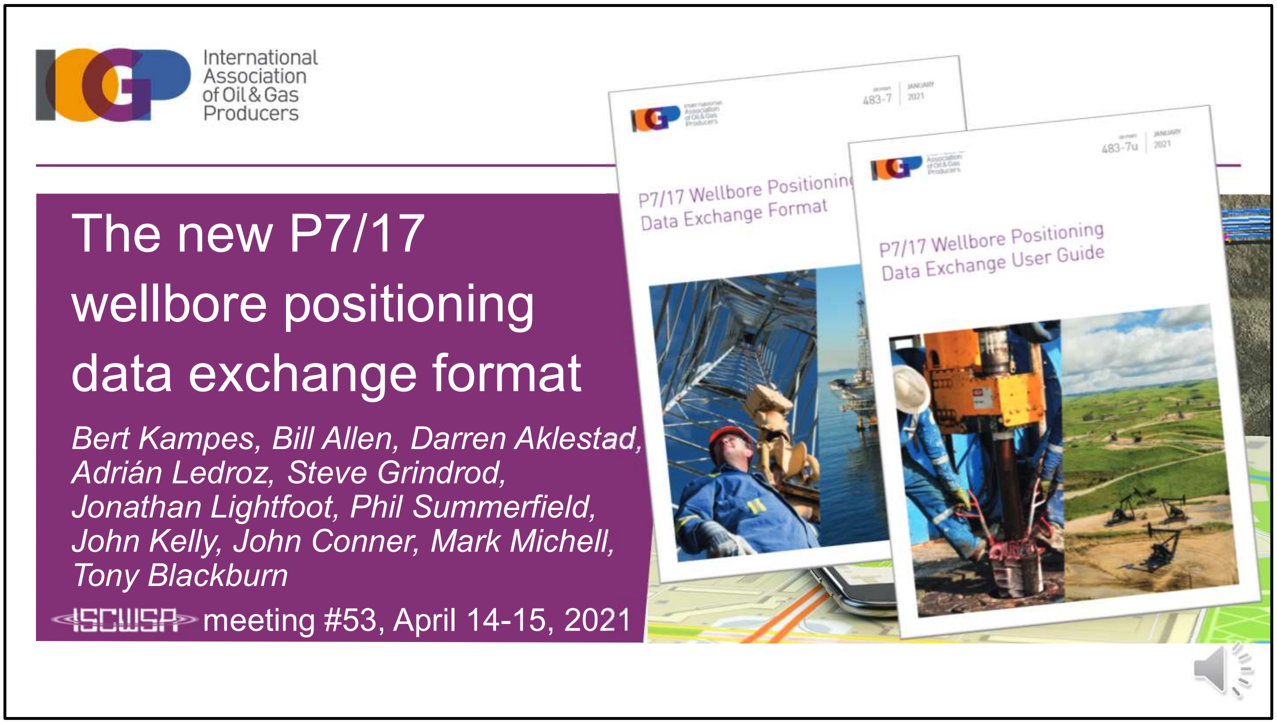


Hi I'm Darren Aklestad and today I'll be presenting to you, information on the newly released IOGP P7/17 Wellbore Positioning Data Exchange format.

As you can see from the first slide, this is the outcome of work by many people not all of them included on this first slide, and today I'm merely the messenger. I'll be updating YOU as part of the larger wellbore construction community, about the existence of this new P7 release, give you details of it's content and capabilities, and encouraging widespread adoption and usage of this standard.

I'd like to thank the I.S.C.W.S.A. for the opportunity to share this presentation today.

The P7/17 format and accompanying user guide was released in February of this year, 2021, by the International Association of Oil and Gas Producers (IOGP), formerly known as simply the OGP when this project was started. There are several supplementary slides at the end of today's presentation which I won't be going through, but are for your reference concerning information about the IOGP organization and key contacts for various related domains. All of this will be available to you when the presentation gets posted to this ISCWSA website meeting minutes in a couple days.

The P7 update was developed and key input was provided by, a volunteer taskforce. The members of this taskforce come from directional companies, data QC companies and Operators.
Many, if not most of these volunteers are also volunteers and/or attendees to ISCWSA meetings and its various sub-committees.

The presentation will utilize the examples in the user guide, which accompanies the updated specification, to demonstrate the capabilities of the new P7/17 format.

Outline

- Overview
- Basic example
- Error model
- Raw sensor data
- Conclusion

2

A brief outline of the presentation is as follows.

I'll give an overview of the format, how it's built up, its main definitions, and also include some brief history and motivation for the project.

We will then jump into a demonstration of a basic example, which comes directly from the user guide, hopefully making this presentation a useful supplement.

We won't be going into high detail of the specification today, but I encourage everyone to download the P7/17 documentation, there is a link for that in this presentation at the end, so you can get that when this presentation is posted to the ISCWSA website.

Next we show how a specific survey tool error model can be included in the format, and finally how raw magnetic and/or gyro sensor data can be included

Format objectives

Provide a standardized way to permanently store final wellbore positioning data in an ascii file to report to regulators and exchange between operators and applications. It is not intended as protocol for real-time operational use (WITSML).

Update the IOGP (UKOOA) P7/2000 format to

- Record raw sensor data
- Add in Error Model definition
- Handle multiple wells, wellbores, surveys
- Align with EPSG coordinate reference system handling
- Extendable

3

Many of you may be familiar with previous versions of the P7 format P7/2000 for wellbore survey data exchange. That format had been adopted by other organizations and regulatory bodies, most notably UKOOA, the United Kingdom Offshore Operators Association, as well as the US Minerals Management Service (MMS) who are now know as the Bureau of Safety and Environmental Enforcement "BSEE", to my latest research and findings, the P7/2000 is still the current required reporting standard for those organizations.

Many directional companies are able to generate the P7/2000 output format for survey reporting to these organizations. We hope this will also become the case for the new format, and the IOGP can work with these other organizations to update or transition to accept the new P7/17 standard in place of P7/2000.

The drivers to consider a format update to the previous year 2000 standard were mainly to include raw sensor data, as well as to handle inclusion of a survey tool error model in the format.

This in large part was because of the efforts of this group "ISCWSA" and its various technical sub-committees who in-turn have raised the emphasis in the operator community on data quality to help control wellbore position uncertainty.

The ability to perform a more detailed QC analysis of survey data is only possible through the exchange of more fundamental sensor data not merely the derived survey tool orientation which was the only requirement and format provision in the P7/2000.

Additional objectives were added as opportunity presented which naturally happens during any update to a standard.
The hard part is to not include too much and keep the scope limited to the original primary objectives.

An added objective that WAS included was to be able to include in a single P7/17 file, more than one “survey” and to include multiple associated wells and wellbores and to encapsulate a “complete” survey record include all survey runs from all sources, not necessarily just a final composite, which is usually the only requirement for regulatory needs.

Additionally we wanted to keep the standard in alignment with other standards or organizations both in terms data definitions and nomenclature as much as possible.
Examples are WITSML, PPDM ,ISCWSA lexicons, API RP78, EPSG, etc.

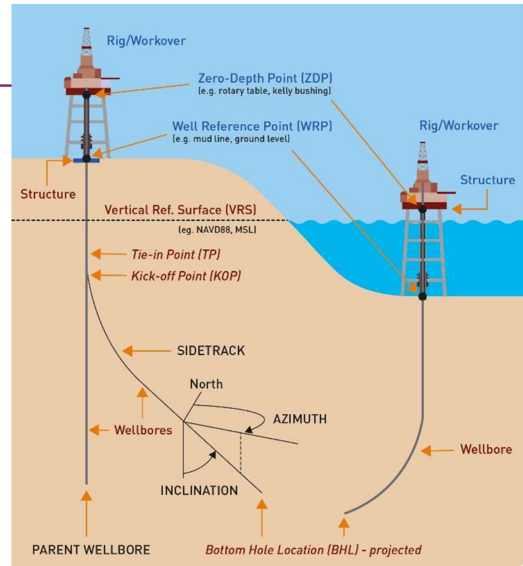
A major portion of the “P” standards that had already been updated through other P standard updates - was the alignment with the standards of the “European Petroleum Survey Group” EPSG, which is also a part of the IOGP organization, that defines the standards concerning geomatics coordinate reference systems.

We were able to simply do a direct copy of that portion of the other P standard or give reference to all the work done by that other taskforce of professionals in the geomatics domain.

And finally as we all know by now, nothing is static in the fast changing world of anything related to data, so the format is extensible as needed.

Terminology

- **ZDP** = Zero-depth Point: wellbore datum (e.g., "DF")
  - Referenced to the Vertical CRS
    e.g., "MSL depth", EPSG code 5715
- **WRP** = Well Reference Point: surface location
  - Referenced to the Projected CRS
    e.g., "NAD27 / Texas Central", EPSG code 32039
- **SRP** = Structure (Site) Reference Point



4

Since the primary purpose for using survey data is for locating wellbores positions, I'll cover a couple terminology points that help us get our well positions anchored.

For all surveys the main references to define are the reference for the measured depth and the surface location.

In the P7 format the term "Zero depth point" (ZDP) is used for what is commonly known as the measured depth reference, many times called simply an elevation, for example the drill-floor elevation or Kelly bushing elevation
This point is really more than an elevation, it should be defined in 3D coordinates, but generally sits straight above the Well Reference Point (WRP), which is the non-movable surface location, also given by its 3D coordinates.
Both the horizontal projected Coordinate Reference System and the Vertical Coordinate Reference System are needed to interpret the 3D coordinates as a location on the Earth.

The Structure or Site Reference Point (SRP) is also a required mandatory defined 3D point, but may have the same coordinates as the well reference point.

The uncertainty of the Well Reference Point and Structure Reference Point are an optional part of their position records, but of course these uncertainty parameters are of prime importance to this group and probably shouldn't be omitted.

Note it is also possible to record the Well Reference Point in relative coordinates from the Structure Reference Point – but that is for QC-ing the data only by doing data cross checks, not as a primary means of defining the Well Reference Point instead of defining it in terms of it's 3D coordinates.

Record identifiers

Identifier	Record Type (block)
IOGP	File identifier. First line of the file.
HC, i,j,k	Common header record (common across the various IOGP data exchange formats)
CC, i,j,k	Comment record (general)
H7, i,j,k	Header record specific to the Wellbore Positioning Data Exchange (P7/17) format
C7, i,j,k	Comment record related to a P7 specific header record
O7	Data record (Wellbore Position Object)
P7	Data record (Surveyed and calculated data)
M7	Data record (MWD raw sensor data)
G7	Data record (Gyro raw sensor data)

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A quick explanation of record identifiers, which you will encounter in the next slides is in order.

The identifiers are at the start of each line in the P7 file and let you know what type of data follows on that line

The record identifiers are pretty intuitive, and simply have a trailing 7 to indicate this is from the P7 standard vs a different P standard.

HC stands for – Header Common
CC stands for – Comment Common
H7 stands for – Header P7 specific
C7 stands for – Comment P7 specific
I'm not going to say p7 specific anymore its implied
O stands for – Object
P stands for – Survey and calculated position data
M stands for – MWD or magnetic raw data
G stands for – Gyro raw data

Format layout

ASCII text file in IOGP comma separated ‘P’-format style

1. Common Header HC (aligned with the EPSG Dataset to define the Coordinate Reference System)

2. Data type specific header H7 (i.e., wellbore survey for P7)

3. Data section P7

Human readable, but to be read/written by software

• Utilizes object crosslinks

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The basic ‘P’ format is a comma separated ASCII file that consists of three blocks.

A quick comment about this being ASCII, which may seem a bit antiquated by some, it was agreed that ASCII was still the most universal of formats ,maybe lacking some of the capabilities of more modern self-describing formats such as XML or JSON, which in turn can have drawbacks that can make them less available or useful to some users if there isn’t some semblance of human readability.

The 1st block is a common header – which contains general project definitions and notably the Coordinate Reference System for which the EPSG Dataset is utilized.

Common header block

```
CC,0,0,0,  ---------------------------------------------
CC,0,0,0,  Example of Implicit CRS/CT Identification
CC,0,0,0,  ---------------------------------------------
HC,1,3,0,CRS Number/EPSG Code/Name/Source,  1, 4267, NAD27,
         9.5,2018:09:06,EPSG,
HC,1,3,0,CRS Number/EPSG Code/Name/Source,  2,32039, NAD27 / Texas South Central,
         9.5,2018:09:06,EPSG,
HC,1,3,0,CRS Number/EPSG Code/Name/Source,  3, 6358, NAVD88 depth (ftUS),
         9.5,2018:09:06,EPSG,
HC,1,3,0,CRS Number/EPSG Code/Name/Source,  4, 4326, WGS 84,
         9.5,2018:09:06,EPSG,
HC,1,6,1,Coordinate System Axis 1       ,2,1,, Northing, north, N,  6,ftUS
HC,1,6,1,Coordinate System Axis 2       ,2,2,, Easting,  east,  E,  6,ftUS
HC,1,6,1,Coordinate System Axis 1       ,3,1,, Depth,    down,  D,  6,ftUS
HC,1,6,2,Conversion Applied             ,2,15498, axis order change (2D),9843,axis order
         reversal (2D)
HC,1,7,0,Transformation Number/EPSG Code/Name/Source,1,15851,NAD27 to WGS 84 (79),
         9.5,2018:09:06,EPSG
```

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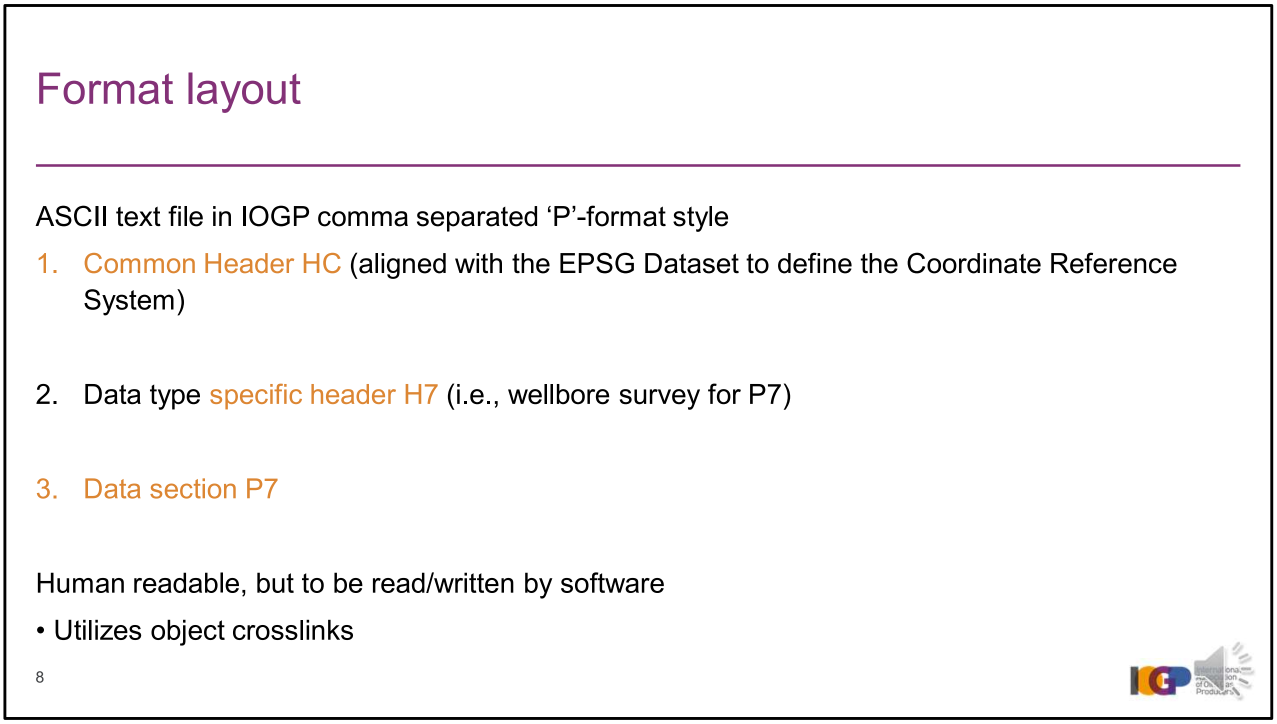
Here is an example of a Common Header block with Comment Common records and Header Common records

A quick note on the highlighted numbers this comes from the user guide and is showing how definitions of things get cross referenced. In this case it is definition of axes for the coordinate reference systems so you can see the Northing and Easting belong to the state plane coordinate system, but the depth axis belongs with the vertical datum definition.



The 2nd block is the data type specific header. as previously shown on the Record identifiers slide, there are specific headers for the type of data file, in this case for P7. These will be H7 specific header record for wellbore survey definitions, for example the definition of the Wellbore. Other P formats would have completely different specific header requirements for example for seismic data.

Specific header block

```
H7,1,1,0,Structure Definition,1,Alpha platform, SRP,1,Platform Centre,2,Offshore,Sea Floor,
        1, 30.207
H7,1,2,1,Well Details,1,Slot C,,, -9.00, 7.50

H7,4,0,0,Position Object Definition,1,Alpha,1,Structure Reference Point,…
O7,0,1,SRP,Alpha, 718541.26, 3151622.18, -192.00, 29.7604000,-95.3698000, 29.7606281,-
        95.3700161,,

O7,0,1,DELTA SITE,    SRP, 718541.26, 3151622.18, -2600.00, 29.7604000,-95.3698000,
        29.7606281,-95.3700161,2.0,
O7,0,2,Slot Delta_9,  WRP, 718535.81, 3151657.82, -2600.00, 29.7603820,-95.3696883,
        29.7606101,-95.3699043,0.1,
```

9

Here is an example of a Specific Header block with H7 type records but can also have Object O7 records.

As can be seen here we definitions for a Structure, a Well, a Structure Reference Point, and a Well Reference Point. These will be explained further in the basic example to follow.

Format layout

ASCII text file in IOGP comma separated 'P'-format style

1. Common Header HC (aligned with the EPSG Dataset to define the Coordinate Reference System)

2. Data type specific header H7 (i.e., wellbore survey for P7)

3. Data section P7

Human readable, but to be read/written by software

- Utilizes object crosslinks

10

And finally the 3rd block is the data section, which contain all the records for the survey measurements.

Data section block

```
CC,0,0,0,,,,,,,                  ft,    deg,     deg,,,,,,,,,
CC,0,0,0,-,----------,--,-,-,-----,-------,----,------,,,,,,,,,
P7,0,1,1,,,3,ZDP,9,Other,          0.00,  0.000,    0.000, ,,,,,,,,
P7,0,1,1,,,2,WRP,9,Other,         26.00,  0.000,    0.005, ,,,,,,,,
P7,0,1,1,,, ,  D,1,Surveyed,      50.00,  0.281,    4.800, ,,,,,,,,
P7,0,1,1,,, ,  D,1,Surveyed,      75.00,  0.472,    4.596, ,,,,,,,,
P7,0,1,1,,, ,  D,1,Surveyed,     100.00,  0.526,    4.183, ,,,,,,,,
```

```
D     0.00   0.000   0.000   9 O
D    32.20   0.000   0.000   9 O
D  1000.00   0.000   0.000   9 O
D  1059.00   1.100 121.500   8 S
D  1161.00   3.600 115.500   8 S
D  1290.00   5.900 123.600   8 S
D  1346.00   5.800 126.900   8 S
D  1453.00   4.300 134.300   8 S
```

UKOOA P7/2000

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Here is an example of a Data Block with the p7 records, this being the most basic of MD, INC, AZIM. For comparison the older P7/2000 format is also shown for the same basic data.

Format layout

ASCII text file in IOGP comma separated 'P'-format style

1. Common Header HC (aligned with the EPSG Dataset to define the Coordinate Reference System)
2. Data type specific header H7 (i.e., wellbore survey for P7)
3. Data section P7

Human readable, but to be read/written by software

- Utilizes object crosslinks

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Because ASCII is used, the format can be inspected in a text editor and is "human readable".

However a computer should be used to read and write the data to the format, thus reducing the potential for formatting errors or file corruption.

The main reason is that once the file contains multiple surveys, then it can become quite difficult to understand the multiple cross referencing used in the format – as we will show in a few slides.

The common header of the 'P' format provides an efficient way to reuse format readers. As an example this means the coordinate reference system HC records should be identical across P files and a reader of a seismic P11 file could also read the HC portion of a P7 file.

Unfortunately there are currently no P7 reader/writers provided or made available in the public domain, hopefully this will change soon.

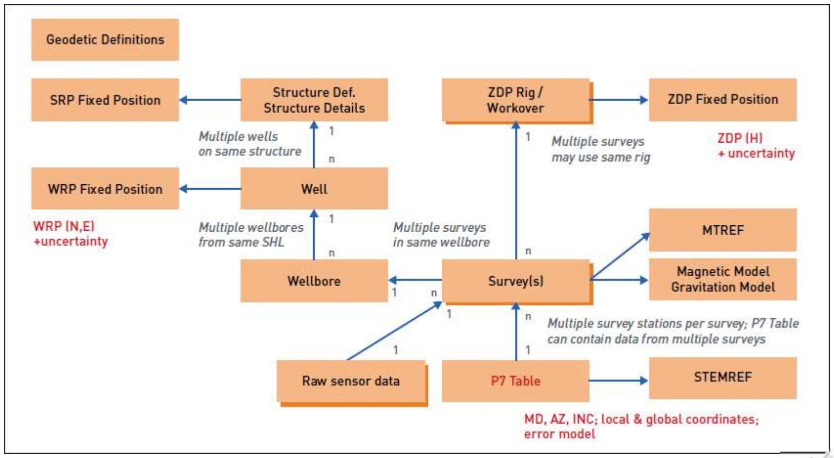
Main objects

A **Survey** is done:

- in a **Wellbore**
- which is in a **Well**
- which is on a **Structure**

With crosslinks to:

- a **ZDP** point (rig/workover)
- **P7 Table**
  - *observables (MD, INC, AZI)*
  - *calculated data (N,E,D etc.)*



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The main OBJECT definition records are for the **Structure** that holds a **Well**, which contains one or more **Wellbores**, in which **Surveys** are performed in.

A P7 file can hold multiple structures, wells and wellbores.

Note that the WRP or Well Reference Point that we just reviewed is linked to the Well.

And that the SRP or Structure Reference Point is linked to the Structure.

While the ZDP Zero Depth Point is crosslinked to the Survey.

The P7 Table are the data records that hold the actual data, such as for MD, INC and AZI.

The P7 Table can point to multiple surveys which may use different zero-depth point references (and units and azimuth North references for that matter).

There is no specific requirement for any data normalization within a file, any combination, units, north references, tool axes, etc can all be combined as long as they are defined.

These links on the right MTREF is a reference to a measurement tool, this would be a specific MWD tool for example, so there could be multiple definitions in the file, the STEMREF is a reference to a Survey Tool Error Model, and as you can see there are also definitions for the reference magnetic model and gravity model associated with the specific survey object.

It is not intended to be a slide to analyse or explain in detail. The point is there are crosslinks and to understand the data one needs to reverse up/down these references.
It may not be immediately clear to people that the Survey does not hold data, but the P7 data records (the “P7 Table”) does.
I’d recommend not to mention all this and not spend time here, but take the quickest path to the examples and data.
Can always come back to this slide when there are questions.

Example record

• Each record (row) has an identifier and comma separated fields

Field	1-4	5	6	7	8	9	10
Field Name		"Project Information"	Project Name	Field Name	Region or Administrative Area	Country Name	Text Country Code
Record	H7,1,0,0	Field Name	1	Saltire	UK North Sea	United Kingdom	GBR

Here is a simple example record.

Each record has an identifier. In this case this is "H7,1,0,0" using fields 1 to 4. It has an H so is a header record
After that identifier there is a record field name. In this case "Project Information".
This is followed by the actual attributes or properties in the following fields.

Format definition – P7 data record

• Example from format definition document showing the fields of the P7 data record

Field	Description	Data Type	Reference Code	Comments
1	Record Identifier	Text		Must be "P7"
2	Record Version	Integer		0
3	P7 Table Number	Integer	P7TABLEREF	Constant for a related block of P7 records
4	Survey Reference Number	Integer	SURVEYREF	
5	Survey Tool Error Model Reference Number	Integer	STEMREF	Leave blank if unknown
6	Survey Tool Error Model Name	Text		(OWSG) error model See notes for format Leave blank if unknown

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The format definition document contains a description of all records.
This example shows the format for the "P7" record.
The document exactly specifies for each field what content is expected. I'm not going to dwell on the specifics of these next slides, just briefly show you the standard fields of P7 records so you get a flavor of all the field types that are encompassed.

As you can see there are multiple references on each record line keeping all the date fully referenced to all its associated meta-data.

The slides can be used for reference later but I suggest the full specification document.

P7 data record (cont.)

Field	Description	Data Type	Reference Code	Comments
7	Position Object Reference Number	Integer	WOBJREF	If pertaining to a defined well object (H7,4,0,0) Otherwise leave blank
8	Position Object Type Abbreviation	Text		See Table 14
9	Observables Status Code	Integer	WOBSSTATUS	Refer to Table 20
10	Observables Status Name	Text		Refer to Table 20
11	Measured Depth (MD)	Float		Same unit as SURVEYREF
12	Inclination (INC)	Float		Degrees
13	Azimuth (AZ)	Float		Same azimuth reference as SURVEYREF

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These slides also show what tables in the specification document have further specific definitions for the data that is expected for each of these fields.

The references will use an integer to the parent referenced object, but there is also a corresponding text field to the meaning of that integer if it comes from a defined field option list.

P7 data record (cont.)

Field	Description	Data Type	Reference Code	Comments
14	Local northing (n)	Float		Same unit as MD Same orientation as AZ
15	Local easting (e)	Float		Same unit as MD Same orientation as AZ
16	Local depth (d)	Float		Same unit as MD
17	Northing (N)	Float		In CRSREF=2 projected CRS as defined in HC,1,3,0 May have different unit and/or orientation than local northing
18	Easting (E)	Float		In CRSREF=2 projected CRS May have different unit and/or orientation than local easting
19	Depth (D)	Float		In CRSREF=3 vertical CRS May have different unit than local depth

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As you can see these other fields of the P7 record are what you would expect associated with survey station record to indicate the position of that survey station.

P7 data record (cont.)

Field	Description	Data Type	Reference Code	Comments
20	Latitude	Float		Optional. In CRSREF=1, the base geographic CRS of the projected CRS
21	Longitude	Float		Optional. In CRSREF=1, the base geographic CRS of the projected CRS
22	Additional Data Fields	Additional	Field List	The number of items must equal that given in the H7,5,0,0 record

And finally trailing fields can be custom added as defined with the extensible field records.

Example cross-referencing

- An object entity is given a REF number in its definition record
- This is cross-referenced in other records (linkages exemplified by the colors)

```
H7,1,1,0,Structure Definition             ,1,DELTA SITE,SRP,1,,1,onshore,Ground Level,,
H7,1,2,0,Well Definition                  ,1,1,WRP,2,4220112345,ALPHA 01,TRC,,,,,SEC 20 TWP 30S R40E,
H7,1,3,0,Wellbore Definition              ,1,1,422011234500,WB00,TRC,,,,ACTUAL,ST00,2018:02:05
H7,1,4,0,Rig/Workover ZDP Definition      ,1,Unknown Rig, ZDP,3,1,Derrick Floor,1,1
H7,1,5,0,Survey Definition                ,1,1,1,WIRELINE GYRO CONTINUOUS,Gyro,,,,,50.00,10950.00,ft,…
H7,1,5,1,Survey Details                   ,1,11,2,MD-Wireline, 1,Indicated depth,1,9,AZ_GRID,4,…
```

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Here is an example of cross referencing which the P formats make extensive use of.

Your close attention to this concept is in order.

If there is only a single survey in a single wellbore this point is not particularly important.

But the cross referencing concept can make it hard for humans to follow the content and is the reason that computers should be used to interpret the ‘P7 content especially in cases where a P7 file contains multiple surveys in the same or in multiple wellbores.

In this slide colors are used to show these cross-references.

For example, the Structure is defined with STRUCTURE_REF = 1 as shown in gray.

Then in the next record, the Well definition is also assigned a 1 in yellow, but there is a cross-reference to the Structure #1 in gray

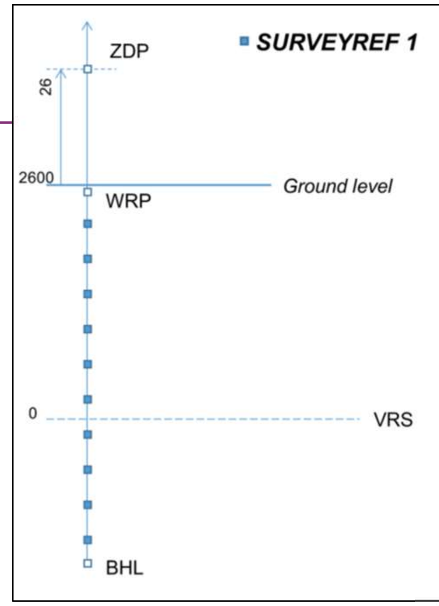
This also occurs for the Wellbore definition #1 in green, which references the previously defined WELL #1 in yellow.

There are other examples here of other records referencing each other, and this is ubiquitous through out P format files.

Basic example

- Straight hole, wireline gyro
- Zero-depth point at 26 ft above ground level
- 2626 ft above MSL

- No raw sensor data, no calculated data, no error model



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Now let’s talk about a basic example.

This example is from the user guide. The user guide includes other examples of much more complicated well construction scenarios to demonstrate the flexibility and completeness of the P7 format, so don’t be put off by this examples simplicity.

We have a basically straight hole and a wireline gyro survey.

The Derrick Floor zero-depth point ZDP is 26 ft above the ground level, which is 2600 ft above Mean Sea Level.
This makes the Derrick Floor sit 2626 ft above MSL.

This examples serves only to demonstrate the minimum requirements.

The initial example does not demonstrate raw sensor data, calculated data or survey tool error model definition. Those will follow.

Mandatory Coordinate Reference System definition

```
IOGP,User Guide Example A,7,1.0,1,2018:08:30,14:42:26, P717 User Guide example A.p717, P7 task force

CC,0,0,0,** IOGP P7 User Guide Example A
CC,0,0,0,** Created by User Guide group on 2018-10-19
CC,0,0,0,** Based on test dataset Input file: "Alpha 01 BIG RIG WIRELINE GYRO CONTINUOUS.PDF"
CC,0,0,0,** Ground Level (GL) is 2600 ftUS above the VRS (NAVD88)
CC 0,0,0,** The ZDP (Derrick Floor) is 26 ftUS above GL (total 2626 ftUS above NAVD88)

CC,0,0,0,  ----------------------------------------------
CC,0,0,0,  Implicit CRS/CT Identification
CC,0,0,0,  ----------------------------------------------
HC,1,3,0,CRS Number/EPSG Code/Name/Source            ,1, 4267, NAD27,                      9.5,2018:09:06,EPSG,
HC,1,3,0,CRS Number/EPSG Code/Name/Source            ,2,32039, NAD27 / Texas South Central, 9.5,2018:09:06,EPSG,
HC,1,3,0,CRS Number/EPSG Code/Name/Source            ,3, 6358, NAVD88 depth (ftUS),         9.5,2018:09:06,EPSG,
HC,1,3,0,CRS Number/EPSG Code/Name/Source            ,4, 4326, WGS 84,                     9.5,2018:09:06,EPSG,
HC,1,6,1,Coordinate System Axis 1                    ,2,1,, Northing, north, N, 12,ftUS
HC,1,6,1,Coordinate System Axis 2                    ,2,2,, Easting,  east,  E, 12,ftUS
HC,1,6,1,Coordinate System Axis 1                    ,3,1,, Depth,    down,  D, 12,ftUS
HC,1,6,2,Coordinate Axis Conversion Applied          ,2,15498,  axis order change (2D),9843,Axis Order Reversal (2D)
HC,1,7,0,Transformation Number/EPSG Code/Name/Source ,1,15851, NAD27 to WGS 84 (79),        9.5,2018:09:06,EPSG,
```

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The P7 format for this basic example starts with the common header.

P7/17 has only a single Coordinate Reference System per file

- One for horizontal, in this case NAD27 / Texas South Central
- One for vertical system datum, NAVD88 for depth using (ftUS) for use onshore USA, or it could be MSL or LAT for example.

All 3D geodetic coordinates of positions are referenced to these.

Vertical coordinates are always stored as depths.

The EPSG name and EPSG codes are used to define the Coordinate Reference Systems, i.e., by means of implicit identification.

It is possible to explicitly define all mapping parameters but that is not required.

These records are part of the IOGP ‘P’ formats Common Header.

Mandatory entity definitions

```
CC,0,0,0,  ----------------------------------------------
CC,0,0,0,  Mandatory Entities
CC,0,0,0,  ----------------------------------------------
H7,1,0,0,Project Information                           ,BETA FIELD,BETA FIELD,Texas,United States,USA
H7,1,1,0,Structure Definition                          ,1,DELTA SITE,SRP,1,pad monument,1,onshore,Ground Level,,
H7,1,2,0,Well Definition                               ,1,1,WRP,2,4220112345,ALPHA 01,TRC,,,,As-built,SEC 20 TWP 30S R40E,2018:02:05
H7,1,3,0,Wellbore Definition                           ,1,1,422011234500,WB00,TRC,,,,Actual,SEC 20 TWP 30S R40E,ST00,2018:02:05
H7,1,4,0,Rig/Workover ZDP Definition                   ,1,Rig A,ZDP,3,1,Derrick Floor,1,1
H7,1,5,0,Survey Definition                             ,1,1,1,WIRELINE GYRO CONTINUOUS,Gyro,,,,,50.00,10950.00,ft,2018:02:05,,TP,2,,
H7,1,5,1,Survey Details                                ,1,11,2,MD-Wireline, 1,Indicated depth,1,9,AZ_GRID,4,Calculated from AZ_TRUE,1,1.780,0,,,,
H7,1,5,2,Operator/Survey Contractor                    ,1,IOGP Exploration,Unknown Contractor,Unknown Job Number
```


The next block defines mandatory objects, i.e., the Structure, Well, Wellbore, Zero-depth Point and Survey.

This provides the Well Identification, type of survey, and observation references such as the unit for the Measured Depth and whether Azimuth is Grid or True.
In this case ft and GRID.
The actual coordinates will be defined in the next block.

Mandatory position objects

```
CC,0,0,0,  ---------------------------------------------
CC,0,0,0,  Mandatory Position Objects
CC,0,0,0,  ---------------------------------------------
H7,4,0,0,Position Object Definition                     ,1,DELTA SITE,   1,Structure Reference Point,depth at Ground Level,1,,,,,,26.00
H7,4,0,0,Position Object Definition                     ,2,Slot Delta_9, 2,Well Reference Point, on Wellpad, 1, 26.0,0.0,0.0, 0.00,0.00,26.00

H7,4,0,0,Position Object Definition                     ,3,DF Rig A,     3,Zero-depth Point,Derrick Floor,   1,    0,  0,  0, 0.00,0.00, 0.00

O7,0,1,SRP, DELTA SITE,    718541.26, 3151622.18, -2600.00, 29.7604000,-95.3698000, 29.7606281,-95.3700161,10.0,
O7,0,2,WRP, Slot Delta_9, 718535.81, 3151657.82, -2600.00, 29.7603820,-95.3696883, 29.7606101,-95.3699043,1.0,3.0
O7,0,3,ZDP, DF Rig A,      718535.81, 3151657.82, -2626.00, 29.7603820,-95.3696883, 29.7606101,-95.3699043,   ,3.0
```

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The next section is about the geometry of mandatory positioning Objects.

The Structure Reference Point coordinates are given, the Well Reference Point, and the Zero-depth Point.

You can recognize the Northing and Easting coordinates of the Well Reference Point in the CRS NAD27 / Texas Central, also the ZDP point being the Derrick Floor at 2626 ft above Mean Sea Level (or actually NAVD88)

---

for observant members of the audience, note that the minus -2626 coordinate for the ZDP means negative depth, i.e., 2626 ft above MSL). As mentioned in the previous slide all vertical coordinates are in terms of Depth.

also for the very observant person, note that geographic coordinates for such positioning object are expected in the base geographic CRS of the projected CRS, and also that they are given in WGS 84.

Note that WGS 84 latitude and longitude are also provided to provide some redundancy and to facilitate mapping and data analytics where a common base CRS is required.

Mandatory P7 Table (MD, INC, AZI)

```
CC,0,0,0,  ----------------------------------------------
CC,0,0,0,  The P7 Table
CC,0,0,0,  ----------------------------------------------
H7,5,0,0,P7 Table Definition                              ,1,Definitive Survey,,,,,,,,0,

CC,0,0,0,-,----------,--,-,-,-----,-------,----,------,,,,,,,,,
CC,0,0,0,,,,Type,,Status,      MD,     INC, AZ_GRID,,,,,,,,,
CC,0,0,0,,,,,,,                ft,     deg,      deg,,,,,,,,,
CC,0,0,0,-,----------,--,-,-,-----,-------,----,------,,,,,,,,,
P7,0,1,1,,,3,ZDP,9,Other,        0.00,  0.000,   0.000, ,,,,,,,,
P7,0,1,1,,,2,WRP,9,Other,       26.00,  0.000,   0.005, ,,,,,,,,
P7,0,1,1,,, ,  D,1,Surveyed,    50.00,  0.281,   4.800, ,,,,,,,,
P7,0,1,1,,, ,  D,1,Surveyed,    75.00,  0.472,   4.596, ,,,,,,,,
P7,0,1,1,,, ,  D,1,Surveyed,   100.00,  0.526,   4.183, ,,,,,,,,
P7,0,1,1,,, ,  D,1,Surveyed,   125.00,  0.579,   3.847, ,,,,,,,,
P7,0,1,1,,, ,  D,1,Surveyed,   150.00,  0.632,   3.567, ,,,,,,,,
P7,0,1,1,,, ,  D,1,Surveyed,   175.00,  0.701,   1.336, ,,,,,,,,
...
P7,0,1,1,,, ,  D,1,Surveyed, 10850.00, 45.662, 229.134, ,,,,,,,,
P7,0,1,1,,, ,  D,1,Surveyed, 10875.00, 48.697, 228.432, ,,,,,,,,
P7,0,1,1,,, ,  D,1,Surveyed, 10900.00, 51.830, 228.287, ,,,,,,,,
P7,0,1,1,,, ,  D,1,Surveyed, 10925.00, 55.016, 228.112, ,,,,,,,,
P7,0,1,1,,, ,  D,1,Surveyed, 10950.00, 58.301, 227.351, ,,,,,,,,
P7,0,1,1,,, ,BHL,6,Projected,10991.00, 58.301, 227.351, ,,,,,,,,

CC,0,0,0,   -- end of file -
```

Finally, the last section is concerned with the survey data in what we call the “P7 Table”.

This table also can hold calculated data as we will see, but in this basic example it is simply the MD, INC, and AZI data.

Some text formatting and column alignment is done in this example for readability. This isn’t required but when generating the file this helps maintain the human readability objective if that’s important to you.

The CC records are Common Comments which can be added to aid readability and describe the data to follow. This can include column header but these are just comments and should not be interpreted as data to be processed. For example we show the azimuth as grid, but this has really already been defined in our previous slide where we defined the H7 record for the Survey to include it’s azimuth reference and the same for the depth units.

P7 Table with calculated data (optional fields)

```
CC,0,0,0,  ---------------------------------------------
CC,0,0,0,  The P7 Table and STEM Definition
CC,0,0,0,  ---------------------------------------------
H7,5,0,0,P7 Table Definition                 ,1,Composite Definitive,1,Minimum Curvature,1077,GNL,0,,0,0,

H7,6,0,0,Survey Tool Error Model Definition  ,1,OWSG_A021Gc_GYRO-NS-CT,OWSG XYZ Accel with XY Static and Continuous Gyro,OWSG
H7,6,0,0,Survey Tool Error Model Definition  ,2,OWSG_A001Mc_MWD,OWSG MWD - Standard,OWSG

CC,0,0,0,-,----------,--,-,-,-----,-------,----,------,-----,------,------,-----------,---------,------,-----------,---------
CC,0,0,0,REF,STEM,,Type,,Status,MD,INC,AZ_GRID,n,e,d,Northing,Easting,Depth,Latitude,Longitude,
CC,0,0,0,,,,,,,ft,deg,deg,ft,ft,ft,ftUS,ftUS,ftUS,deg,deg,
CC,0,0,0,-,----------,--,-,-,-----,-------,----,------,-----,------,------,-----------,---------,------,-----------,---------

CC,0,0,0,### Survey 1 Gyro starts here
P7,0,1,1,1,OWSG_A021Gc_GYRO-NS-CT,3,ZDP,9,Other,       0.00,  0.000,   0.000,   0.00,   0.00,   0.00,  718535.81,  3151657.82,  -2626.00, 29.7603819, -95.3696883,
P7,0,1,1,1,OWSG_A021Gc_GYRO-NS-CT,2,WRP,9,Other,      26.00,  0.000,   0.005,   0.00,   0.00,  26.00,  718535.81,  3151657.82,  -2600.00, 29.7603819, -95.3696883,
P7,0,1,1,1,OWSG_A021Gc_GYRO-NS-CT, ,  D,1,Surveyed,   50.00,  0.281,   4.800,   0.06,   0.00,  50.00,  718535.87,  3151657.82,  -2576.00, 29.7603822, -95.3696883,
P7,0,1,1,1,OWSG_A021Gc_GYRO-NS-CT, ,  D,1,Surveyed,   75.00,  0.472,   4.596,   0.22,   0.02,  75.00,  718536.03,  3151657.84,  -2551.00, 29.7603825, -95.3696881,

P7,0,1,1,1,OWSG_A021Gc_GYRO-NS-CT, ,  D,1,Surveyed,  100.00,  0.526,   4.183,   0.44,   0.03, 100.00,  718536.25,  3151657.85,  -2526.00, 29.7603831, -95.3696881,
P7,0,1,1,1,OWSG_A021Gc_GYRO-NS-CT, ,  D,1,Surveyed,  125.00,  0.579,   3.847,   0.68,   0.05, 125.00,  718536.49,  3151657.87,  -2501.00, 29.7603839, -95.3696881,
…
```

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With the previous slide the basic example ended, but of course in many cases the P7 Table would include the calculated data, and not just the standard survey MD INC AZ.

As shown here, the P7 Table contains the MD,INC,AZI from the previous slide, but now also includes columns for the calculated survey position North East Down, in this case using the minimum curvature calculation method, then including the CRS map coordinates Northing and Easting and Latitude and Longitude.

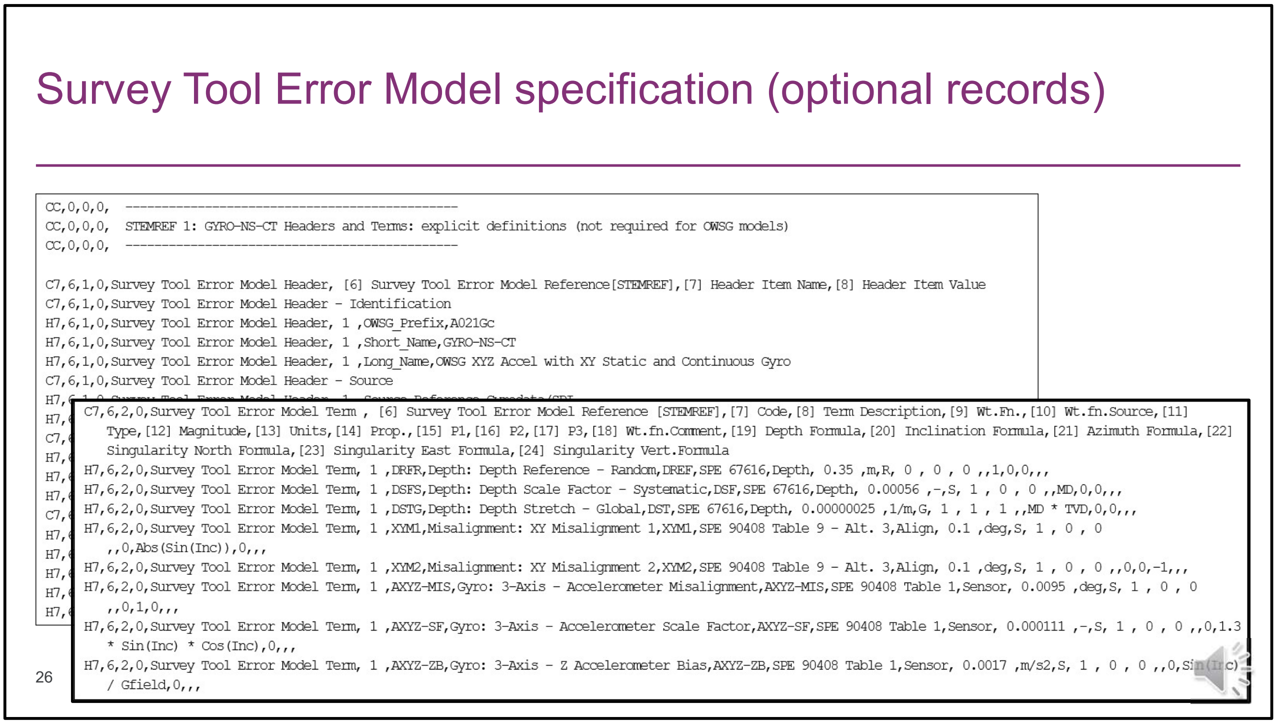
Note these Lat/Long values are in the base coordinate reference system, this is different from the mandatory position objects that also showed the WGS84 lat/long values. The WGS84 values could be added as extension fields but are not part of the default P7 record definition.

You may also notice that the OWSG error model tool code for OWSG_A021Gc_Gyro-NS-CT is indicated at each P7 record. More on this in the next slide.

The fields to be included in a P7 record can also include the results of error model position calculations including the specific covariance matrix values for each station.

--- extra information; not needed to be mentioned ---

Note: geographic coordinates in the base geographic CRS of the projected CRS. The fixed position elements have the WGS 84 coordinates, but not the wellbore path – although those can be added as additional field extension fields, they are not the default fields of the record.



In the previous slide, we had referenced a standard OWSG survey tool error model name which is assigned to each P7 survey station record.

If a standard model name is used such as from the OWSG catalog then it isn't necessary to explicitly define all the details of that specific tool error model in the P7 file, but instead it is identified simply by its name.

It is possible to include a full explicit survey tool error model specification in the P7 format.

To define a Survey Tool Error Model, the P7 format uses a Survey Tool Error Model Header and a record for the Survey Tool Error Model Term (for each term in the model).

These are shown on the screen. Please refer to the P7 format specification for details in how to define the Survey Tool Error Model header and terms, which are aligned with the ISCWSA error term specification.

These records are based on the existing Error Model Excel spreadsheet format defining the OWSG error model with the 'term' block moved under the 'header' block (instead of side by side as in Excel) and converted to csv format

But note again that the explicit definition is not needed to be entered in the P7 file if the standard OWSG models are used and can be directly referenced by tool code name.

Additionally this is not a perfect 1:1 copy of the strings in the Excel Error Model spreadsheet because they may contain commas. Fields in the ‘P’-format are comma separated and therefore cannot contain extra text commas and these need to be replaced

Storing raw sensor data (optional records)

```
H7,1,5,0,Survey Definition                         ,2,1,1,MWD intermediate,Magnetic,2,,,,11012.00,21262.00,ft,2018:02:05,,TP,4,,
H7,2,0,0,Measurement Tool Definition               ,2,MWD intermediate,1,Magnetic, manufacturer, serial#,

H7,3,0,0,Geomagnetic Model Definition              ,1,,WMM,2015,
H7,3,1,0,Gravity Model Definition                  ,1,GARM


M7,0,2,  1,2019:11:09:06:56:48.92 ,1 ,1 , 11012.00, 66.460, 225.670,  -731.60,   373.94, 10813.94,  0.875371, -8.927728,  3.907951, -12904, -44978,    272,  -
   5.600, 243.244, 9.784819, 46793, 58.723, 9.784819, 46793, 58.723, 2.272, 1.779,
M7,0,2,  2,2019:11:09:07:43:00.39 ,1 ,1 , 11107.00, 75.100, 225.290,  -794.44,   310.04, 10845.18, -8.139017, -4.813401,  2.515998, -45794,  -7196,  -6376,
   59.400, 315.375, 9.784819, 46793, 58.723, 9.784819, 46793, 58.723, 2.272, 1.779,
M7,0,2,  3,2019:11:09:07:58:33.94 ,1 ,1 , 11139.00, 77.230, 226.190,  -816.12,   287.79, 10852.83,  9.403544,  1.624274,  2.162816,  45089,  -9855,  -7709,  -
   99.800, 158.520, 9.784819, 46793, 58.723, 9.784819, 46793, 58.723, 2.272, 1.779,
M7,0,2,  4,2019:11:09:08:13:38.32 ,1 ,1 , 11170.00, 78.400, 226.670,  -837.01,   265.84, 10859.38,  7.974252,  5.318165,  1.967511,  45131,   9031,  -8437, -
   123.700, 135.871, 9.784819, 46793, 58.723, 9.784819, 46793, 58.723, 2.272, 1.779,
M7,0,2,  5,2019:11:09:08:29:11.87 ,1 ,1 , 11202.00, 81.670, 225.750,  -858.81,   243.09, 10864.91,  9.680646, -0.135176,  1.417569,  41803, -17840, -11127,  -
   89.200, 173.123, 9.784819, 46793, 58.723, 9.784819, 46793, 58.723, 2.272, 1.779,
M7,0,2,  6,2019:11:09:09:14:54.17 ,1 ,1 , 11296.00, 90.240, 224.670,  -924.81,   176.61, 10871.54, -4.026558,  8.917838, -0.040986,   -998,  43349, -17591,
   155.700,  66.441, 9.784819, 46793, 58.723, 9.784819, 46793, 58.723, 2.272, 1.779,
…
```

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And finally how to include raw sensor data.

In this example from an MWD tool (or any magnetic tool) we are using M7 records. As previously mentioned there are also a G7 records for including Gyro raw sensor data

The RAW data records are linked to a specific survey.

Please reference the format definition for the meaning of each of these columns, comment records could be included to provide column labels as was shown in the basic example.

In this case for a MWD survey, the format allows for a block of records that have approximately 30 pre-defined comma separated fields that contain properties of each survey station such as:

the datetime stamp, measured depth, inclination, azimuth, reference values, calculated data as shown before and of course the raw accelerations and magnetometer values on each axis

The Measurement tool would also contain references to axes orientation and configuration records for that specific tool and how that maps to the specific raw sensor values. There isn't necessarily a predefined assumption of tri-axial sensor packages a custom definition could be included.

Additionally the P7 file can contain a separate record section with references to the original raw sensor data, but contain corrected sensor data as would be the results of an axial correction or MSA correction. This could also include the exact scale and bias offsets used to make the sensor value corrections. Obviously this could also be done for any other type of sag or depth correction also.

Conclusion

- The authors would like to thank the many people who offered up their time and advice to help the taskforce finalize the P7/17 format
  - Incl. Neil Bergstrom and MagVar for hosting the basecamp collaboration site
- Both the P7/17 format description and its user guide are freely available from the IOGP Bookstore at https://www.iogp.org/bookstore/product/p7-17-wellbore-positioning-data-exchange-format/
  - User guide: starting point
  - Format definition: implementation
- Encourage adoption in applications and for submission as directional survey records
- How to provide a public domain reader of P-Formats? (/format validator or report generator)

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This concludes this presentation.
We would like to thank all people who have contributed their time and wisdom to help to get this format published at IOGP.

The format description and user guide can be downloaded from the IOGP bookstore, they do ask for your e-mail address but there is no cost for the download.

Finally, we encourage implementation in well construction software to be able to read and write the P7/17 format, and hope of course that these files can be used as permanent directional survey records.

There are no concrete plans for this, but it would be helpful if there was a public domain reader/writer software implementation available so that it does not have to be implemented separately by each entity as we know we have done for the ISCWSA calculations. We are looking for volunteers willing to help in this regard.

Software that has already implemented the other 'P'-formats for seismic positioning data for example the IOGP P1, P2, and P6 formats of course can re-use the common header and methods associated with p file formats, but this will generally not be the case in wellbore software.

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Note: IOGP bookstore does require an email address to get access to the documents, but at no cost.

International Association of Oil & Gas Producers

For more information please contact:

Lucyna Kryla-Straszewska

Geomatics Manager

lks@iogp.org

www.iogp.org

Registered Office
City Tower
Level 14
40 Basinghall Street
London EC2V 5DE
United Kingdom
T +44 (0)20 3763 9700

Brussels Office
Avenue de Tervuren 188A
B-1150 Brussels
Belgium
T +32 (0)2 790 7762

Houston Office
19219 Katy Freeway
Suite 175
Houston, TX 77094
United States
T +1 (713) 261 0411

reception@iogp.org

(additional information on IOGP on following slides)

International Association of Oil & Gas Producers

History of the 'P' formats

- Dating back to the 1980s, 'P' formats have been used to record marine seismic positioning data, and since the year 2000, for well deviation data as well. Originally developed by UKOOA (now OGUK), the UK offshore upstream association, the 'P' formats are widely adopted by the industry. In 2006, IOGP's Geomatics Committee took ownership of the formats as part of the Association's commitment to technological leadership.
- Walter Jardine, past Geomatics Committee chair, elaborates on the key enhancements in the revised 'P' formats. "Version 1.0 of the P1/11, P2/11 and P6/11 formats, released in 2012, put all IOGP formats under a 'common header'. The formats include a computer readable, rigorous definition of Coordinate Reference Systems that supports the fundamental objective of ensuring the geodetic integrity of position data. The new P7/17 format also utilises the common header structure."

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IOGP works on behalf of the world’s oil and gas companies and organisations to promote safe, responsible and sustainable exploration and production

The Association encompasses many of the world's leading publicly-traded, private and state-owned oil and gas companies, industry associations and major upstream service companies

Global Membership – 83 Members

Map shows locations of Member Head Offices. Many operate globally.

International Association of Oil & Gas Producers

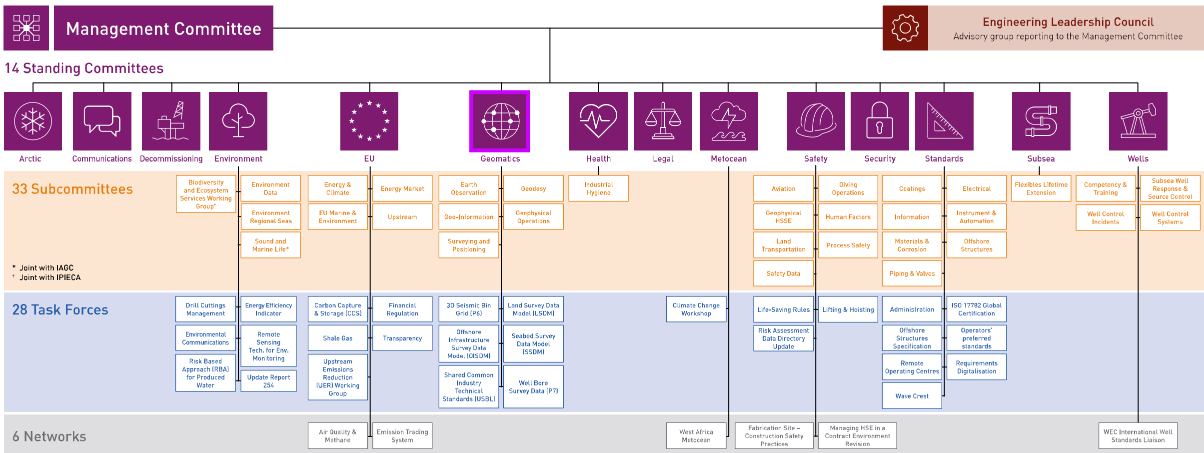
IOGP Committees 2019

Participants (~3000) come from member companies and organisations, bringing with them a wide range of know-how, data and experience

With support from IOGP's Secretariat, the work of the committees reaches a wider global audience through publications, events and an expanding media programme

Committee Structure

Committee structure details are correct as of 1st January 2019



35 For more information on Committees and their work, please visit www.iogp.org

The Geomatics Committee – objectives and activities

Providing global guidance. Publish & maintain:

- EPSG Geodetic Parameter Dataset – the de-facto global standard for CRS and geodetic parameters
- Surveying and Positioning & Geodesy guidance notes
- Industry standard position data exchange formats – P1, P2, P6, P7
- GIS data models – SSDM, LSDM, OISDM
- Geospatial Integrity of Geoscience Software, test guidance and data (GIGS)

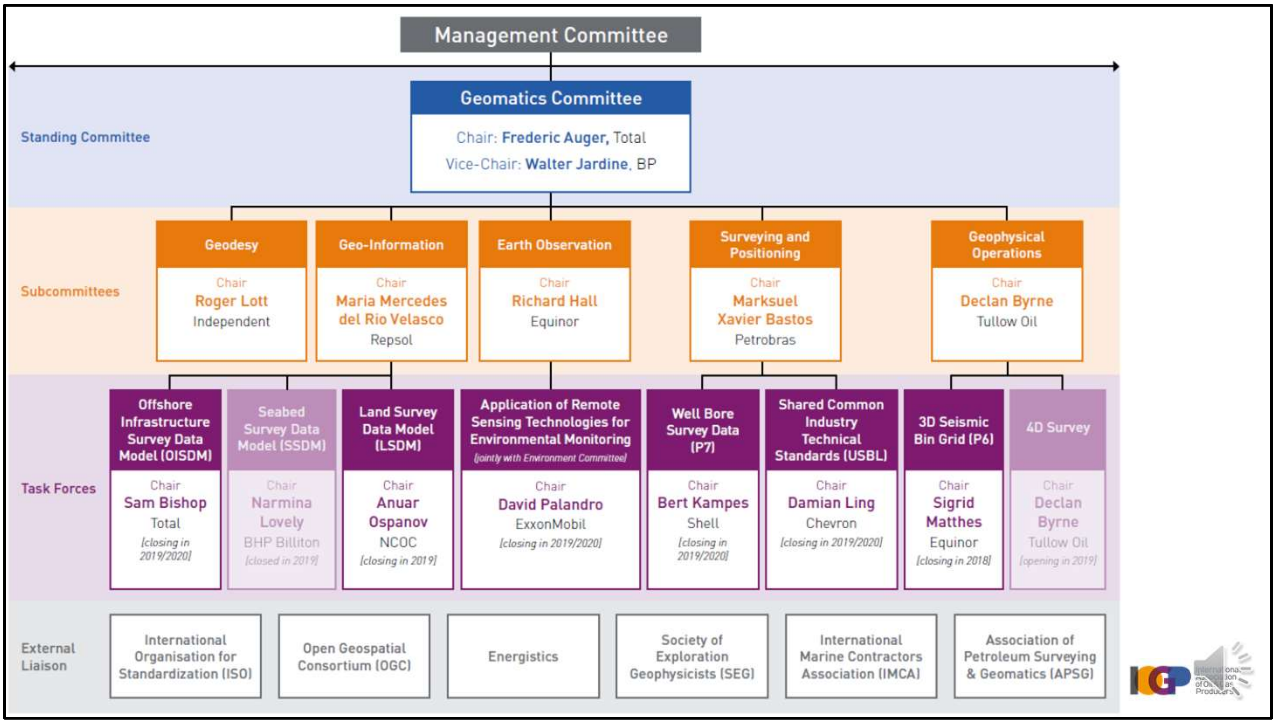
Liaison with industry standards organisations: IMCA, SEG, ISO, APSG, OGC, Energistics, CAPP

Advocacy with Regulators, Data Repositories

Forum for exchange of experience and knowledge:

- Biannual committee meetings
- Annual Geomatics Industry Days
- Five active Subcommittees in addition to various number of Task Forces and Working Groups
- Initialisation and support of industry initiatives – e.g. IOGP / IPIECA
  Oil Spill Response (Common Operating Picture - COP), OGEO Portal

International Association of Oil & Gas Producers



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