate type. There are a number of possibilities for different position types, often thousands of meters apart.

There is provision for all but the "R" and "G" coordinates to be recorded with both geodetic and projection coordinates. The latitude, longitude coordinates may be recorded as degrees,minutes,decimal seconds and hemisphere or as signed decimal degrees. Some software may assume one or the other.

The receiver or trace records are designed for streamer traces and include the trace or receiver number (e.g. 7, 8 & 9 in black) and easting and northing coordinates (X,Y's). The trace/receiver format support 3 sets of trace coordinates per record.

Because the fields are of fixed width, the precision which can be recorded is limited based on the projection. The original format was intended for North Sea operations and as such did not address some projections and unit types which might exceed the field width for X,Y. It does however allow for implied decimals, which if not recognized can create loading and mapping problems.




This is far and away the number one format in use. It is used for land, marine, transition zone and ocean bottom seismic data.

It was last reviewed in 1983 (I was one of the reviewers!).

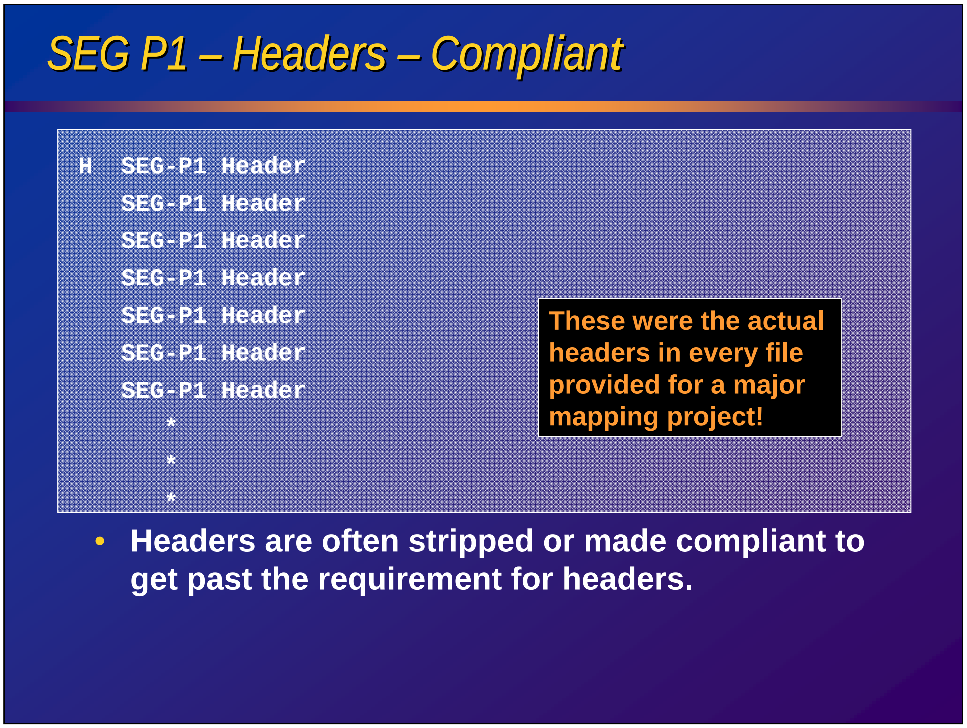
This format is supported in some form by almost every workstation and seismic database software system.

# SEG P1 – Pretty normal – incorrect headers

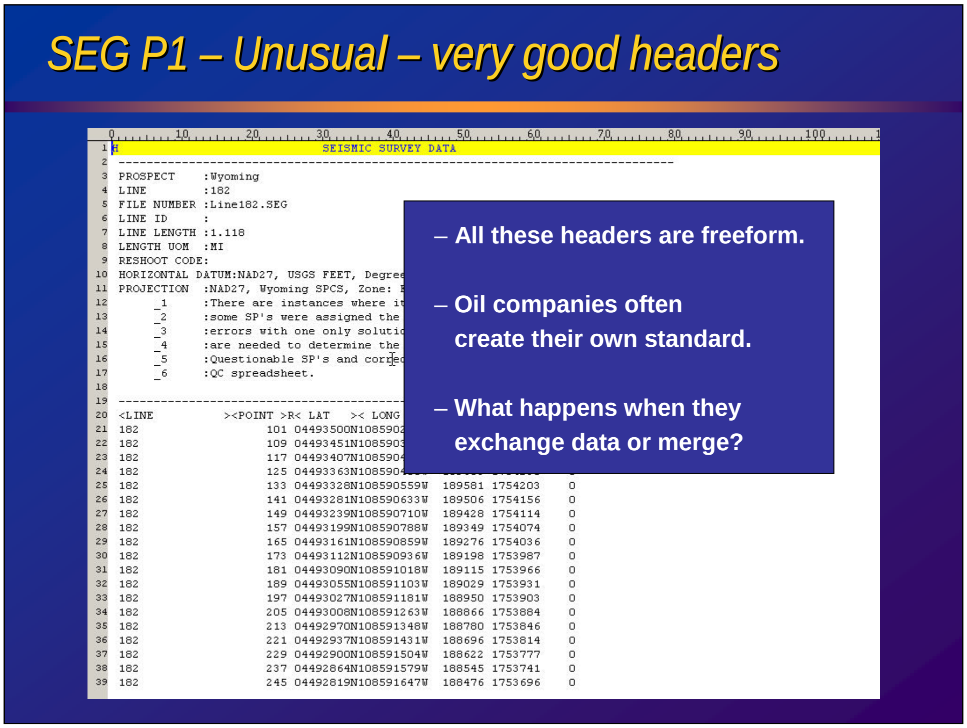
POWDER RIVER BASIN, WYOMING SEGP1 FORMAT XY'S

| | | |
|---|---|---|
| 182 | 101 | 578770.05347346. |
| 182 | 109 | 578539.65347195. |
| 182 | 117 | 578303.75347061. |
| 182 | 125 | 578064.65346927. |
| 182 | 133 | 577842.95346821. |
| 182 | 141 | 577616.85346677. |
| 182 | 149 | 577376.45346549. |
| 182 | 157 | 577137.15346427. |
| 182 | 165 | 576913.65346313. |
| 182 | 173 | 576676.05346163. |
| 182 | 181 | 576422.05346099. |
| 182 | 189 | 576160.05345991. |
| 182 | 197 | 575919.75345908. |
| 182 | 205 | 575665.75345849. |
| 182 | 213 | 575403.25345733. |
| 182 | 221 | 575146.05345637. |
| 182 | 229 | 574921.25345522. |
| 182 | 237 | 574684.85345413. |
| 182 | 245 | 574475.55345275. |
| 182 | 253 | 574235.35345172. |
| 182 | 261 | 573981.65345035. |
| 182 | 269 | 573763.75344896. |
| 182 | 277 | 573516.05344757. |
| 182 | 285 | 573293.45344613. |
| 182 | 293 | 573079.05344496. |
| 182 | 301 | 572840.55344343. |
| 182 | 309 | 572600.05344210. |
| 182 | 317 | 572358.15344090. |
| 182 | 325 | 572138.05343941. |
| 182 | 333 | 571901.15343807. |
| 182 | 341 | 571695.55343661. |
| 182 | 349 | 571457.75343548. |
| 182 | 357 | 571229.15343437. |
| 182 | 365 | 571002.85343282. |
| 182 | 373 | 570780.65343147. |

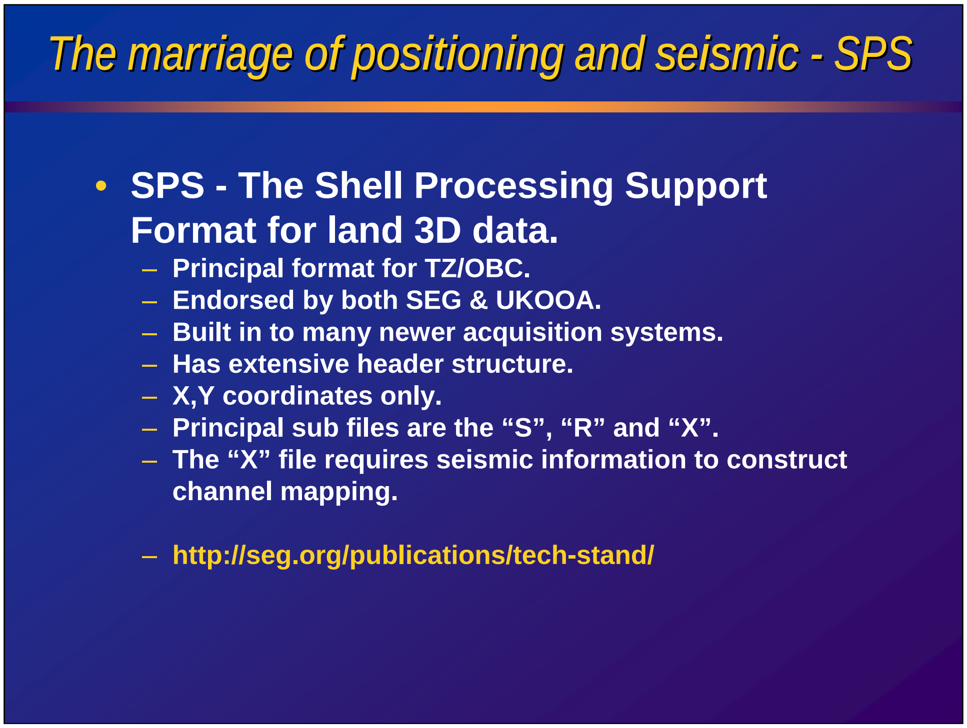
A typical amended / modified SEG-P1 format. Most everything of use except the coordinates are missing.




I received a large land project in which all the headers were the same and every header record had SEG-P1 Header in it.
That made it compliant to the format.




Here is a proper SEG-P1, which has had a compliant and complete set of headers added as well as geodetic coordinates.




SPS is the Shell Processing Support format. Pretty obvious who came up with the format.

It was intended to replace SEG-P1 as a land format. It is also used for TZ/OBS data.

It was the first format/standard that was jointly endorsed by both UKOOA and SEG.

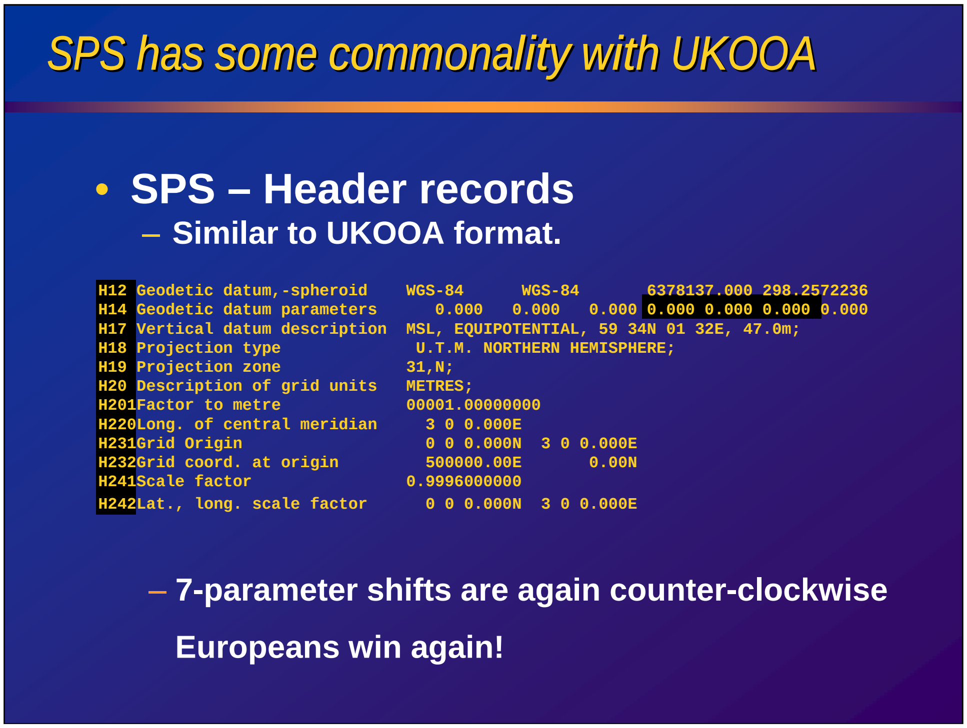
Many seismic recording systems, which integrate GPS now support SPS as a recording format.

It supports a header structure quite similar to UKOOA.

It does not allow for the recording of geodetic coordinates, which is a weakness.

The format utilizes sub files containing the source positions, the receiver positions and the relationship records for associating the seismic traces/groups/stations with positioning data.

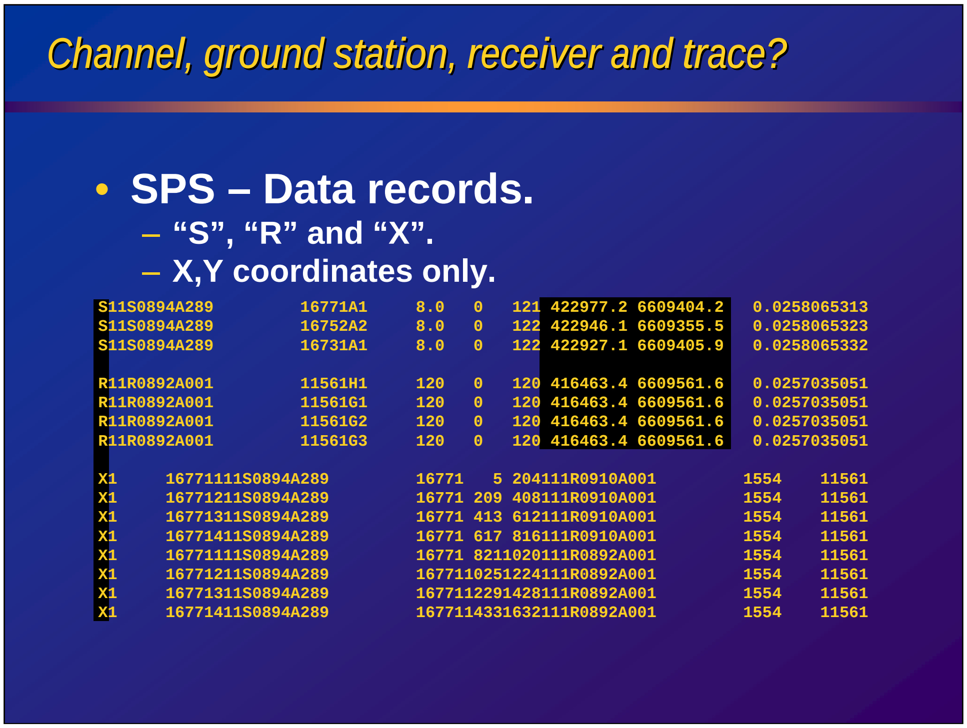
This format can be obtained at the SEG website as well.




You can see a similarity between UKOOA and SPS headers.

Again, you cannot make assumptions about the datum parameters as to sign convention or translation methodology.

Because the format is intended for land and TZ data, there is additional structure and fielding to address things like vertical datum and corrections applied.



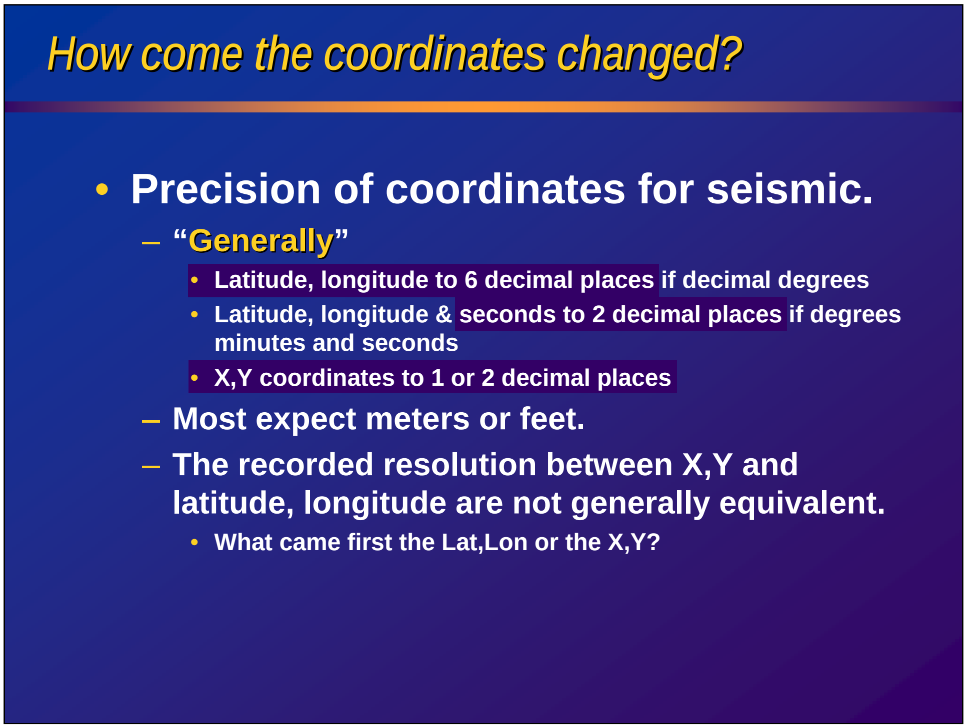

This is an example of the record structures within SPS.

The "S" prefix indicates the source records.

"R" for the receivers or ground stations

And "X" for the trace to shot relationships.

The "X" records are essential for facilitating the merge of the positioning data with the seismic data.



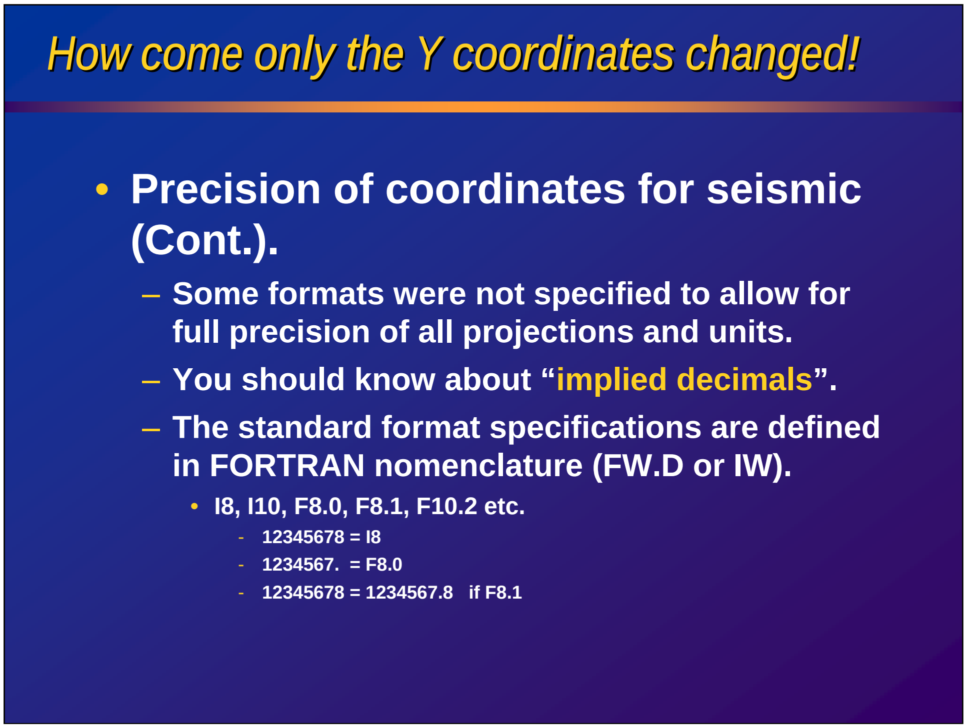

Because the formats are varied, especially those which are created outside the standards, the precision of the coordinates should be addressed.

Though this is subject to discussion or "cussin" I have labeled these as general. For seismic usage, latitude, longitude should be displayed at 6 decimal places if +/- decimal degrees and to two decimal places of seconds if displayed as degrees minutes and decimal seconds. This conforms to the "standard" formats.

Eastings and northings (X,Y) should be displayed to 1 or 2 decimal places depending on the units. Given meters as the base measure, the standard formats allow for 1 to 2 decimal places. Feet would then be acceptable at 1 decimal place.

There is in some formats a discrepancy between the precision of latitude,longitude and X,Y such that transforming one to the other does not guarantee the same answer. It may be that 7 decimal places of decimal degrees or 3 places of decimal seconds may be required to match 2 decimal places of x or y or depending on units and projection even 1 decimal place of x,y.

When interpreting formats containing both latitude,longitude and x,y, tests may be required to assess the precision of one or the other before data loading.




Again the history of the format often defines what its limitations may be in terms of precision.

Be aware of implied decimals. In order to conform to a specific formats field widths, some coordinates may be multiplied so that the actual decimal point can be dropped to allow for more digits.

Also be aware that this is inherently part of the format and can legally occur in either the lat,lons or the x,y's. Most of these formats were originally written in Fortran, whose format descriptor for both latitude,longitude and, x,y was always floating point for the decimal portion of the coordinate (e.g. decimal degrees, decimal seconds, x or y). By defining the field as F11.6 or F10.1 a coordinate without a decimal place "implied" the precision or number of decimals. Including a decimal point merely overrides the format.

Changes in languages has caused issues and even strict changes in interpretation of the formats by some software developers and users of the formats.

## DMSH,DMSSS,IMPLIED,SIGNED, UNSIGNED!

```
G965                     1435302716.67N 88 1 4.46W1319785.111054512.  11.5190 40318
S1157                    1336302341.76N 8758 2.26W 407074.23362764.0   3.9221 45502
R1349                    1016 30120536N  87545847W  1351066210962203 54194103170817
R3 D                  8371518303017010N 880305980W  1309321 11072824     0152
S1029                    1278 30.359719 -88.0006781324907.211019956. 13.10200 01250
```

- All of these records come from the same project.

- There are 4 different formats for Latitude & Longitude.
- There are 5 different formats for X,Y + 1 change of units.
- There are 4 different formats for depth / elevation.
- Two of the records are UKOOA P1/84.
- Two of the records are UKOOA P1/90.
- One was made up in the field.
- Some of them were in the same files.

**How good are you with a text editor?**

**If not, what do your DBF and SHP files look like?**

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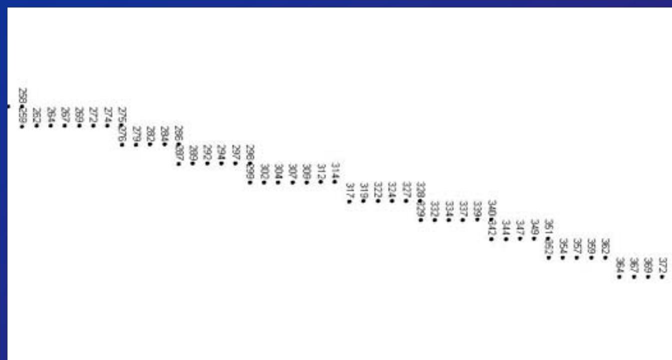
Also be aware that this is inherently part of the format and can legally occur in either the lat,lons or the x,y's. Most of these formats were originally written in Fortran, whose format descriptor for both latitude,longitude and, x,y was always floating point for the decimal portion of the coordinate (e.g. decimal degrees, decimal seconds, x or y). By defining the field as F11.6 or F10.1 a coordinate without a decimal place "implied" the precision or number of decimals. Including a decimal point merely overrides the format.

Changes in languages has caused issues and even strict changes in interpretation of the formats by some software developers and users of the formats.

## *Wonder why they shot it like that, looks like stairs!*



– **If you misidentify or do not understand the precision of coordinates**

Not understanding the precision of the coordinates can lead to interesting results in how other software may see them.

Conversely exporting coordinates at less than needed precision can also cause similar issues.


Because the formats are varied, especially those which are created outside the standards, the precision of the coordinates should be addressed.

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When interpreting formats containing both latitude,longitude and x,y, tests may be required to assess the precision of one or the other before data loading.

## *How to solve / understand the issues*

- Learn basic Geodesy.
- Realize that Metadata must be retained along with coordinates.
- Exchange data according to accepted standards.
- Understand precision and presentation of coordinates.
- Join or support the APSG and get involved in change.
- Support the EPSG/OGP geodetic database (www.epsg.org).

## *Remember everything is about good positioning!*

# *And applying the right tools & knowledge!*

2007 ESRI Petroleum User's Group Workshop

# Positioning Issues Related to Seismic Data

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***THANK YOU!***