Making Seismic Data Easier To Handle

Jill Lewis, CEO Troika International Ltd., Committee Member SEG Technical Standards Liaison, EarthIQ, OGP Geomatics Committee, Energistics Format Enthusiast
20 Years Old
Pool c++ objects
Data Management Products
  Transcription
  Format QC
  Database, TraceStore, Data Management Systems
  Workstation Loading Preparation
  Encapsulation and Unencapsulation
  Disk Crawling
QC and Consultancy Services

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DPTS Transcription Operator, Manager QC, Sales
Tape Technology – 11 Transcription centres worldwide, MD
Troika International – Tunbridge Wells, Aberdeen, Houston
SEG Technical Standards Committee
  SEGY1.0
  SEGD2.2
  SEGD3
  SEGY2 (under review)

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- Making sure newly received seismic data is ready for processing and interpretation - without the need to convert it into a different format
- Easier methods to check data quality and completeness
- Developing a natural data flow for how you handle seismic data
- Benefits of the recently ratified SEGD 3.0 field tape standard
- Benefits of the latest draft of SEGY2 standard for storing geophysical data
Shopping

A VERY EXPENSIVE SHOP
A VERY EXPENSIVE ITEM FROM A CONTRACT
What is it?

It’s in the contract

Seismic Field Data Management
What is in the packages?
DFS III
In February 1968 Texas Instruments started to advertise the DFS III. If the original DFS with 9000 amplifiers was the first generation Digital Field System, and the DFS-10000 was the second generation Digital Field System, then the new system was the third generation Digital Field System or DFS III. A dynamic range of 174 dB was optimistically claimed, with dynamic resolution of 84 dB. It was the first TI seismic system to use integrated analog and digital circuits ("chips") on a large scale, and was still in widespread use 10 years later.

DFS IV
The DFS IV was announced in late 1970, with the big innovation of instantaneous floating point gain: the gain was changed for each sample so that the amplitude of the signal input to the converter was nearly at full scale.

DFS V
In August 1975 Texas Instruments started advertising the DFS V. It was a dramatically more compact and lower power system, offering up to 120 channels in only four "man portable" modules. By the time the seismic industry collapsed at the end of 1981, TI had delivered over 1000 systems, which will probably remain an all time record for number manufactured of any one design of seismic recording system.

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Standards

FREE
seg.org/ts
Step 1 - Contracts

Standard Clauses in the Contract +
  e.g. Transcription
  SEG format AND REVISION NUMBER
  Level of QC
  Recovery Methods
  Header Data Population
  Meta-Data Collection and Provision
  Listings
  Plots

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Step 2 – QA Reports

*TAPE=13702.tap
FORMAT=SEGD_DMX
BYTES=173046340
LINEID=M92-4560
RECLEN=5632
DT=2
DATATYPE=FIELD
NSEIS=960
NAUX=27
ENSEMB=FFID
RANGE=9995,9998
RANGE=101,127

*TAPE=N85-24.sgy
TAPEFILE=1
FORMAT=SEGY
BYTES=16482256
LINEID=N85-24
RECLEN=6064
DT=4
DATATYPE=POSTSTACK
FOLD=1
UNITS=METRES
ENSEMB=cdp
RANGE=1001,3614
Step 3 – QC Visuals - field
Step 3 – QC Visuals - NTG
Step 3 – QC Post-Stack
Step 4 – Random Checks

3592 and LTO – less than 8 seconds
Job number: 8119
Line number: 22
Reel number: 25493505
Data traces per ensemble: 1
Sample interval (this reel): 4000
Samps per trace (this reel): 1516
Sample format code: 1 (IBM 32-bit floating-point)
CDP fold: 1
Trace sort code: 4 (horizontally stacked)
Vertical sum code: 1
Gain recovered flag: 1
Amplitude recovery method: 4
Measurement units: 1 (metres)
Impulse signal polarity: 1

Line Id extracted from header: 'N85-22A'
Expected length of trace records: 6304 bytes
Normal {Normal completion}
Magma 5.x for read and list

tcl> input read -listmode pattern -idbyte 1 -todeof
Read  Input tape: N85-22A.sgy

<table>
<thead>
<tr>
<th>Record Parity Error</th>
<th>Super</th>
</tr>
</thead>
<tbody>
<tr>
<td>Id bytes 1 to 16</td>
<td></td>
</tr>
<tr>
<td>c3f0 f140 c3d3 c9c5 d5e3 407a 40c7 4be2</td>
<td>3200 n/a - 1 1 1</td>
</tr>
<tr>
<td>0000 1fb7 0000 0016 0185 0001 0001 0000</td>
<td>400 n/a - 1 2 1</td>
</tr>
<tr>
<td>0000 0001 0000 0001 0000 0001 0000 0000</td>
<td>6304 n/a - 1 3 1</td>
</tr>
</tbody>
</table>

---- 2996 records of same length omitted from listing ----

<table>
<thead>
<tr>
<th>Length Status</th>
<th>File Record</th>
<th>File</th>
</tr>
</thead>
<tbody>
<tr>
<td>0000 obb6 0000 obb6 0000 059a 0000 0000</td>
<td>6304 n/a - 1 3000 1</td>
<td></td>
</tr>
</tbody>
</table>

/
/
/
/
End-of-file (File 1, 3000 records)
/
/
End-of-file (File 2, 0 records)
Normal {Normal completion}
Life of field – NPD The Petroleum Act addresses this issue in section 55 below. No data can be deleted in Norway without prior permission being granted by the authorities. So far LOF has not been addressed in this respect.

SeaBed acquisition

MicroSeismic

Etc.
Make Data Management of Structured Data Easier

Check Data – don’t let the contractors give you want they want to

Utilise the work of Format Bodies – so let’s see what they have been up to.....
Extended source support

• Support for complex shooting schemes
  • Multiple source initiations per shot record
  • Multiple sources firing simultaneously

• Support for complex source configurations
  • Traces and measurements for sources and parts of sources

• Support more source types
  • Electromagnetic source
  • No source/record not synchronized with source

• Align SEG-D with SPS standard and/or SEG-Y revision 1 and Px/12 positioning support
Support for New Technology

- Microseismic
- Under over cabling
- Seabed
- EM
- CSEM
- Transition
- Complex Arrays
- Receiver Organised Data

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• Appendix F (Tape device block size) - ?
• Storage of SEGD records
  – One header block spanning multiple tape blocks
  – A trace spanning multiple tape blocks
  – Fixed/variable block devices
  – Disk storage
  – Transfer across network

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New features in revision 3.0 proposal

- **Table Of Contents file**
  - Stored at end (or beginning) of tape
  - Lists all SEGD records on a tape
  - Enable fast access to data
  - May be stored on disk (to simplify data mgt)

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**CHAPTER I.**

**Preliminary Definitions and Theorems.**

§ 1. Algebraic numbers. Algebraic integers. Degree of an algebraic number .......................................................... 1
§ 2. Algebraic number realms. ................................................................. 3
§ 3. Generation of a realm ................................................................. 3
§ 4. Degree of a realm. Conjugate realm. Conjugate numbers ........... 5
§ 5. Forecast of remaining chapters ............................................... 5

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Survey information

- Standardizing storage of common survey information
  - Vessel/crew identification
  - Survey area name
  - Client identification
  - Job identification
  - Line identification (Record set ID)

Trailer
- Positioning Edits, Trust Flag
- Data Edits
- Comments
- Freeform for other information
- In other words the Observers Logs

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Timestamp

- All records, traces, measurements and events tagged with an absolute, microsecond accurate timestamp.
- Counting microseconds since 6 Jan 1980 (GPS epoch)
  - 8 byte integer
  - Negative timestamps allowed
  - 292471 years range
  - Defined back to 1 Jan 1970 (SEG-D epoch)
  - Leap seconds must be added to UTC timestamp (General Header)

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Positions

- Coordinate Reference System information stored as General Header
- SEG-Y Rev 1 stanza format + support for EPSG CRS ID.
  - Manual entry of parameters or using EPSG ID
- Any geographic, projected, or earth referenced CRS supported (1, 2 or 3 coordinates)
- Any number of CRS supported (One or two recommended)
- Position coordinates stored in Trace Header (receivers/sources) or General Header (sources)
- Two coordinate tuples per 96 byte position header
  - Most common: One geographic and one projected
- Contains type, timestamp and quality information
- A trace may contain any number of positions
General

- All header blocks (with a few exceptions) have an identification byte (byte 32) to allow blocks to be optional and be placed in e.g. Trace header in any order.
- A table in SEGD standard will identify all types of header
  - Client info
  - Channelset block 1
  - Channelset block 2
  - Position block 1
  - Position block 2
  - Airgun source
  - Vibroseis source
  - Additional source info
  - Extended trace header info 1
  - Etc etc

- Goal: Selfdescribing data, enable automated processing
General headers

- Added header blocks
  - Vessel/crew identification (with abbreviation?) ASCII*32
  - Area name (with abbreviation?) ASCII*32
  - Client name (with abbreviation?) ASCII*32
  - Job name/number/identification ASCII*32
  - Line name/number/identification ASCII*32
- More accurate timestamp defined (exactly defines time of first sample)
  - Used in general header
  - Source header
  - Trace header
Source header

- Used to be General header N
- Expand source header to contain most of SPS (needed to process SEGD automatically)
- Needed more than 32 bytes -> put common info into extended source info header
- One header block per source (single/combined)
- Can be put into trace header (e.g. in case of slipsweep acquisition)
- Quality information, timing

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Channelset

- Reformatted due to large number of new requirements
  - Samplerate
  - Starttime/endtime
  - Number of channels/samples
  - Filter definition extended
- 64 bytes (Channelset header block 1 & 2)
- Notch filter frequencies? Keep, remove or extend?

- Removed sensitivity from chset header (put into trace header) (only sensors with same sensitivity could be in same channelset, each sensor have different sensitivity)
Trace header

- Increased in size (255*32 byte)
- Partly defined in SEGD standard
- Partly user defined (more space available than in rev 2.x)
- Can contain position of trace
- Can contain source headers
General trailer

- Completely reformatted from Rev 2.x
- Consists of separate blocks of different (userdefined) information
- Each block starts with a description block defining type and size.
- Some blocks predefined
  - Edits
  - Positions (SEGD, P1, P2)
  - Text comments
  - Observer log
  - TOC?

[GT Desc Block (32 byte)][Block 1 (x*32byte)][GTDB][Block2][GTDB][Block3]....
SUPPORT FOR LITTLE ENDIAN DATA TYPES

9015 20 bit binary
9022 8 bit quaternary
9024 16 bit quaternary
9036 24 bit 2's complement integer
9038 32 bit 2's complement integer
9042 8 bit hexadecimal
9044 16 bit hexadecimal
9048 32 bit hexadecimal
9058 32 bit IEEE
9080 64 bit IEEE

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SEG Y rev 2 – under review

SEG Technical Standards Committee

Unchanged Items

2.1. Unchanged Items

- EBCDIC encoding allowed for text
- The size of the original 3200-byte
- Textual File Header, 400-byte Binary
- File Header and initial 240-byte Trace

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Unchanged Items

Magma Utility Shell Program Version 5.1.0.alpha1
Copyright (c) 1995-2013 by Troika International
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[Tcl version 8.4.16]
====
Magma license checked out
====
tcl> tdevs
tcl> tdevs21
tcl> tchanger devices
tcl> rtapi installed
0
tcl> tmount diskfile auto N85-24.sgy -name input -access read -directory C:/MagmaJobs/Data/2Dproject
input
tcl> input read -listmode pattern -idbyte 1 -records 50
Read Input tape: N85-24.sgy

<table>
<thead>
<tr>
<th>Id bytes</th>
<th>Length</th>
<th>Count</th>
<th>Status</th>
<th>File Record</th>
<th>File</th>
</tr>
</thead>
<tbody>
<tr>
<td>c3f0 f140 c3d3 c9c5 d5e3 407a 40c7 4be2</td>
<td>3200 n/a</td>
<td>-</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>0000 1fb7 0000 0018 0185 0001 0001 0000</td>
<td>400 n/a</td>
<td>-</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>0000 0001 0000 0001 0000 0002 0000 0000</td>
<td>6304 n/a</td>
<td>-</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>---- 46 records of same length omitted from listing ----</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0000 0030 0000 0030 0000 0019 0000 0000</td>
<td>6304 n/a</td>
<td>-</td>
<td>1</td>
<td>50</td>
<td>1</td>
</tr>
</tbody>
</table>
Normal [Normal completion]
Downward Compatibility to SEGY1.0

- First 240 bytes of trace headers to remain the same.

- Edit to binary header - as long as undefined fields were filled with binary zeros

- Multiple EBCDIC headers as per SEGY Rev 1.0 under same rules to provide downward compatibility to SEGY.

- Deprecate Rev 1.0 name and rename SEGY Rev 1.0 to SEGY1.0

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SEGY 1.0 – Trace Header

X coordinate of ensemble (CDP) position of this trace (scalar in Trace Header bytes 71-72 applies). The coordinate reference system should be identified through an extended header Location Data stanza (see section D-1).

Y coordinate of ensemble (CDP) position of this trace (scalar in bytes Trace Header 71-72 applies). The coordinate reference system should be identified through an extended header Location Data stanza (see section D-1).

For 3-D poststack data, this field should be used for the in-line number. If one in-line per SEG Y file is being recorded, this value should be the same for all traces in the file and the same value will be recorded in bytes 3205-3208 of the Binary File Header.

For 3-D poststack data, this field should be used for the cross-line number. This will typically be the same value as the ensemble (CDP) number in Trace Header bytes 21-24, but this does not have to be the case.
Changes for SEGY2.0

- Allow 240 byte trace header extensions, using a text string in the last 8 bytes of each extension to identify its contents
- Support up to $2^{31}$ samples per trace and traces per ensemble
- Permit arbitrarily large and small sample intervals (double precision option)
- Added 3-byte and 8-byte sample formats

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Changes for SEGY 2.0

- Support microsecond date and time stamps
- Provide for additional precision in coordinates, depths, elevations (Can use lat/long and UTM directly)
- Synchronize coordinate reference system specification with SEG-D rev 3
- Backward compatible with rev 1 (with edit to binary header) as long as undefined fields were filled with binary zeros
On Tape and On Disk

One important class of media that does not conform to the variable length record model is the disk file, which is defined on modern systems as a byte stream without any structure. It has become common practice to write SEG Y data to disk, including CDROM, for data distribution. Certain rules have to be followed for this to work correctly. Appendix A defines how SEG Y data should be written to a disk file. In order to make SEG Y consistent with the SEG D Rev 3.0 standard, Appendix B defines a tape label for SEG Y tapes, using a format based on the RP66 Storage Unit Label.
3.3. Number Formats
In the 1975 SEG Y standard, all binary values are defined as using “big-endian” byte ordering. This conformed to the IBM tape standard and means that, within the bytes that make up a number, the most significant byte (containing the sign bit) is written closest to the beginning of the file and the least significant byte is written closest to the end of the file. This byte ordering convention is maintained in this revision of the SEG Y format and it should be adhered to for all conforming versions of SEG Y. This is independent of the medium to which a particular SEG Y file is written (i.e. the byte ordering is no different if the file is written to tape on a mainframe or to disk on a PC).
3.5. Coordinates
Knowing the source and trace locations is a primary requirement for processing seismic data, and knowing the location of the processed data with respect to other data is essential for interpretation. Traditionally seismic coordinates have been supplied as geographic coordinates and/or grid coordinates. SEG Y accommodates either form. However locations are ambiguous without clear coordinate reference system (CRS) definition. SEG Y rev 1 significantly expands the ability to define the CRS used for the coordinates contained within the Binary Header, the Extended Textual Headers and the Trace Headers. **A SINGLE CRS MUST** be used for all coordinates within an individual SEG Y data set. Additionally the coordinate units must be the same. EPSG reference is not considered to be enough on it’s own.
Binary Header

BYTE NUMBER
3213-32141 Number of data traces per ensemble. **Mandatory for prestack data**
3215-3216 Number of auxiliary traces per ensemble. **Mandatory for prestack data.**
3217-3218 Sample interval in microseconds (µs). **Mandatory for all data types**
3221-3222 Number of samples per data trace. **Mandatory for all types of data.**

Note: The sample interval and number of samples in the Binary File Header should be for the primary set of seismic data traces in the file
3225-3226 Data sample format code. **Mandatory for all data.**
1 = 4-byte IBM floating-point
2 = 4-byte, two's complement integer
3 = 2-byte, two's complement integer
4 = 4-byte fixed-point with gain (obsolete)
5 = 4-byte IEEE floating-point
6 = Not currently used
7 = Not currently used
8 = 1-byte, two's complement integer
Binary Header

BYTE NUMBER
3227-32286 Ensemble fold — The expected number of data traces per trace ensemble (e.g. the CMP fold). Mandatory
3229-32306 Trace sorting code (i.e. type of ensemble):
-1 = Other (should be explained in user Extended Textual File Header stanza
0 = Unknown
1 = As recorded (no sorting)
2 = CDP ensemble
3 = Single fold continuous profile
4 = Horizontally stacked
5 = Common source point
6 = Common receiver point
7 = Common offset point
8 = Common mid-point
9 = Common conversion point Mandatory.
Binary Header

3255-32566
Measurement system: **Mandatory**.
If Location Data stanzas are included in the file, this entry must agree with the Location Data stanza. If there is a disagreement, the last Location Data stanza is the controlling authority.
1 = Meters
2 = Feet
Binary Header

3501-35026
SEG Y Format Revision Number. This is a 16-bit unsigned value. This field is mandatory for all versions of SEG Y, although a value of zero indicates “traditional” SEG Y conforming to the 1975 standard.

3503-35046
Fixed length trace flag. A value of one indicates that all traces in this SEG Y file are guaranteed to have the same sample interval and number of samples. This field is mandatory for all versions of SEG Y, although a value of zero indicates “traditional” SEG Y conforming to the 1975 standard.
Binary Header

3505-35066
Number of 3200-byte, **Extended Textual File Header** records following the Binary Header. A value of zero indicates there are no Extended Textual File Header records (i.e. this file has no Extended Textual File Header(s)). A value of -1 indicates that there are a variable number of Extended Textual File Header records and the end of the Extended Textual File Header is denoted by an ((SEG: EndText)) stanza in the final record. A positive value indicates that there are exactly that many Extended Textual File Header records. Note that, although the exact number of Extended Textual File Header records may be a useful piece of information, it will not always be known at the time the Binary Header is written and it is not mandatory that a positive value be recorded here. **This field is mandatory for all versions of SEG Y, although a value of zero indicates “traditional” SEG Y conforming to the 1975 standard**
6.3. Stanza Example

Definer name = J and J Example Seismic Ltd.
Line Name Convention = CDA
Line Name = Sample MicroSeismic 1
First Trace In Data Set = 101
Last Trace In Data Set = 1021
First SP In Data Set = 2001
Last SP In Data Set = 6032

Coverage type = full-fold
Perimeter coordinate type = I,J
Perimeter node number = 10
Perimeter node coordinates = 334.0000, 908.0000
Perimeter node coordinates = 654.0000, 908.0000
Perimeter node coordinates = 654.0000, 833.0000
Perimeter node coordinates = 900.0000, 833.0000
Perimeter node coordinates = 900.0000, 721.0000
Perimeter node coordinates = 1352.0000, 721.0000
Perimeter node coordinates = 1352.0000, 289.0000
Perimeter node coordinates = 802.0000, 289.0000
Perimeter node coordinates = 802.0000, 368.0000
Perimeter node coordinates = 334.0000, 368.0000
Coverage Perimeter comment = 48 fold data

Data Sample Measurement Unit = Millivolts
Volt conversion = 0.001
... additional stanzas or blank records to end of 3200-byte Extended Textual Header

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Trace Headers

1-4 Trace sequence number within line — Numbers continue to increase if the same line continues across multiple SEG Y files. **Mandatory.**

9-12 Original field record number. **Mandatory.**

13-16 Trace number within the original field record. **Mandatory.**

-1 = Other
  0 = Unknown
  1 = Time domain seismic data
  2 = Dead
  3 = Dummy
  4 = Time break

Etc Etc Etc to 39 = Rotational sensor – Pitch

40 = Rotational sensor – Roll

41 = Rotational sensor – Yaw

42 ... 64 = Reserved

65 ... N = optional use, (maximum N = 32,767) **Mandatory.**

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Trace Headers

73-76 Source coordinate - X.
77-80 Source coordinate - Y.
81-84 Group coordinate - X.
85-88 Group coordinate - Y.
The coordinate reference system should be identified through an extended header Location Data stanza (see section D-1). If the coordinate units are in seconds of arc, decimal degrees or DMS, the X values represent longitude and the Y values latitude. A positive value designates east of Greenwich Meridian or north of the equator and a negative value designates south or west.

89-90 Coordinate units:
1 = Length (meters or feet)
2 = Seconds of arc
3 = Decimal degrees
4 = Degrees, minutes, seconds (DMS)
Trace Headers

115-116 Number of samples in this trace. **Mandatory.**

117-1188 - Sample interval for this trace. Microseconds (µs) for time data, Hertz (Hz) for frequency data, meters (m) or feet (ft) for depth data. The number of bytes in a trace record must be consistent with the number of samples written in the trace header. This is important for all recording media; but it is particularly crucial for the correct processing of SEG Y data in disk files (see Appendix C). **Mandatory**
128 byte Tape Label

Compatible with SEGD

Table 4 SEG Y Tape Label
Field Description Bytes Start - end byte
1 Storage Unit Sequence Number 4 1 - 4
2 SEG Y Revision 5 5 - 9
3 Storage Unit Structure (fixed or variable) 6 10 - 15
4 Binding Edition 4 16 - 19
5 Maximum Block Size 10 20 - 29
6 Producer Organization Code 10 30 - 39
7 Creation Date 11 40 - 50
8 Serial Number 12 51 - 62
9 Reserved 6 63 - 68
10 Storage Set Identifier 60 69 - 128
Encapsulation

- Necessary with High Capacity Media
- Hardware summary
- Linear Serpentine recording
- 4 TB capacity using JC/JY media
- 1.6 TB capacity using JB/JX media
- 500 GB capacity using JK media
- 800 MBps burst data rate
- Compact 3.8 in x 7.8 in x 18.4 in dimensions

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Energistics serves as the facilitator, custodian and advocate for the development and adoption of technical open data exchange standards in the upstream oil and gas industry.

MIMOSA, an operations and maintenance open systems alliance, is a not-for-profit trade association dedicated to developing and encouraging the adoption of open information standards for Operations and Maintenance in manufacturing, fleet, and facility environments.

PIDX International provides a global forum for delivering the process, information and technology standards that facilitates seamless, efficient electronic business within the oil and natural gas industry and its trading community.

POSC Caesar Association (PCA) is a non-profit global standardization member organization that shall promote the development of open specifications to be used as standards for enabling the interoperability of data, software and related matters.

Professional Petroleum Data Management Association (PPDM) is a global not-for-profit organization within the petroleum industry to promote professional petroleum data management through the development and dissemination of best practices.

The Open Geospatial Consortium (OGC) is an international industry consortium of over 480+ companies, government agencies and universities participating in a consensus process to develop publicly available interface standards.

The OPC Foundation is dedicated to ensuring interoperability in automation by creating and maintaining open specifications that standardize the communication of acquired process data, alarm and event records, historical data, and batch data to multi-vendor enterprise systems and between production devices.

The Pipeline Open Data Standard Association (PODS) was created to develop and support open data storage and interchange standards to meet the specific data management needs of pipeline companies.

SEG The Society of Exploration Geophysicists is a not-for-profit organization that promotes the science of applied geophysics and the education of geophysicists. The Society fulfills its mission through its publications, conferences, forums, web sites, and educational opportunities.

SEG EarthIQ ????

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In Conclusion

• Standards
  • Standards
    • Standards
      • Standards
        • Standards
          • Standards

• And Good Logical Workflows