WP2 GROUND RESEARCH, WORK SITE INSPECTION AND IMPROVED DRILLING TECHNOLOGIES

D.2.1 Geothermal – IDM for Drilling Processes

***GEOFIT**: Deployment of novel GEOthermal systems, technologies and tools for energy efficient building retroFITting, has received funding from the European Commission H2020 Programme under Grant Agreement No. 792210*

DISCLAIMER

The opinion stated in this report reflects the opinion of the authors and not the opinion of the European Commission.

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Executive summary

This document (D2.1) states the Geothermal Information Delivery Manual (IDM) for drilling processes involved in the GEOFIT project. The IDM for drilling processes specifies an integrated reference tool to collect the information and data from the different processes involved during drilling operations performance required by the GEOBIM model proposed in the project. The specification of an IDM for GEOFIT project and the need of providing an integrated model for drilling processes is one of the main outcomes of this deliverable as it is a very complex environment. The data acquisition processes and data workflows are produced in real time conditions and different data formats may be found. Within the GEOBIM project context, the IDM is aimed at providing the unified reference for the processes and data required by BIM by identifying the discrete processes that must be undertaken during drilling operations, the information required for their execution and the results obtained from these operations. In general terms, this IDM represents a real challenge because it must specify:

- How drilling processes fit the global GEOBIM model and how relevant they are;
- Who are the actors creating, consuming and benefitting from the data collected during drilling;
- What is the final valuable information created and to be used;
- How this amount of data shall be supported by virtual tools and software.

1 Introduction

Drilling works in urban environments remains as bottleneck in the geothermal based retrofitting in urban areas. Logistics and civil disturbance coordination are the main drawbacks to deploy geothermal based retrofitting in urban areas, for this reason, the deployment of real time stability and monitoring technologies are paramount during drilling in a project like GEOFIT. Drilling through hard rocks has been detected as a critical and limiting factor to economically develop significant geothermal project in several areas. The high costs and the need for new technology development is a key factor to be overcome within the context of GEOFIT project. Problems faced while drilling hard rocks are not only restricted to slow penetration rate, but also whit the non-productive time linked with several problems such as drill string failure, wellbores out of gauge, stuck pipe associated to block instability that falls into the well, and fluid losses due to fractures among others. Through proper technologies and modelling methods, GEOFIT project intends to improve drilling performance in different fronts, hard rocks drilling, reduction of vibrations, optimal wells for cost-effective geothermal systems installation and intelligent management, monitoring and reporting of drilling process to enhance GEOBIM platform capabilities.

2 Scope

Retrofitting projects are usually at loss of proper documentation from which to start with, but if this happens in this context, in the field of underground works, this lack is even greater. Following this argument, the scope of this deliverable is to define a set of procedures and tools related to data acquisition from subterranean affected areas. These tools and procedures will be linked with current GEOBIM Open Standards development; this shall enable the potential use of underground information for the

GEOBIM

GEOBIM is an integrated Geographical Information System (GIS) – Geo Thermal and BIM platform developed within the GOFIT project that allows to bridging the gap between Geo and BIM. More information about GEOBIM is available within deliverable D6.3.

integration of the BIM designed solutions for underground geothermal facilities. A further potential use of underground information must be considered as well, as it may be compatible with 3D cities models, allowing henceforth, improved communication among the whole value chain, from geothermal end users to the city administration. To reach these objectives, an information delivery manual (IDM) must be defined and issued. The IDM aims at providing the integrated reference process information and data required by GEOBIM, by linking discrete processes undertaken within drilling processes, which are specific for geothermal based systems construction, with the information required for their execution and consequently, collecting and managing the results from such processes.

In summary, the following chapters of this deliverable describes the methodology applied to define the IDM to develop the Drilling Information Delivery Manual (D-IDM), its components, the methodology employed the modelling standards which are relevant and the data formats in order to make easier the use of BIM technology in the GEOFIT project.

3 Methodology

The methods applied to define the Drilling IDM encompassed a review of information collection and management practice supported by GEOFIT project partners, as well as the review of, scientific and technical literature, relevant codes, applicable regulations and standards.

The starting point is to understand what an IDM is and how it can be applied within the drilling processes. The IDM proposes a methodology that captures (and progressively integrates) business processes whilst at the same time provides detailed specifications for the information that needs to be exchanged during the project. To further support these information exchange specifications, IDM also proposes a set of reusable modular functions that handle the basic information ideas in Architecture/Engineering/Construction and Facilities Management (AEC/FM) and that can be used to assist the development of further information exchange specifications [1].

Drilling processes are performed in heterogeneous environments and the diverse information collected is mostly inconsistent from the point of view of the database construction (elaboration). The information flow contains real time data (logged while drilling) and measuring procedures executed during the drilling. These facts reflect the need of a data management model that supports any intention to implement drilling information within BIM modelling. The methodology to be applied also must consider applicable standards in terms of data objects definition. Literature review may drive to use a functional demonstrated framework to apply data modelling interoperable with BIM modelling. A preliminary approach suggests investigating “Wellsite Information Transfers Standard Markup Language” (WITSML) as a practical option applicable within GEOFIT project.

4 Modelling standards to be applied

This chapter is largely based on the ‘’Building Smart’ “Building Smart” (BS) guidelines from International Alliance for Interoperability [1]. The relevance of this source is that BS has created solid and functional BIM basis procedures to be applied in a wide range of industrial applications. For more information, see reference 1.

According to the BS guidelines, the Building Information Modelling (BIM) is an approach to describing and displaying the information required for the design, construction and operation of constructed facilities. It can bring together the numerous threads of different information used in construction into a single operating environment - reducing, and often eliminating, the need for the many types of paper document currently in use.

However, to use BIM effectively and for benefit to be unlocked, the quality of communication between different parties involved in the construction process needs significant improvement. If the information required is available when it is needed and the quality of information is satisfactory, the construction process will itself be significantly improved.

For this to happen, there must be a common understanding of the building processes and of the information that is needed for and results from their execution.

4.1 Industry Foundation Classes

IFC (Industry Foundation Classes) is an international standard, EN ISO16739:2017- Industry Foundation Classes (IFC) - for data sharing in the construction and asset management industries. It specifies a conceptual data schema and an exchange file format for Building Information Model data. It represents an open international standard for BIM data that is exchanged and shared among software applications used by the various participants in a built environment construction or asset management project. buildingSMART International has the ownership for the IFC standard. ISO and buildingSMART International has signed a copyright agreement securing both organizations right to publish the standard [2].

The Industry Foundation Classes (IFC) provide a comprehensive reference to the totality of information within the lifecycle of a constructed facility. It has been created as an integrated whole in response to business needs identified by the international building construction community. It does not incorporate, however, a comprehensive reference to the individual processes within building construction.

On the other hand, the Information Delivery Manual (IDM) aims at providing the integrated reference for process and data required by BIM by identifying the discrete processes undertaken within building construction, the information required for their execution and the results of that activity. It will specify:

- Where a process fits and why it is relevant;
- Who are the actors creating, consuming and benefitting from the information;
- What is the information created and consumed;
- How the information should be supported by software solutions.

Thanks to this, IFC will closely reflect the real project needs and accelerate the use of BIM in those projects. It will also help to realize an integrated project information as the key driver for process improvement which is a specific goal for the AEC/FM industry, as required by many industry analysts.

In general, it is a common practice that industry and scientific sectors introduce standards to use specific software and specialized information systems and tools in their domains of knowledge. The use of standards enhances the capability of interoperate within different software environments and in modern days, also on internet-based services.

Consequently, one of the mains issues to solve in GEOFIT project concerns this interoperability/integrability between datasets, and this challenge is also critical in drilling tasks.

The ambition in GEOFIT is to accomplish this task with a combined use of a deep metadata architecture together with semantic tagging, controlled vocabularies and ingestion transformation procedures. In short, at the ingestion time, each dataset is transformed and enriched so that the output can be easily “linked” to other datasets. The following key-stones are the basis of this activity in GEOFIT:

- Data format and conventions: logged data are treated to follow coherent internal conventions, e.g. date, formats, time frames, units, length, type of data in digital/analogue values, etc.
- Data enrichment: adding new information to the incoming datasets to improve the informative value of the dataset and ensure internal interoperability, e.g. terms standardization using controlled vocabularies, addresses components, global unique id for rows, records, etc.
- Data structuring: under commonly agreed sets of standards and specifications a methodology is developed to manage and handle data sets, semantics and processes with links to other data management/exchange/display tools or platforms.

4.2 Standards sources to be used

- ISO/TC 59/SC 13, Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM).
- Nowadays ISO and CEN are working together in order to developed standards parallel. Additionally, CEN/TC 442 is developing their own standards (only in the European framework) (see 4.3).
- ISO / TC 211, Geographic information/Geomatics. Which collaborates with ISO / TC 59 / SC 13 through the joint working group ISO / TC 59 / SC 13 / JWG 14. They are developing Project ISO/CD 19166
- Geographic information -- BIM to GIS conceptual mapping (B2GM). Even there is no documents available, it could be useful in the future.

4.3 CEN/TC 442 - Building Information Modelling (BIM)

CENT/TC 442 is a technical body from the European Committee for Standardization which is aimed at promoting standardization in the field of structured semantic life-cycle information for the building environment. The committee developed a structured set of standards, specifications and reports which specify methodologies to define, describe, exchange, monitor, record and securely handle asset data, semantics and processes with links to geospatial and other external data. The introduction of common standards and operating methods in BIM guarantees interoperability among the information exchange parties within BIM environment. According to CEN/TC 442 Business Plan [2], interoperability can be achieved without standardization, but it conditions the project to agree on its own rules and deliveries. A high level of expertise and resources is required, and utilization of information in the construction life-cycle is not ensured.

Efficient interoperability requires a set of standards and implementation. The three pillars of interoperability are:

- A standardized way to store and exchange data models and implement them in software packages;
- A common understanding of terminology and data-semantic structure;
- An agreed set of information delivery specifications for the information sender to support the processes of the information recipient.

An efficient object-based interoperability is conditioned by three sets of standards:

- Data Model standards to specify data structure for entities, geometry and related properties as well as classification for exchanging data models. The data model ensures exchange of object-based information;
- Data Dictionary standards to specify data structure for defining data-semantic concepts (entity, property, classification...) and relations between them;
- Process standards to specify how to describe the required information supporting a given process.

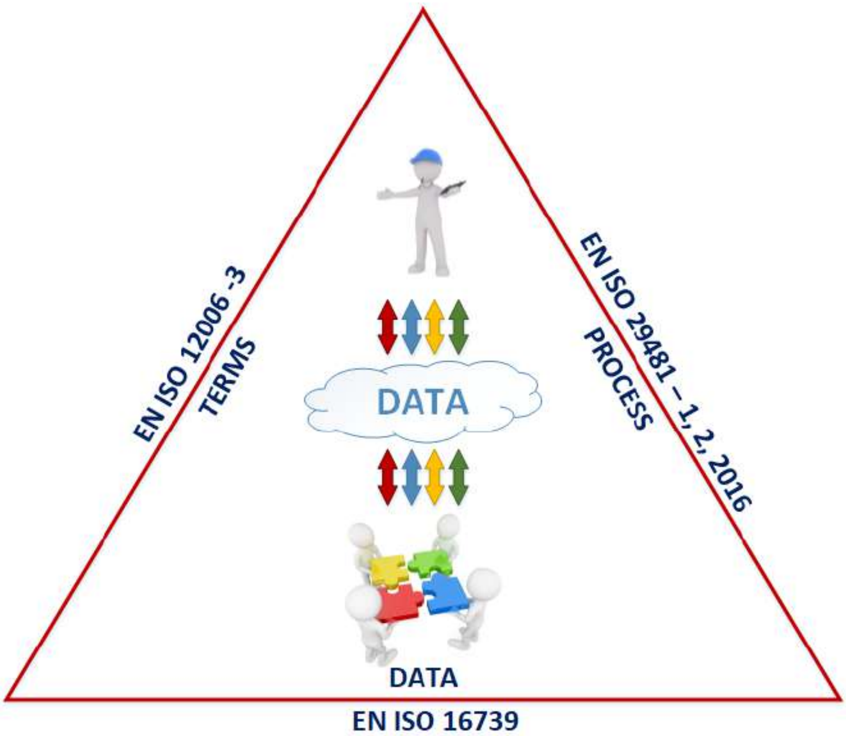

Figure 1. Standards used in BIM processes. Source: own elaboration based on Ref.2

Additionally, TC 442 has published last year EN ISO 19650, Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) - Information management using building information modelling:

Part 1: Concepts and principles

Part 2: Part 2: Delivery phase of the assets

4.4 BIM Maturity Map (BMM)

BMM is a strategy to monitor and evaluate the level of maturity of a project within the BIM context. The level of maturity reached for the specific project is evaluated by some indicators or criteria that consider the following aspects:

- The content;
- The digitalization levels;
- The interoperability capabilities;
- The collaboration capacity.

For the drilling process this maturity map is also applicable, and it is very important to state which is the level of maturity in terms of these 4 indicators.

Complementarily, Figure 2. shows the BIM Maturity Map developed. It maps four degrees of maturity (horizontal) mentioned above in terms of content, digitization, interoperability and collaboration, and five areas of maturity as follows:

- **Level 0 Non BIM**: Unmanaged computer aided design (CAD) including 2D drawings, and text with paper-based or electronic exchange of information but without common standards and processes. Essentially this is a digital drawing board.
- **Level 1 Basic**: Managed CAD, with the increasing introduction of spatial coordination, standardised structures and formats as it moves towards Level 2 BIM. This may include 2D information and 3D information such as visualisations or concept development models. Level 1 can be described as 'Lonely BIM' as models are not shared between project team members.

- **Level 2 Elementary**: Managed 3D environment with data attached, but created in separate discipline-based models. These separate models are assembled to form a federated model, but do not lose their identity or integrity. Data may include construction sequencing (4D) and cost (5D) information. This is sometimes referred to as 'pBIM' (proprietary BIM). In the UK the Government Construction Strategy published in May 2011, stated that the '...Government will require fully collaborative 3D BIM (with all project and asset information, documentation and data being electronic) as a minimum by 2016'. This represents a minimum requirement for Level 2 BIM on centrally-procured public projects.

- **Level 3 Advanced**: A single collaborative, online, project model with construction sequencing (4D), cost (5D) and project lifecycle information (6D). This is sometimes referred to as 'iBIM' (integrated BIM) and is intended to deliver better business outcomes.

- **Level 4 Optimal**: Level 4 introduces the concepts of improved social outcomes and wellbeing.

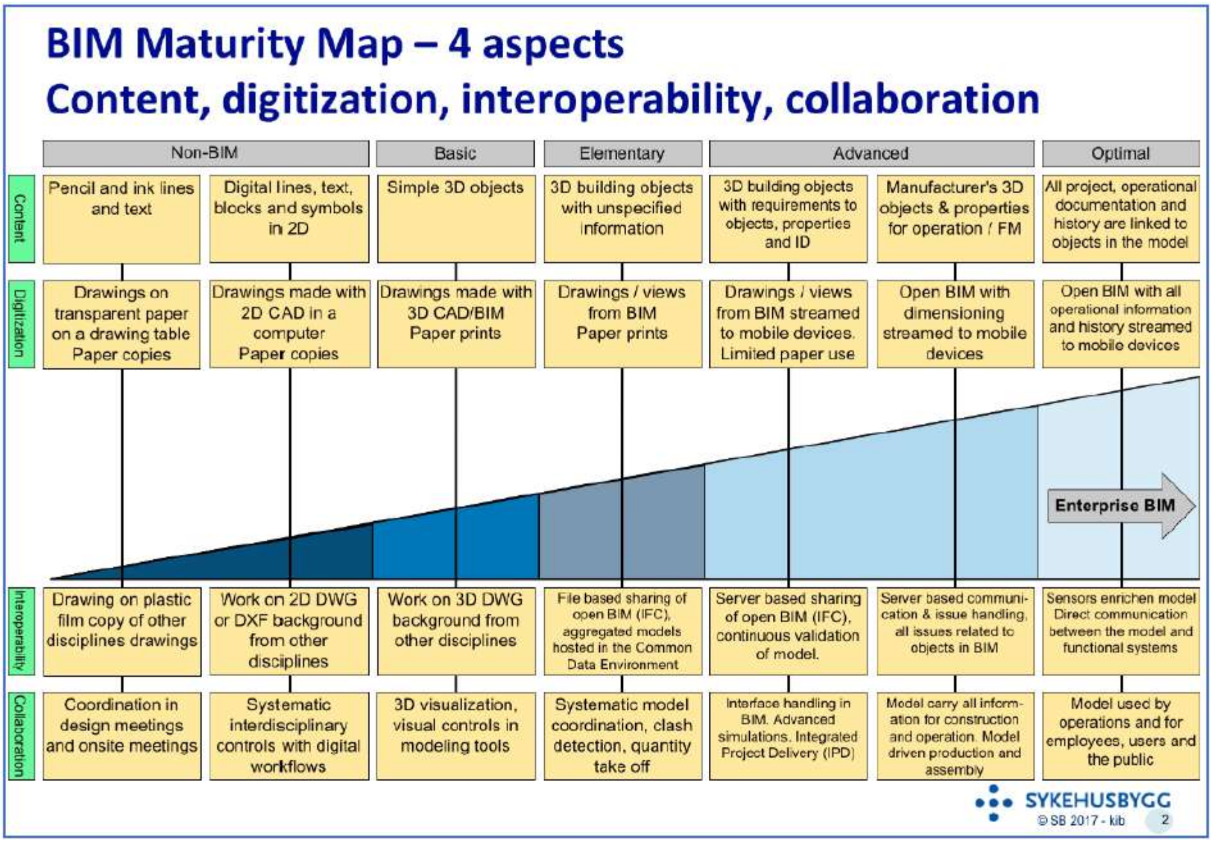

Figure 2. BIM Maturity Map. Source: Ref. 2

There are several current national BIM standardization projects and more will probably be seen as implementation increases. Therefore, it is necessary to understand what are the available standards including the implementation of existing ISO standards, from ISO/TC 59/SC 13 and ISO/TC 184/SC 4. The nature of BIM is evolving rapidly and the above diagram will be revised on a regular basis. [2]

To reach the knowledge about the level of maturity and readiness within the GEOFIT project and its drilling process, some internal research strategies have been developed. The strategies are detailed in section 5 of this report to state the level of maturity of GEOFIT BIM modelling capacity regarding drilling.

4.5 ISO 29481: Definition of the Information Delivery Manual

As shown in Figure 1. EN ISO 16739:2016 is an international standard for BIM data exchanged and shared among software applications used by the various participants in a built environment construction or asset management project. The content of the data exchanged is highly driven by the lifecycle stage, the involved disciplines and the level of development, or more generally speaking by the processes involved.

Information Delivery Specifications should capture (and progressively integrate) construction processes whilst at the same time providing detailed specifications regarding the information that a user fulfilling a particular ***role*** would need to provide at a particular point within an asset's lifecycle.

From the end-user point of view, this leads to the so-called Information Delivery Manual (IDM) (see EN ISO 29481[1]); from a BIM point of view, the associated description is called Model View Definition (MVD) defining a subset of the complete IFC model or equivalent, with strict specifications regarding the attribute description.

An Information Delivery Manual comprises the following elements:

- An interaction/transaction map and/or a process map;
- Exchange requirement(s).

The interaction/transaction map defines the roles involved and the transactions between roles.

The process map shows the activities for each role and interactions/transactions between activities for different roles. A swim lane diagram is commonly used as a process map.

[1] There are two parts of EN ISO 29481:

Part 1: Methodology and format, published on 2017 (so that EN ISO 29481-1 :2017)

Part 2: Interaction framework, published on 2016 (so that EN ISO 29481-2 :2016).

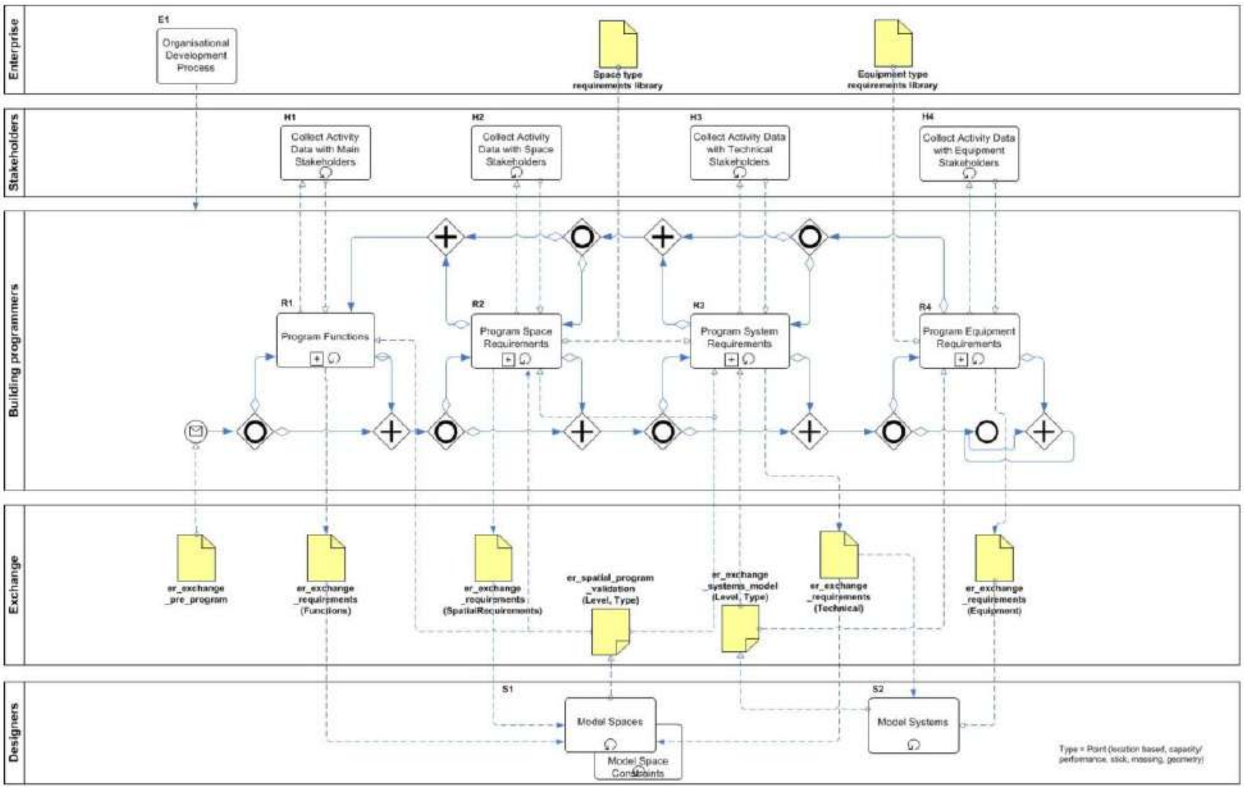

Figure 3. Swim Lane Diagram used like Process Map. Source: Building SMART

To achieve the BIM information highway, there are many IDM's and MVD's to be developed.

MVD are not only required for a specific data exchange schema and for quality checks, but also having a solution that can be used as a master file that could be adapted on project level.

The actions to be taken are:

- Develop a framework for BIM Guidelines (see ISO/TS 12911);
- Define current Use Cases;
- Support Energy Assessment for practical implementation of EN 15603 (Energy performance of buildings - Overall energy use and definition of energy ratings);
- Support lifecycle cost estimation and assessment, in order to provide a practical implementation of CEN/TC 350 (Sustainability of construction works) related standards
- Support asset Management and Operation, documentation of which is a common challenge in all projects;
- Support building Application, in which digital rules and processing can substantially improve both efficiency and quality of the industry interaction with Planning and Regulatory Authorities.

MVD will be discussed in Work Package 5 and Work Package 6 of the GEOFIT project and it is not the purpose of this deliverable.

In conclusion, the published standards to be applied to define the IDM for drilling processes are:

Table 1. BIM Published standards

Reference	Publication date

EN ISO 12006-3:2016 Building construction - Organization of information about construction works - Part 3: Framework for object-oriented information (ISO 12006- 3:2007)	2016-10-19
EN ISO 16739:2016 Industry Foundation Classes (IFC) for data sharing in the construction and facility management industries (ISO 16739:2013)	2016-10-19
EN ISO 29481-1:2017 Building information models - Information delivery manual - Part 1: Methodology and format (ISO 29481 – 1: 2016)	2017-10-11
EN ISO 29481-2:2016 Building information models - Information delivery manual - Part 2: Interaction framework (ISO 29481-2:2012)	2016-10-19

5 Involved Parties and Roles

In a BIM project, the definition of actors is considered as a first step. This is because all processes are owned by (performed by) a particular, identifiable actor with specific roles [3]. Actors are identified on process models by boxes in which processes are contained. These boxes are known as either ‘’pools’’ or ‘’lanes’’. A Pool represents a Participant in a Process. It also acts as a graphical container for a set of processes performed by the participant that can be described in sequence.

Figure 4. Pool containing multiple lines with actors. Source Ref. [3]

A Lane is a partition within a Pool that extends over its entire length. Lanes are used to organize processes. In particular, lanes can be used to categorize processes within the participant role e.g. by representing sub-actors or departments of an organization.

5.1 Processes

Processes may be either “compound” meaning that they can be broken down further into smaller sub-processes or “atomic” meaning that further breakdown is not possible as it shown in Figure 4.

An atomic process is termed a “Task”. The task is the basic unit of the Business Process Modelling Notation (BPMN) notation. A compound process may be shown on a business process diagram either with its sub-processes collapsed or expanded.

In a collapsed sub-process, the details of the sub-process are not visible in the diagram. A “plus” sign in the lower-centre of the shape indicates that this is a sub-process and has a lower-level of detail.

In an expanded sub-process, the boundary of the sub-process is expanded and the details (a process) are visible within its boundary [3].

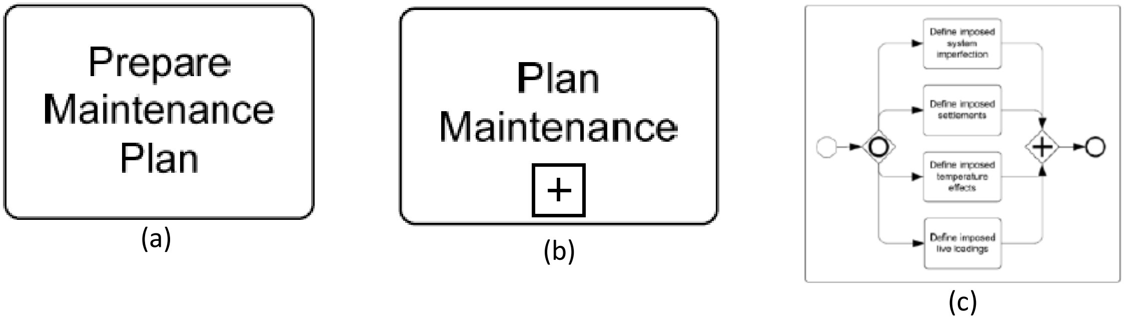

Figure 5. Examples of (a) Task, (b) Collapsed sub-process and (c) Expanded sub-process

To define the IDM for drilling processes, this notation is also suitable and will be employed in further steps.

5.2 IDM Target Groups

In general terms, the target groups for which IDM is designed, include:

5.2.1 Executive User

An executive user is a person who:

- makes the decision to use IFC based information exchange
- is aware of the business process concerned and the impact that improvements in its execution will have at the business level
- does not need to have technical detail about the use of information within the process
- does not need to know about software development or the IFC model

5.2.2 End user

An end user is a person who:

- uses IFC for information exchange in practice
- needs to know exactly what information to expect and how to use it in the business process
- does not need to know about software development or the IFC model

5.2.3 Solution provider

A solution provider is a person or organization that:

- writes a software application with an IFC interface
- needs to know what executive and end users expect from their software solution
- needs to have a detailed technical knowledge of the IFC model [1]

These targets groups can be identified and nominated within the IDM for GEOFIT project.

6 Drilling Processes Description

In this section, the drilling process will be described; this is needed because the knowledge about the works to be done on the demo sites will facilitate the understanding about the level of detail and the amount of information that would be available to meet IDM data collection and the exchange requirements. Firstly, the technical challenges are described, secondly the drilling process will be defined and finally, the description of the tools employed during drilling will lead to the understanding of the drilling data that can be collected in GEOFIT project demo sites and how they shall be managed within the GeoBIM model.

6.1 Technical challenges of rock drilling

A geothermal reservoir is a volume of rocks in the subsurface which exploitation in terms of heat can be economically profitable.

Within the group of high-temperature geothermal reservoirs there are "Hot Dry Rock" (HDR) geothermal reservoirs, which are exploited by the techniques called "stimulation of geothermal reservoirs" (EGS: Enhanced Geothermal System). They consist of fracturing a mass of deep rock to create a geothermal reservoir allowing the circulation of fluids inside it. These reservoirs not require high thermal gradients, but a very specific geological context [7].

Common rock types in geothermal reservoirs include granite, granodiorite, quartzite, greywacke, basalt, rhyolite and volcanic tuff. Compared to the sedimentary formations of most oil and gas reservoirs, geothermal formations are, by definition, hot (production intervals from 160°C to above 300°C) and are often hard (240+ MPa compressive strength), abrasive (quartz content above 50%), highly fractured (fracture apertures of centimetres), and under-pressured. They often contain corrosive fluids, and some formation fluids have very high solids content (TDS in some Imperial Valley brines is above 250,000 ppm). These conditions mean that drilling is usually difficult—rate of penetration and bit life are typically low,14 corrosion is often a problem.

Common geothermal systems almost always contain dissolved or free carbon dioxide (CO_2) and hydrogen sulphide (H_2S) gases. While these gases contribute to the corrosion problem, H_2S in particular limits the materials that can be used for drilling equipment and for casing to the lower strength steels, because higher strength steels will fail by sulphide stress cracking 107. H2S also presents a substantial safety hazard during the drilling process. These material limitations, and the associated safety hazards, increase the cost of drilling geothermal wells. lost circulation is frequent and severe, and most of these problems are aggravated by high temperature [8].

The study of the site conditions and the information available will make possible to consider many of these limitations described above. GEOFIT project gives an opportunity to create an information drilling workflow for the specific works planned in the different demo sites, providing added value information to create a BIM layer or dimension specifically created for drilling processes.

6.2 Drilling processes description

The drilling processes that shall be performed in the different pilot sites are:

6.2.1 Rotary percussive drilling

This system uses compressed air to power a down-hole percussive hammer but also to remove detritus and push them out of the borehole. Rotation is given by a drilling head at the same time.

This system can reach -800m depth and (out diameter) OD 600mm, being also able to work in small-sized places.

This system is appropriate to drill in consolidated soils such as granites, mudstones or gneiss. Reaching even a high drilling speed.

6.2.2 Double-head drilling

Appropriate for non-consolidated soils (i.e.: “high difficulty”), since it let drill and case at the same time. The rig has two drilling heads: one that powers the rods and another one that powers the casing.

When drilling in non-cohesive soils (sand, gravel), casing goes before the bit in order to keep borehole walls stable and surrounding strata away from bentonite and other fluids. On the other hand, in cohesive soils casing could not be necessary, drilling just using bit+rods.

This rig can reach up to OD 600mm and is appropriate for alluvial aquifers.

6.2.3 Reverse circulation drilling

It consists of a rotary drilling system where fluid is injected through the space existing between the borehole walls and the rods, being detritus pushed away through the rods' inner face. Doing this the borehole walls remain stable.

Drilling fluid can be either water or bentonite, depending on soil characteristics.

This system is appropriate to drill in non-cohesive materials such as clays, clayey sand, gravels and so on.

6.3 Instruments and tools

The basic tools to be used during drilling works are:

- Drill bit
- Drag bit
- DTH Hammer
- Drill pipes

6.4 Drilling data

The drilling data parameters are typically registered manually in a specific datasheet to control de borehole geology and allow managing properly the terrain.

Some new machines allow installing an auto log parameters control, to be able to audit all the drilling parameters and controls, also from the desk in the main office.

6.5 Drilling data workflows

The importance of tackling unstructured data across the drilling involved in GEOFIT project, where significant use of a proper workflow and a state-of-the-art data management application system must be promoted within the project team in charge of drilling chapter. The project rollout is aimed at achieving the absolute integration of drilling and completion information into one centralized database system. A specific workflow and process culture is required to ensure that all critical data, including operation-related information, are being captured meticulously during the lifecycle of the wells.

The integrated real-time workflow must be provided by proper applications to support the fast creation of log-scale geo-steering models ahead of drilling, facilitating interactive updates to geo-steering models while drilling, and enabling re-planning of wells using updated models to deliver consistent wellbore placement. This reach information may also be stored and managed by the GeoBIM tool to guarantee the life-cycle of the wells.

Drilling data workflow is expected to deliver:

- Accurate and reliable directional drilling information
- True 3D visualization of the structure, stratigraphy, well logs and well paths, using dynamic data in a real-time setting
- Seismic and geophysical interpretation calibration

At the end, the information gathered may be also employed to improve drilling methods, techniques and information management.

7 Data formats and standards

The need to find a standard for drilling processes developed in GEOFIT project has been covered by the state-of-the-art analysis and from a deep literature review discussed and listed within this section. Different references have suggested to consider the Wellsite Information Transfer Standard Markup Language (WITSML). The WITSML standard was developed from Energy Standards Resource Centre (Energetics), which is an international non-profit membership organization, to provide a seamless flow of well data between operators and service companies in the petroleum industry. The objectives are to speed up and enhance the decision making and to reduce the costs during drilling.

Within the heterogeneous environment, which is normally found in practice, the risk of conflicts to ensure consistent repository of information is tremendous. The data workflow contains also real time processes for logging while drilling (LWD) and measurement while drilling (MWD). For these reasons, the WITSML data model represents a wide range of objects such as wellbore, mud-log, well-log and rig instrumentation. See Figure 5. [4]

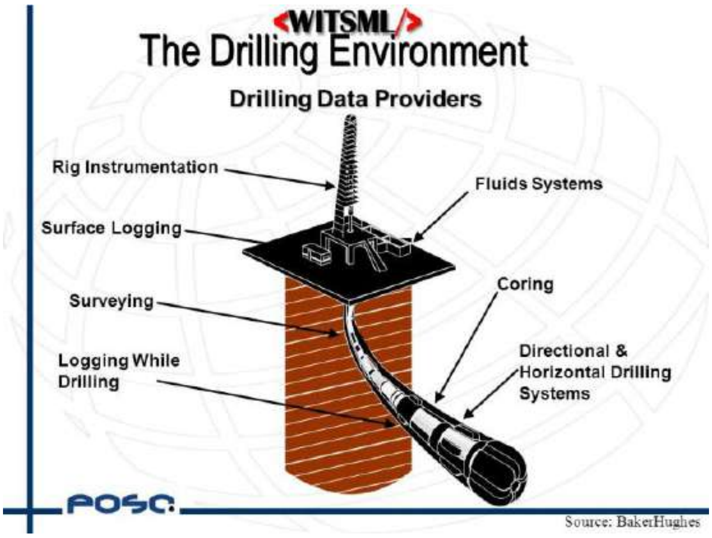

Figure 6. Typical objects of a WITSML model. Source: Ref. [4]

7.1 Drilling data acquisition

The technology behind WITSML is based on the internet standards (W3C, SOAP, WSDL[2], and XML) and has its own XML schema as the starting point is the Wellsite Information Transfer Specification (WITS) schema. This initial schema had to be improved to guaranty the next evolution for data exchanged based on Markup Languages.

Beside the XML schema a set of profiles based on the Web Service Description Language (WSDL) has been developed. For an easier understanding what functionality from different servers may be used, three profiles are defined:

- Data transfer profile. A server that provides "near-real time" data from one or more wells while drilling and may also contain relevant data sets from associated offset wells.

[2] Web Service Description Language

- Data management profile. A server that can maintain a longer-term data store and also support functionality in addition to the basic capabilities of the Data Transfer server.
- Archival profile. A server that is used to maintain a historical record of data in WITSML accessible format. The WITSML data model covers all drilling related data.

Currently this standard is driven and used in the oil extraction industry, but it comes also into focus for an integral view on geothermal data. [4]

7.2 Wellsite Information Transfer Specification

The WELLSITE INFORMATION TRANSFER SPECIFICATION (WITS) is an industry open standard data communication format used by Petrospec Technologies in its software. The WITS standard is intended for use at the wellsite. It is a recommended format by which service companies and operating companies can exchange data.

WITS defines a set of pre-defined records for specific data values. Additionally, users may add data items in the fields marked SPARE.

WITS is a multi-level transmission format. This arrangement offers a basic transmission format (LEVEL 0), and additional levels with increasingly flexibility. At the lowest levels, a fixed format ASCII data stream is transmitted; at the highest level a self-defining customizable data stream is available.

A WITS data stream is made up of a series of data records. Each data record type can be created independently of other data record types and each has a unique trigger variable and sampling interval. The activity on the rig determines which records are applicable at any given time so that only appropriate data is transmitted.

7.3 WITS Pre-Defined Record Types

In order to select the GEOFIT project drilling data sets, the WITS pre-defined record types must be considered, selecting only the ones applicable within the GEOFIT project context. The record types are listed below (records that are not used in the GEOFIT use case are marked with strikethrough characters):

Table 2. WITS Pre-defined record types. Source: DigiDrill Support. Ref. 5

Record Number	Name	Description
01	General Time-Based	Drilling data gathered at regular time intervals
02	Drilling - Depth Based	Drilling data gathered at regular depth intervals
03	Drilling - Connections	Data gathered at drilling connections
04	Hydraulics	Hydraulics data gathered while circulating
05	Trip - Time	Tripping data gathered while running in/pulling out
06	Trip - Connections	Tripping data gathered at tripping connections
07	Survey/Directional	Directional/Survey data
08	MWD Formation Evaluation	MWD Formation Evaluation data
09	MWD Mechanical	MWD Mechanical data
10	Pressure Evaluation	Pressure Evaluation data
11	Mud Tank Volumes	Mud Tank (Pit) Volume data
12	~~Chromatograph Cycle-Based~~[2]	~~Chromatograph Cycle data~~
13	~~Chromatograph Depth-Based~~[2]	~~Chromatograph data averaged over depth intervals~~
14	Lagged Mud Properties	Mud Property data-based returns depth increments
15	Cuttings / Lithology	Cuttings Lithology and related data

16	~~Hydrocarbon Show~~ (NA[3])	~~Hydrocarbon Show related data~~
17	Cementing	Well Cementing operations data
18	Drill Stem Testing	Well Testing operations data
19	Configuration	Drill string and Rig Configuration data
20	Mud Report	Mud Report data
21	Bit Report	Bit Report data
22	Remarks	Freeform Comments
23	Well Identification	Well Identification data
24	~~Vessel Motion / Mooring Status~~[2]	~~Vessel Motion and Mooring Status data~~
25	~~Weather / Sea State~~[2]	~~Weather and Sea State data~~

7.4 Records Description

The records listed in table 2 are shown in the second level of detail. Each record is widely explained; however, not all the fields may be relevant to the context of the project. Drilling companies shall finally decide which one amongst the attributes is covered by the equipment and systems used during drilling operations.

7.4.1 RECORD # 1: GENERAL TIME-BASED

ITS Record ID 1	Logical Record Type 151	Auto/Manual AUTOMATIC
Trigger [TIME] Transmit at a specified time interval (secs)		
Data Source Data acquired in real-time and computed over the trigger interval; record transmitted, and computation reset when triggering interval occurs		

Item	Description	Long Mnemonic	Short Mnemonic	Type	Length	Metric Units	FPS Units
1	Well Identifier	WELLID	WID	A	16	----	----
2	Sidetrack/Hole Sect No.	STKNUM	SKNO	S	2	----	----
3	Record Identifier	RECID	RID	S	2	----	----
4	Sequence Identifier	SEQID	SQID	L	4	----	----
5	Date	DATE	DATE	L	4	----	----
6	Time	TIME	TIME	L	4	----	----
7	Activity Code	ACTCOD	ACTC	S	2	----	----
8	Depth Bit (meas)	DEPTBITM	DBTM	F	4	M	F
9	Depth Bit (vert)	DEPTBITV	DBTV	F	4	M	F
10	Depth Hole (meas)	DEPTMEAS	DMEA	F	4	M	F
11	Depth Hole (vert)	DEPTVERT	DVER	F	4	M	F
12	Block Position	BLKPOS	BPOS	F	4	M	F
13	Rate of Penetration (avg)	ROPA	ROPA	F	4	M/HR	F/HR
14	Hookload (avg)	HKLA	HKLA	F	4	KDN	KLB
15	Hookload (max)	HKLX	HKLX	F	4	KDN	KLB
16	Weight-on-Bit (surf,avg)	WOBA	WOBA	F	4	KDN	KLB
17	Weight-on-Bit (surf,max)	WOBX	WOBX	F	4	KDN	KLB
18	Rotary Torque (surf,avg)	TORQA	TQA	F	4	KNM	KFLB
19	Rotary Torque (surf,max)	TORQX	TQX	F	4	KNM	KFLB
20	Rotary Speed (surf,avg)	RPMA	RPMA	S	2	RPM	RPM
21	Standpipe Pressure (avg)	SPPA	SPPA	F	4	KPA	PSI
22	Casing (Choke) Pressure	CHKP	CHKP	F	4	KPA	PSI
23	Pump Stroke Rate #1	SPM1	SPM1	S	2	SPM	SPM
24	Pump Stroke Rate #2	SPM2	SPM2	S	2	SPM	SPM
25	Pump Stroke Rate #3	SPM3	SPM3	S	2	SPM	SPM

[3] Not applicable

26	Tank Volume (active)	TVOLACT	TVA	F	4	M3	BBL
27	Tank Volume Change (act)	TVOLCACT	TVCA	F	4	M3	BBL
28	Mud Flow Out %	MFOP	MFOP	S	2	%	%
29	Mud Flow Out (avg)	MFOA	MFOA	F	4	L/M	GPM
30	Mud Flow In (avg)	MFIA	MFIA	F	4	L/M	GPM
31	Mud Density Out (avg)	MDOA	MDOA	F	4	KGM3	PPG
32	Mud Density In (avg)	MDIA	MDIA	F	4	KGM3	PPG
33	Mud Temperature Out (avg)	MTOA	MTOA	F	4	DEGC	DEGF
34	Mud Temperature In (avg)	MTIA	MTIA	F	4	DEGC	DEGF
35	Mud Conductivity Out (avg)	MCOA	MCOA	F	4	MMHO	MMHO
36	Mud Conductivity In (avg)	MCIA	MCIA	F	4	MMHO	MMHO
37	Pump Stroke Count (cum)	STKC	STKC	L	4	----	----
38	Lag Strokes	LAGSTKS	LSTK	S	2	----	----
39	Depth Returns (measured)	DEPTRETM	DRTM	F	4	M	F
40	Gas (avg.)	GASA	GASA	F	4	%	%
41	< SPARE 1 >	SPARE1	SPR1	F	4	----	----
42	< SPARE 2 >	SPARE2	SPR2	F	4	----	----
43	< SPARE 3 >	SPARE3	SPR3	F	4	----	----
44	< SPARE 4 >	SPARE4	SPR4	F	4	----	----
45	< SPARE 5 >	SPARE5	SPR5	F	4	----	----

7.4.2 RECORD # 2: DRILLING DEPTH-BASED

WITS Record ID 2	**Logical Record Type 152**	**Auto/Manual AUTOMATIC**
Trigger [DEPTH] Transmit at a specified depth interval (feet or meters)		
Data Source Data acquired in real-time when on-bottom drilling NEW hole and computed over the trigger interval		

Item	**Description**	**Long Mnemonic**	**Short Mnemonic**	**Type**	**Length**	**Metric Units**	**FPS Units**
1	Well Identifier	WELLID	WID	A	16	----	----
2	Sidetrack/Hole Sect No.	STKNUM	SKNO	S	2	----	----
3	Record Identifier	RECID	RID	S	2	----	----
4	Sequence Identifier	SEQID	SQID	L	4	----	----
5	Date	DATE	DATE	L	4	----	----
6	Time	TIME	TIME	L	4	----	----
7	Activity Code	ACTCOD	ACTC	S	2	----	----
8	Depth Hole (meas)	DEPTMEAS	DMEA	F	4	M	F
9	Depth Hole (vert)	DEPTVERT	DVER	F	4	M	F
10	Rate of Penetration (avg)	ROPA	ROPA	F	4	M/HR	F/HR
11	Weight-on-Bit (surf,avg)	WOBA	WOBA	F	4	KDN	KLB
12	Hookload (avg)	HKLA	HKLA	F	4	KDN	KLB
13	Standpipe Pressure (avg)	SPPA	SPPA	F	4	KPA	PSI
14	Rotary Torque (surf,avg)	TORQA	TQA	F	4	KNM	KFLB
15	Rotary Speed (surf,avg)	RPMA	RPMA	S	2	RPM	RPM
16	Bit Revolutions (cum)	BTREVC	BRVC	L	4	----	----

17	Mud Density In (avg)	MDIA	MDIA	F	4	KGM3	PPG
18	ECD at Total Depth	ECDTD	ECDT	F	4	KGM3	PPG
19	Mud Flow In (avg)	MFIA	MFIA	F	4	L/M	GPM
20	Mud Flow Out (avg)	MFOA	MFOA	F	4	L/M	GPM
21	Mud Flow Out %	MFOP	MFOP	S	2	%	%
22	Tank Volume (active)	TVOLACT	TVA	F	4	M3	BBL
23	Cost/Distance (inst)	CPDI	CPDI	F		$/M	$/F
24	Cost/Distance (cum)	CPDC	CPDC	F	4	$/M	$/F
25	Bit Drilled Time	BTDTIME	BDTI	F	4	HR	HR
26	Bit Drilled Distance	BTDDIST	BDDI	F	4	M	F
27	Corr. Drilling Exponent	DXC	DXC	F	4	----	----
28	< SPARE 1 >	SPARE1	SPR1	F	4	----	----
29	< SPARE 2 >	SPARE2	SPR2	F	4	----	----
30	< SPARE 3 >	SPARE3	SPR3	F	4	----	----
31	< SPARE 4 >	SPARE4	SPR4	F	4	----	----

7.4.3 RECORD # 3: DRILLING CONNECTIONS

WITS Record ID 3	**Logical Record Type 153**	**Auto/Manual AUTOMATIC**
Trigger [EVENT] Transmit when first back on bottom following a drilling connection		
Data Source Data acquired from first off-bottom to back on-bottom		

Item	**Description**	**Long Mnemonic**	**Short Mnemonic**	**Type**	**Length**	**Metric Units**	**FPS Units**
1	Well Identifier	WELLID	WID	A	16	----	----
2	Sidetrack/Hole Sect No.	STKNUM	SKNO	S	2	----	----
3	Record Identifier	RECID	RID	S	2	----	----
4	Sequence Identifier	SEQID	SQID	L	4	----	----
5	Date	DATE	DATE	L	4	----	----
6	Time	TIME	TIME	L	4	----	----
7	Activity Code	ACTCOD	ACTC	S	2	----	----
8	Depth Connection (meas)	DEPTCONM	DCNM	F	4	M	F
9	Depth Connection (vert)	DEPTCONV	DCNV	F	4	M	F
10	Depth Hole (meas)	DEPTMEAS	DMEA	F	4	M	F
11	Depth Hole (vert)	DEPTVERT	DVER	F	4	M	F
12	Elapsed Time Bottom-Slips	ETIMEBTS	ETBS	S	2	SEC	SEC
13	Elapsed Time In-Slips	ETIMESLP	ETSL	S	2	SEC	SEC
14	Elapsed Time Slips-Bottom	ETIMESTB	ETSB	S	2	SEC	SEC
15	Elapsed Time Pumps-Off	ETIMEPOF	ETPO	S	2	SEC	SEC
16	Running Speed - up (max)	RSUX	RSUX	F	4	M/S	FPM
17	Running Speed - down (max)	RSDX	RSDX	F	4	M/S	FPM
18	Hookload (max)	HKLX	HKLX	F	4	KDN	KLB
19	String Weight (rot,avg)	STRGWT	STWT	F	4	KDN	KLB
20	Torque - Make Up (max)	TORQMUX	TQMX	F	4	KNM	KFLB
21	Torque - Breakout (max)	TORQBOX	TQBX	F	4	KNM	KFLB

22	< SPARE 1 >	SPARE1	SPR1	F	4	----	----
23	< SPARE 2 >	SPARE2	SPR2	F	4	----	----
24	< SPARE 3 >	SPARE3	SPR3	F	4	----	----
25	< SPARE 4 >	SPARE4	SPR4	F	4	----	----
26	< SPARE 5 >	SPARE5	SPR5	F	4	----	----

7.4.4 RECORD # 4: HYDRAULICS

WITS Record ID 4	Logical Record Type 154	Auto/Manual AUTOMATIC
Trigger [TIME] Transmit at a specified time interval (secs)		
Data Source Data acquired in real-time while circulating drilling fluid. Not sent if no circulation is taking place. Minimum and maximum values reset when record is transmitted. Other items should reflect the input and output variables used in the most recent hydraulics calculation prior to transmission.		

Item	Description	Long Mnemonic	Short Mnemonic	Type	Length	Metric Units	FPS Units
1	Well Identifier	WELLID	WID	A	16	----	----
2	Sidetrack/Hole Sect No.	STKNUM	SKNO	S	2	----	----
3	Record Identifier	RECID	RID	S	2	----	----
4	Sequence Identifier	SEQID	SQID	L	4	----	----
5	Date	DATE	DATE	L	4	----	----
6	Time	TIME	TIME	L	4	----	----
7	Activity Code	ACTCOD	ACTC	S	2	----	----
8	Depth Hole (meas)	DEPTMEAS	DMEA	F	4	M	F
9	Depth Hole (vert)	DEPTVERT	DVER	F	4	M	F
10	Depth Bit (meas)	DEPTBITM	DBTM	F	4	M	F
11	Depth Bit (vert)	DEPTBITV	DBTV	F	4	M	F
12	Mud Density In (avg)	MDIA	MDIA	F	4	KGM3	PPG
13	Mud Flow In (avg)	MFIA	MFIA	F	4	L/M	GPM
14	Standpipe Pressure (avg)	SPPA	SPPA	F	4	KPA	PSI
15	Plastic Viscosity	PV	PV	F	4	CP	CP
16	Yield Point	YP	YP	F	4	PA	PHSF
17	Pressure Loss - bit	PLB	PLB	F	4	KPA	PSI
18	Pressure Loss - string	PLDS	PLDS	F	4	KPA	PSI
19	Pressure Loss - annulus	PLA	PLA	F	4	KPA	PSI
20	Pressure Loss - surface	PLSU	PLSU	F	4	KPA	PSI
21	Pressure Loss - mud motor	PLMM	PLMM	F	4	KPA	PSI
22	Pressure Loss - MWD tool	PLMWD	PLMW	F	4	KPA	PSI
23	Pressure Loss - % at bit	PLPB	PLPB	F	4	%	%
24	Bit Hydraulic Power	BHP	BHP	F	4	KW	HP
25	Bit Hydraulic Power/Area	BHPA	BHPA	F	4	KWM2	HSI
26	Jet Impact Force	JIF	JIF	F	4	KDN	LB
27	Jet Velocity	JV	JV	F	4	M/S	FPS
28	Annular Velocity (min)	AVELN	AVN	F	4	M/S	FPM
29	Annular Velocity (max)	AVELX	AVX	F	4	M/S	FPM
30	ECD at Total Depth	ECDTD	ECDT	F	4	KGM3	PPG
31	ECD at Bit	ECDBIT	ECDB	F	4	KGM3	PPG
32	ECD at Casing Shoe	ECDCSG	ECDC	F	4	KGM3	PPG
33	Pump Hydraulic Power	PHP	PHP	F	4	KW	HP
34	Calc/Obs Press.Loss ratio	PLCO	PLCO	F	4	%	%
35	< SPARE 1 >	SPARE1	SPR1	F	4	----	----
36	< SPARE 2 >	SPARE2	SPR2	F	4	----	----

37	< SPARE 3 >	SPARE3	SPR3	F	4	----	----
38	< SPARE 4 >	SPARE4	SPR4	F	4	----	----
39	< SPARE 5 >	SPARE5	SPR5	F	4	---	----

7.4.5 RECORD #5: TRIPPING/CASING RUN TIME-BASED

WITS Record ID 5	Logical Record Type 155	Auto/Manual AUTOMATIC
Trigger [TIME] Transmit at a specified time interval (secs)		
Data Source Data aquired in real-time and computed over the trigger interval. Only sent when tripping. Average, minimum and maximum values reset when this record OR Record 6 (Tripping/Casing Connection Based) is transmitted		

Item	Description	Long Mnemonic	Short Mnemonic	Type	Length	Metric Units	FPS Units
1	Well Identifier	WELLID	WID	A	16	----	----
2	Sidetrack/Hole Sect No.	STKNUM	SKNO	S	2	----	----
3	Record Identifier	RECID	RID	S	2	----	----
4	Sequence Identifier	SEQID	SQID	L	4	----	----
5	Date	DATE	DATE	L	4	----	----
6	Time	TIME	TIME	L	4	----	----
7	Activity Code	ACTCOD	ACTC	S	2	----	----
8	Depth Bit (meas)	DEPTBITM	DBTM	F	4	M	F
9	Depth Bit (vert)	DEPTBITV	DBTV	F	4	M	F
10	Depth Hole (meas)	DEPTMEAS	DMEA	F	4	M	F
11	Depth Hole (vert)	DEPTVERT	DVER	F	4	M	F
12	Trip Number	TRIPNUM	TNUM	S	2	----	----
13	In-Slips Status	STATUSIS	STIS	A	2	----	----
14	Hookload (avg)	HKLA	HKLA	F	4	KDN	KLB
15	Block Position	BLKPOS	BPOS	F	4	M	F
16	Running Speed - up (max)	RSUX	RSUX	F	4	M/S	FPM
17	Running Speed - down (max)	RSDX	RSDX	F	4	M/S	FPM
18	Fill/Gain Volume Obs.(cum)	FVOLOC	FVOC	F	4	M3	BBL
19	< SPARE 1 >	SPARE1	SPR1	F	4	----	----
20	< SPARE 2 >	SPARE2	SPR2	F	4	----	----
21	< SPARE 3 >	SPARE3	SPR3	F	4	----	----
22	< SPARE 4 >	SPARE4	SPR4	F	4	----	----
23	< SPARE 5 >	SPARE5	SPR5	F	4	---	----

7.4.6 RECORD # 6: TRIPPING/CASING CONNECTION-BASED

WITS Record ID 6	Logical Record Type 156	Auto/Manual AUTOMATIC
Trigger [EVENT] Transmit when first out of slips following a connection		
Data Source Data acquired in real-time and computed from first out of slips to next first out of slips. Only sent when tripping. Average and maximum values reset following the transmission of the record		

Item	Description	Long Mnemonic	Short Mnemonic	Type	Length	Metric Units	FPS Units
1	Well Identifier	WELLID	WID	A	16	----	----
2	Sidetrack/Hole Sect No.	STKNUM	SKNO	S	2	----	----
3	Record Identifier	RECID	RID	S	2	----	----

4	Sequence Identifier	SEQID	SQID	L	4	----	----
5	Date	DATE	DATE	L	4	----	----
6	Time	TIME	TIME	L	4	----	----
7	Activity Code	ACTCOD	ACTC	S	2	----	----
8	Depth Bit (meas)	DEPTBITM	DBTM	F	4	M	F
9	Depth Bit (vert)	DEPTBITV	DBTV	F	4	M	F
10	Depth Hole (meas)	DEPTMEAS	DMEA	F	4	M	F
11	Depth Hole (vert)	DEPTVERT	DVER	F	4	M	F
12	Trip Number	TRIPNUM	TNUM	S	2	----	----
13	Connections Done	CONNDONE	CDON	S	2	----	----
14	Connections Remaining	CONNREM	CREM	S	2	----	----
15	Elapsed Time In-Slips	ETIMESLP	ETSL	S	2	SEC	SEC
16	Elapsed Time Out-of-Slips	ETIMEOS	ETOS	S	2	SEC	SEC
17	Running Speed -up (max)	RSUX	RSUX	F	4	M/S	FPM
18	Running Speed -up (avg)	RSUA	RSUA	F	4	M/S	FPM
19	Running Speed -down (max)	RSDX	RSDX	F	4	M/S	FPM
20	Running Speed -down (avg)	RSDA	RSDA	F	4	M/S	FPM
21	Hookload (max)	HKLX	HKLX	F	4	KDN	KLB
22	Hookload (min)	HKLN	HKLN	F	4	KDN	KLB
23	Hookload (avg)	HKLA	HKLA	F	4	KDN	KLB
24	Torque - Make Up (max)	TORQMUX	TQMX	F	4	KNM	KFLB
25	Torque - Breakout (max)	TORQBOX	TQBX	F	4	KNM	KFLB
26	Fill/Gain Volume Obs.	FVOLO	FVO	F	4	M3	BBL
27	Fill/Gain Volume Exp.	FVOLE	FVE	F	4	M3	BBL
28	Fill/Gain Volume Obs.(cum)	FVOLOC	FVOC	F	4	M3	BBL
29	Fill/Gain Volume Exp (cum)	FVOLEC	FVEC	F	4	M3	BBL
30	< SPARE 1 >	SPARE1	SPR1	F	4	----	----
31	< SPARE 2 >	SPARE2	SPR2	F	4	----	----
32	< SPARE 3 >	SPARE3	SPR3	F	4	----	----
33	< SPARE 4 >	SPARE4	SPR4	F	4	----	----
34	< SPARE 5 >	SPARE5	SPR5	F	4	---	----

7.4.7 RECORD # 7: SURVEY / DIRECTIONAL

WITS Record ID 7	**Logical Record Type 157**	**Auto/Manual AUTO(MWD)/MANUAL**
Trigger [EVENT] Transmit when new survey data values are received and computed (MWD) or when manually triggered by operator		
Data Source Data acquired in real-time by MWD tools or entered manually from other sources		

Item	Description	Long Mnemonic	Short Mnemonic	Type	Length	Metric Units	FPS Units
1	Well Identifier	WELLID	WID	A	16	----	----
2	Sidetrack/Hole Sect No.	STKNUM	SKNO	S	2	----	----
3	Record Identifier	RECID	RID	S	2	----	----
4	Sequence Identifier	SEQID	SQID	L	4	----	----
5	Date	DATE	DATE	L	4	----	----
6	Time	TIME	TIME	L	4	----	----
7	Activity Code	ACTCOD	ACTC	S	2	----	----

8	Depth Svy/reading (meas)	DEPTSVYM	DSVM	F	4	M	F
9	Depth Svy/reading (vert)	DEPTSVYV	DSVV	F	4	M	F
10	Pass Number	PASSNUM	PASS	S	2	----	----
11	Depth Hole (meas)	DEPTMEAS	DMEA	F	4	M	F
12	Svy Type	SVYTYPE	STYP	A	8	----	----
13	Svy Inclination	SVYINC	SINC	F	4	DEG	DEG
14	Svy Azimuth (uncorrected)	SVYAZU	SAZU	F	4	DEG	DEG
15	Svy Azimuth (corrected)	SVYAZC	SAZC	F	4	DEG	DEG
16	Svy Magnetic Toolface	SVYMTF	SMTF	F	4	DEG	DEG
17	Svy Gravity Toolface	SVYGTF	SGTF	F	4	DEG	DEG
18	Svy North-South Position	SVYNS	SNS	F	4	M	F
19	Svy East-West Position	SVYEW	SEW	F	4	M	F
20	Svy Dog Leg Severity	SVYDLS	SDLS	F	4	DGHM	DGHF
21	Svy Rate of Walk	SVYWALK	SWLK	F	4	DGHM	DGHF
22	< SPARE 1 >	SPARE1	SPR1	F	4	----	----
23	< SPARE 2 >	SPARE2	SPR2	F	4	----	----
24	< SPARE 3 >	SPARE3	SPR3	F	4	----	----
25	< SPARE 4 >	SPARE4	SPR4	F	4	----	----
26	< SPARE 5 >	SPARE5	SPR5	F	4	---	----

7.4.8 RECORD # 8: MWD FORMATION EVALUATION

WITS Record ID 8	Logical Record Type 158	Auto/Manual AUTOMATIC
Trigger [TIME], [DEPTH] or [TIME/DEPTH] Transmit at specified time interval (secs), depth interval (feet or meters) based on hole depth when drilling new hole or making a new pass, or a combination of these.		
Data Source Data acquired in real-time and computed over the trigger interval. Record transmitted and computations reset when triggering interval occurs. If DEPTH-triggered, then only on-bottom data is included in computations. Depths of MWD sensors transmitted in the record are the depths for the last valid reading for that sensor. Record is not sent if not circulating or tool is not operating		

Item	**Description**	**Long Mnemonic**	**Short Mnemonic**	**Type**	**Length**	**Metric Units**	**FPS Units**
1	Well Identifier	WELLID	WID	A	16	----	----
2	Sidetrack/Hole Sect No.	STKNUM	SKNO	S	2	----	----
3	Record Identifier	RECID	RID	S	2	----	----
4	Sequence Identifier	SEQID	SQID	L	4	----	----
5	Date	DATE	DATE	L	4	----	----
6	Time	TIME	TIME	L	4	----	----
7	Activity Code	ACTCOD	ACTC	S	2	----	----
8	Depth Hole (meas)	DEPTMEAS	DMEA	F	4	M	F
9	Depth Hole (vert)	DEPTVERT	DVER	F	4	M	F
10	Depth Bit (meas)	DEPTBITM	DBTM	F	4	M	F
11	Depth Bit (vert)	DEPTBITV	DBTV	F	4	M	F
12	Pass Number	PASSNUM	PASS	S	2	----	----
13	Depth Resis 1 sensor (meas)	DEPTRS1M	DR1M	F	4	M	F
14	Depth Resis 1 sensor (vert)	DEPTRS1V	DR1V	F	4	M	F
15	Resis 1 reading	MR1	MR1	F	4	OHMM	OHMM
16	Resis 1 (borehole corr)	MR1C	MR1C	F	4	OHMM	OHMM
17	Depth Resis 2 sensor (meas)	DEPTRS2M	DR2M	F	4	M	F
18	Depth Resis 2 sensor (vert)	DEPTRS2V	DR2V	F	4	M	F

19	Resis 2 reading	MR2	MR2	F	4	OHMM	OHMM
20	Resis 2 (borehole corr)	MR2C	MR2C	F	4	OHMM	OHMM
21	Depth G.Ray 1 sensor(meas)	DEPTGR1M	DG1M	F	4	M	F
22	Depth G.Ray 1 sensor(vert)	DEPTGR1V	DG1V	F	4	M	F
23	Gamma Ray 1 reading	MG1	MG1	F	4	API	API
24	Gamma Ray 1(borehole corr)	MG1C	MG1C	F	4	API	API
25	Depth G.Ray 2 sensor(meas)	DEPTGR2M	DG2M	F	4	M	F
26	Depth G.Ray 2 sensor(vert)	DEPTGR2V	DG2V	F	4	M	F
27	Gamma Ray 2 reading	MG2	MG2	F	4	API	API
28	Gamma Ray 2(borehole corr)	MG2C	MG2C	F	4	API	API
29	Depth Por 1 sensor (meas)	DEPTP1M	DP1M	F	4	M	F
30	Depth Por 1 sensor (vert)	DEPTP1V	DP1V	F	4	M	F
31	Porosity Tool 1 reading	MPO1	MPO1	F	4	----	----
32	Depth Por 2 sensor (meas)	DEPTP2M	DP2M	F	4	M	F
33	Depth Por 2 sensor (vert)	DEPTP2V	DP2V	F	4	M	F
34	Porosity Tool 2 reading	MPO2	MPO2	F	4	----	----
35	Downhole Fluid Temp (ann)	MFTANN	MFTA	F	4	DEGC	DEGF
36	Downhole Fluid Temp (pipe)	MFTPIPE	MFTP	F	4	DEGC	DEGF
37	Downhole Fluid Resis (ann)	MFRANN	MFRA	F	4	OHMM	OHMM
38	Downhole Fluid Resis (pipe)	MFRPIPE	MFRP	F	4	OHMM	OHMM
39	Depth Form Density (meas)	DEPTFDM	DFDM	F	4	M	F
40	Depth Form Density (vert)	DEPTFDV	DFDV	F	4	M	F
41	Formation Density	MFD	MFD	F	4	G/CC	G/CC
42	Depth Caliper (meas)	DEPTCALM	DCLM	F	4	M	F
43	Depth Caliper (vert)	DEPTCALV	DCLV	F	4	M	F
44	Caliper	MCLP	MCLP	F	4	MM	IN
45	Pore Pressure Grad MWD	MFPP	MFPP	F	4	KGM3	PPG
46	Frac Pressure Grad MWD	MFFP	MFFP	F	4	KGM3	PPG
47	< SPARE 1 >	SPARE1	SPR1	F	4	----	----
48	< SPARE 2 >	SPARE2	SPR2	F	4	----	----
49	< SPARE 3 >	SPARE3	SPR3	F	4	----	----
50	< SPARE 4 >	SPARE4	SPR4	F	4	----	----
51	< SPARE 5 >	SPARE5	SPR5	F	4	---	----
52	< SPARE 6 >	SPARE6	SPR6	F	4	----	----
53	< SPARE 7 >	SPARE7	SPR7	F	4	----	----
54	< SPARE 8 >	SPARE8	SPR8	F	4	----	----
55	< SPARE 9 >	SPARE9	SPR9	F	4	----	----

7.4.9 RECORD # 9: MWD MECHANICAL

WITS Record ID 9	Logical Record Type 159	Auto/Manual AUTOMATIC
Trigger [TIME], [DEPTH] or [TIME/DEPTH] Transmit at specified time interval (secs), depth interval (feet or meters) based on hole depth when drilling new hole or making a new pass, or a combination of these		

Data Source Data acquired in real-time and computed over the trigger interval. Record transmitted and computations reset when triggering interval occurs. If DEPTH-triggered, then only on-bottom data is included in computations. Record is not sent if not circulating or tool is not operating

Item	Description	Long Mnemonic	Short Mnemonic	Type	Length	Metric Units	FPS Units
1	Well Identifier	WELLID	WID	A	16	----	----
2	Sidetrack/Hole Sect No.	STKNUM	SKNO	S	2	----	----
3	Record Identifier	RECID	RID	S	2	----	----
4	Sequence Identifier	SEQID	SQID	L	4	----	----
5	Date	DATE	DATE	L	4	----	----
6	Time	TIME	TIME	L	4	----	----
7	Activity Code	ACTCOD	ACTC	S	2	----	----
8	Depth Hole (meas)	DEPTMEAS	DMEA	F	4	M	F
9	Depth Hole (vert)	DEPTVERT	DVER	F	4	M	F
10	Depth Bit (meas)	DEPTBITM	DBTM	F	4	M	F
11	Depth Bit (vert)	DEPTBITV	DBTV	F	4	M	F
12	Pass Number	PASSNUM	PASS	S	2	----	----
13	Bottom-hole annulus press	MBHPANN	MBPA	F	4	KPA	PSI
14	Bottom-hole internal press	MBHPINT	MBPI	F	4	KPA	PSI
15	Downhole Wt-on-Bit (avg)	MWOBA	MWBA	F	4	KDN	KLB
16	Downhole Wt-on-Bit (max)	MWOBX	MWBX	F	4	KDN	KLB
17	Downhole Torque (avg)	MTORQA	MTQA	F	4	KNM	KFLB
18	Downhole Torque (max)	MTORQX	MTQX	F	4	KNM	KFLB
19	Downhole Motor RPM	MMMRPM	MMRP	S	2	RPM	RPM
20	MWD Tool Alternator Voltage	MALTVOLT	MALT	S	2	V	V
21	< SPARE 1 >	SPARE1	SPR1	F	4	----	----
22	< SPARE 2 >	SPARE2	SPR2	F	4	----	----
23	< SPARE 3 >	SPARE3	SPR3	F	4	----	----
24	< SPARE 4 >	SPARE4	SPR4	F	4	----	----
25	< SPARE 5 >	SPARE5	SPR5	F	4	---	----
26	< SPARE 6 >	SPARE6	SPR6	F	4	----	----
27	< SPARE 7 >	SPARE7	SPR7	F	4	----	----
28	< SPARE 8 >	SPARE8	SPR8	F	4	----	----
29	< SPARE 9 >	SPARE9	SPR9	F	4	----	----

7.4.10 RECORD # 10: PRESSURE EVALUATION

WITS Record ID 10	**Logical Record Type 160**	**Auto/Manual AUTOMATIC/MANUAL**
Trigger [EVENT] Transmit when new pressure evaluation data values are available		
Data Source Data acquired in real-time and computed over the trigger interval. Record transmitted and compuations reset when the record is transmitted		

Item	Description	Long Mnemonic	Short Mnemonic	Type	Length	Metric Units	FPS Units
1	Well Identifier	WELLID	WID	A	16	----	----
2	Sidetrack/Hole Sect No.	STKNUM	SKNO	S	2	----	----
3	Record Identifier	RECID	RID	S	2	----	----

4	Sequence Identifier	SEQID	SQID	L	4	----	----
5	Date	DATE	DATE	L	4	----	----
6	Time	TIME	TIME	L	4	----	----
7	Activity Code	ACTCOD	ACTC	S	2	----	----
8	Depth Hole (meas)	DEPTMEAS	DMEA	F	4	M	F
9	Depth Hole (vert)	DEPTVERT	DVER	F	4	M	F
10	Depth Sample (meas)	DEPTSAMM	DSAM	F	4	M	F
11	Depth Sample (vert)	DEPTSAMV	DSAV	F	4	M	F
12	Est. Form. Pore Press Grad.	FPOREPG	FPPG	F	4	KGM3	PPG
13	Est. Form. Frac Press Grad.	FFRACPG	FFPG	F	4	KGM3	PPG
14	Est. Form. Overburden Grad.	FOBPG	FOPG	F	4	KGM3	PPG
15	Est. Kick Tolerance	KTOL	KTOL	F	4	KGM3	PPG
16	Max. Permitted SICP (init)	PSIPX	PSIP	F	4	KPA	PSI
17	Connection Gas (avg)	CONNGASA	CGSA	F	4	%	%
18	Connection Gas (max)	CONNGASX	CGSX	F	4	%	%
19	Connection Gas (last)	CONNGASL	CGSL	F	4	%	%
20	Last Trip Gas	TRIPGAS	TGAS	F	4	%	%
21	Shale Density	SHALEDEN	SDEN	F	4	G/CC	G/CC
22	Cuttings CEC	CEC	CEC	F	4	MEHG	MEHG
23	Cavings %	CAVINGS	CAV	S	2	%	%
24	Corr. Drilling Exponent	DXC	DXC	F	4	----	----
25	< SPARE 1 >	SPARE1	SPR1	F	4	----	----
26	< SPARE 2 >	SPARE2	SPR2	F	4	----	----
27	< SPARE 3 >	SPARE3	SPR3	F	4	----	----
28	< SPARE 4 >	SPARE4	SPR4	F	4	----	----
29	< SPARE 5 >	SPARE5	SPR5	F	4	---	----
30	< SPARE 6 >	SPARE6	SPR6	F	4	----	----
31	< SPARE 7 >	SPARE7	SPR7	F	4	----	----
32	< SPARE 8 >	SPARE8	SPR8	F	4	----	----
33	< SPARE 9 >	SPARE9	SPR9	F	4	----	----

7.4.11 RECORD # 11: MUD TANK VOLUMES

WITS Record ID 11	Logical Record Type 161	Auto/Manual AUTOMATIC
Trigger [TIME] Transmit at a specified time interval (secs)		
Data Source Data acquired in real-time and computed over the trigger interval; record transmitted and computations reset when triggering interval occurs		

Item	Description	Long Mnemonic	Short Mnemonic	Type	Length	Metric Units	FPS Units
1	Well Identifier	WELLID	WID	A	16	----	----
2	Sidetrack/Hole Sect No.	STKNUM	SKNO	S	2	----	----
3	Record Identifier	RECID	RID	S	2	----	----
4	Sequence Identifier	SEQID	SQID	L	4	----	----
5	Date	DATE	DATE	L	4	----	----
6	Time	TIME	TIME	L	4	----	----
7	Activity Code	ACTCOD	ACTC	S	2	----	----
8	Depth Hole (meas)	DEPTMEAS	DMEA	F	4	M	F
9	Depth Hole (vert)	DEPTVERT	DVER	F	4	M	F
10	Tank Volume (total)	TVOLTOT	TVT	F	4	M3	BBL

11	Tank Volume (active)	TVOLACT	TVA	F	4	M3	BBL
12	Tank Volume Change (total)	TVOLCTOT	TVCT	F	4	M3	BBL
13	Tank Volume Change (active)	TVOLCACT	TVCA	F	4	M3	BBL
14	Tank Volume Reset Time	TVRESET	TVRT	L	4	----	----
15	Tank 01 Volume	TVOL01	TV01	F	4	M3	BBL
16	Tank 02 Volume	TVOL02	TV02	F	4	M3	BBL
17	Tank 03 Volume	TVOL03	TV03	F	4	M3	BBL
18	Tank 04 Volume	TVOL04	TV04	F	4	M3	BBL
19	Tank 05 Volume	TVOL05	TV05	F	4	M3	BBL
20	Tank 06 Volume	TVOL06	TV06	F	4	M3	BBL
21	Tank 07 Volume	TVOL07	TV07	F	4	M3	BBL
22	Tank 08 Volume	TVOL08	TV08	F	4	M3	BBL
23	Tank 09 Volume	TVOL09	TV09	F	4	M3	BBL
24	Tank 10 Volume	TVOL10	TV10	F	4	M3	BBL
25	Tank 11 Volume	TVOL11	TV11	F	4	M3	BBL
26	Tank 12 Volume	TVOL12	TV12	F	4	M3	BBL
27	Tank 13 Volume	TVOL13	TV13	F	4	M3	BBL
28	Tank 14 Volume	TVOL14	TV14	F	4	M3	BBL
29	Trip Tank 1 Volume	TTVOL1	TTV1	F	4	M3	BBL
30	Trip Tank 2 Volume	TTVOL2	TTV2	F	4	M3	BBL
31	< SPARE 1 >	SPARE1	SPR1	F	4	----	----
32	< SPARE 2 >	SPARE2	SPR2	F	4	----	----
33	< SPARE 3 >	SPARE3	SPR3	F	4	----	----
34	< SPARE 4 >	SPARE4	SPR4	F	4	----	----
35	< SPARE 5 >	SPARE5	SPR5	F	4	---	----

7.4.12 RECORD # 14: LAGGED CONTINUOUS MUD PROPERTIES

WITS Record ID 14	Logical Record Type 164	Auto/Manual AUTOMATIC
Trigger [TIME], [DEPTH] or [TIME/DEPTH] Transmit at the specified time interval (secs), depth interval (feet or meters) based on the returns depth, or a combination of these.		
Data Source Data acquired in real-time and computed over the interval. Record transmitted and computations reset when the triggering interval occurs. If a depth interval is specified, it is active until bottoms-up occurs. Time intervals, if specified, are reset following the transmission of the record by either depth or time trigger. Not sent if no circulation is taking place		

Item	Description	Long Mnemonic	Short Mnemonic	Type	Length	Metric Units	FPS Units
1	Well Identifier	WELLID	WID	A	16	----	----
2	Sidetrack/Hole Sect No.	STKNUM	SKNO	S	2	----	----
3	Record Identifier	RECID	RID	S	2	----	----
4	Sequence Identifier	SEQID	SQID	L	4	----	----
5	Date	DATE	DATE	L	4	----	----
6	Time	TIME	TIME	L	4	----	----
7	Activity Code	ACTCOD	ACTC	S	2	----	----
8	Depth Returns (meas)	DEPTRETM	DRTM	F	4	M	F
9	Depth Returns (vert)	DEPTRETV	DRTV	F	4	M	F
10	Mud Density In (lagd)	MDIL	MDIL	F	4	KGM3	PPG
11	Mud Density Out (avg)	MDOA	MDOA	F	4	KGM3	PPG
12	Mud Temperature In (lagd)	MTIL	MTIL	F	4	DEGC	DEGF
13	Mud Temperature Out (avg)	MTOA	MTOA	F	4	DEGC	DEGF
14	Mud Conductivity In (lagd)	MCIL	MCIL	F	4	MMHO	MMHO
15	Mud Conductivity Out (avg)	MCOA	MCOA	F	4	MMHO	MMHO

16	Hyd.Sulfide Haz.Pot. (avg)	HSHPA	HHPA	F	4	PPM	PPM
17	Hyd.Sulfide pH (avg)	HSPHA	HPHA	F	4	----	----
18	Hyd.Sulfide pHS (avg)	HSPHSA	HPSA	F	4	%	%
19	Gas In (lagd)	GASIL	GSIL	F	4	%	%
20	Gas (avg)	GASA	GASA	F	4	%	%
21	Gas (max)	GASX	GASX	F	4	%	%
22	Carbon Dioxide (avg)	CO2A	CO2A	L	4	PPM	PPM
23	Hydrogen Sulfide (avg)	HSA	HSA	L	4	PPM	PPM
24	Hydrogen Sulfide (max)	HSX	HSX	L	4	PPM	PPM
25	< SPARE 1 >	SPARE1	SPR1	F	4	----	----
26	< SPARE 2 >	SPARE2	SPR2	F	4	----	----
27	< SPARE 3 >	SPARE3	SPR3	F	4	----	----
28	< SPARE 4 >	SPARE4	SPR4	F	4	----	----
29	< SPARE 5 >	SPARE5	SPR5	F	4	---	----

7.4.13 RECORD # 15: CUTTINGS / LITHOLOGY

WITS Record ID 15	Logical Record Type 165	Auto/Manual MANUAL
Trigger [EVENT] Transmission is operator-initiated		
Data Source Manually-entered data from sample examination sent when new data values are available		

Item	Description	Long Mnemonic	Short Mnemonic	Type	Length	Metric Units	FPS Units
1	Well Identifier	WELLID	WID	A	16	----	----
2	Sidetrack/Hole Sect No.	STKNUM	SKNO	S	2	----	----
3	Record Identifier	RECID	RID	S	2	----	----
4	Sequence Identifier	SEQID	SQID	L	4	----	----
5	Date	DATE	DATE	L	4	----	----
6	Time	TIME	TIME	L	4	----	----
7	Activity Code	ACTCOD	ACTC	S	2	----	----
8	Depth Sample (meas)	DEPTSAMM	DSAM	F	4	M	F
9	Depth Sample (vert)	DEPTSAMV	DSAV	F	4	M	F
10	Description type	DESCTYPE	DESC	A	8	----	----
11	Lith 1 type	L1TYPE	L1TY	A	16	----	----
12	Lith 1 %	L1PERC	L1PC	S	2	%	%
13	Lith 1 classification	L1CLASS	L1CL	A	16	----	----
14	Lith 1 color	L1COLOR	L1CO	A	16	----	----
15	Lith 1 texture	L1TEXT	L1TX	A	16	----	----
16	Lith 1 hardness	L1HARD	L1HD	A	16	----	----
17	Lith 1 grain size	L1SIZE	L1SZ	A	16	----	----
18	Lith 1 roundness	L1ROUND	L1RD	A	16	----	----
19	Lith 1 sorting	L1SORT	L1SO	A	16	----	----
20	Lith 1 matrix/cement	L1MATCEM	L1MC	A	16	----	----
21	Lith 1 accessories	L1ACC	L1AC	A	16	----	----
22	Lith 1 porosity	L1POR	L1PO	F	4	%	%
23	Lith 1 permeability	L1PERM	L1PE	F	4	MD	MD
24	Lith 2 type	L2TYPE	L2TY	A	16	----	----
25	Lith 2 %	L2PERC	L2PC	S	2	%	%
26	Lith 2 classification	L2CLASS	L2CL	A	16	----	----
27	Lith 2 color	L2COLOR	L2CO	A	16	----	----
28	Lith 2 texture	L2TEXT	L2TX	A	16	----	----
29	Lith 2 hardness	L2HARD	L2HD	A	16	----	----
30	Lith 2 grain size	L2SIZE	L2SZ	A	16	----	----

31	Lith 2 roundness	L2ROUND	L2RD	A	16	----	----
32	Lith 2 sorting	L2SORT	L2SO	A	16	----	----
33	Lith 2 matrix/cement	L2MATCEM	L2MC	A	16	----	----
34	Lith 2 accessories	L2ACC	L2AC	A	16	----	----
35	Lith 2 porosity	L2POR	L2PO	F	4	%	%
36	Lith 2 permeability	L2PERM	L2PE	F	4	MD	MD
37	Lith 3 type	L3TYPE	L3TY	A	16	---- -	---
38	Lith 3 %	L3PERC	L3PC	S	2	%	%
39	Lith 3 classification	L3CLASS	L3CL	A	16	----	----
40	Lith 4 type	L4TYPE	L4TY	A	16	----	----
41	Lith 4 %	L4PERC	L4PC	S	2	%	%
42	Lith 4 classification	L4CLASS	L4CL	A	16	----	----
43	Lith 5 type	L5TYPE	L5TY	A	16	----	----
44	Lith 5 %	L5PERC	L5PC	S	2	%	%
45	Lith 5 classification	L5CLASS	L5CL	A	16	----	----
46	Fossils	FOSS	FOSS	A	16	----	----
47	Composite Show	COMPSHOW	SHOW	A	16	----	----
48	Bulk Density	BULKDEN	BDEN	F	4	G/CC	G/CC
49	Cuttings Gas	GASCUTT	GCUT	F	4	%	%
50	Calcimetry Calcite %	CCAL	CCAL	F	4	%	%
51	Calcimetry Dolomite %	CDOL	CDOL	F	4	%	%
52	Cuttings CEC	CEC	CEC	F	4	MEHG	MEHG
53	Cavings %	CAVINGS	CAV	S	2	%	%
54	Shale Density	SHALEDEN	SDEN	F	4	G/CC	G/CC
55	< SPARE 1 >	SPARE1	SPR1	F	4	----	----
56	< SPARE 2 >	SPARE2	SPR2	F	4	----	----
57	< SPARE 3 >	SPARE3	SPR3	F	4	----	----
58	< SPARE 4 >	SPARE4	SPR4	F	4	----	----
59	< SPARE 5 >	SPARE5	SPR5	F	4	---	----

7.4.14 RECORD # 17: CEMENTING

WITS Record ID 17	**Logical Record Type 167**	**Auto/Manual AUTOMATIC**
Trigger [TIME] Transmit at a specified time interval (secs)		
Data Source Data acquired in real-time (possibly via Level 0 transfer). Averages are computed over the triggering interval and reset when the record is transmitted. Record only transmitted during a cementing operation		

Item	**Description**	**Long Mnemonic**	**Short Mnemonic**	**Type**	**Length**	**Metric Units**	**FPS Units**
1	Well Identifier	WELLID	WID	A	16	----	----
2	Sidetrack/Hole Sect No.	STKNUM	SKNO	S	2	----	----
3	Record Identifier	RECID	RID	S	2	----	----
4	Sequence Identifier	SEQID	SQID	L	4	----	----
5	Date	DATE	DATE	L	4	----	----
6	Time	TIME	TIME	L	4	----	----
7	Activity Code	ACTCOD	ACTC	S	2	----	----
8	Depth Hole (meas)	DEPTMEAS	DMEA	F	4	M	F
9	Depth Hole (vert)	DEPTVERT	DVER	F	4	M	F
10	Depth Casing Shoe (meas)	DEPTCSGM	DCGM	F	4	M	F
11	Depth Casing Shoe (vert)	DEPTCSGV	DCGV	F	4	M	F
12	Cem Pump Pressure (avg)	CEMPPA	CPPA	F	4	KPA	PSI
13	Hookload (avg)	HKLA	HKLA	F	4	KDN	KLB

14	Block Position	BLKPOS	BPOS	F	4	M	F
15	Cem Flow Rate In (calc)	CEMFIC	CFIC	F	4	M3/M	BPM
16	Cem Flow Rate In (avg)	CEMFIA	CFIA	F	4	M3/M	BPM
17	Cem Flow Rate Out (avg)	CEMFOA	CFOA	F	4	M3/M	BPM
18	Cem Flow Out %	CEMFOP	CFOP	S	2	%	%
19	Cem Fluid Dens In (avg)	CEMDIA	CDIA	F	4	KGM3	PPG
20	Cem Fluid Dens Out (avg)	CEMDOA	CDOA	F	4	KGM3	PPG
21	ECD at Casing Shoe	ECDCSG	ECDC	F	4	KGM3	PPG
22	Cem Fluid Temp In (avg)	CEMTIA	CTIA	F	4	DEGC	DEGF
23	Cem Fluid Temp Out (avg)	CEMTOA	CTOA	F	4	DEGC	DEGF
24	Cem Stage Number	CEMSTAGE	CSTG	S	2	----	----
25	Cem Depth to DV Tool	DEPTDVT	DDVT	F	4	M	F
26	Cem Fluid Type/Batch	CEMFTYPE	CTYP	A	16	----	----
27	Cem Cumulative Returns	CEMCUMRT	CCRT	F	4	M3	BBL
28	Cem Indiv Vol Pumped	CEMIVOL	CIVL	F	4	M3	BBL
29	Cem Cement Vol Pumped	CEMCVOL	CCVL	F	4	M3	BBL
30	Cem Total Vol Pumped	CEMTVOL	CTVL	F	4	M3	BBL
31	Cem Volume to Bump Plug	CEMBPVOL	CBVL	F	4	M3	BBL
32	Cem No./Status of Plug(s)	CEMPLUGS	CPLG	A	8	----	----
33	Cem Job Type	CEMJTYP	CJTY	A	16	----	----
34	< SPARE 1 >	SPARE1	SPR1	F	4	----	----
35	< SPARE 2 >	SPARE2	SPR2	F	4	----	----
36	< SPARE 3 >	SPARE3	SPR3	F	4	----	----
37	< SPARE 4 >	SPARE4	SPR4	F	4	----	----
38	< SPARE 5 >	SPARE5	SPR5	F	4	---	----

7.4.15 RECORD # 18: DRILL STEM TESTING

WITS Record ID 18	Logical Record Type 168	Auto/Manual AUTOMATIC
Trigger [TIME] Transmit at a specified time interval (secs)		
Data Source Data acquired in real-time (possibly via Level 0 transfer). Record only sent during a drill stem testing operation		

Item	Description	Long Mnemonic	Short Mnemonic	Type	Length	Metric Units	FPS Units
1	Well Identifier	WELLID	WID	A	16	----	----
2	Sidetrack/Hole Sect No.	STKNUM	SKNO	S	2	----	----
3	Record Identifier	RECID	RID	S	2	----	----
4	Sequence Identifier	SEQID	SQID	L	4	----	----
5	Date	DATE	DATE	L	4	----	----
6	Time	TIME	TIME	L	4	----	----
7	Activity Code	ACTCOD	ACTC	S	2	----	----
8	DST identification	DSTID	DSID	A	8	----	----
9	DST Intvl Top Depth (meas)	DEPTDITM	DDTM	F	4	M	F
10	DST Intvl Top Depth (vert)	DEPTDITV	DDTV	F	4	M	F
11	DST Intvl Bott Depth (meas)	DEPTDIBM	DDBM	F	4	M	F
12	DST Intvl Bott Depth (vert)	DEPTDIBV	DDBV	F	4	M	F
13	DST Tool Time	DSTTTIME	DTTI	L	4	HR	HR
14	DST State of Well	DSTSTATE	DSTA	S	2	----	----
15	DST Surf Pressure, Tubing	DSTSPTUB	DSPT	F	4	KPA	PSI
16	DST Surf Pressure, Casing	DSTSPCAS	DSPC	F	4	KPA	PSI
17	DST Surf Temp, Tubing	DSTSTTUB	DSTT	F	4	DEGC	DEGF
18	DST Bottom Hole Pressure	DSTBHP	DBHP	F	4	KPA	PSI

19	DST Bottom Hole Temp	DSTBHT	DBHT	F	4	DEGC	DEGF
20	DST Liquid Flow Rate	DSTLIQFR	DLFR	F	4	M3/D	BPD
21	DST Gas Flow Rate	DSTGASFR	DGFR	F	4	MCMD	MCFD
22	DST Total Flow Rate	DSTTOTFR	DTFR	F	4	M3/D	BPD
23	DST Cum Liquid Production	DSTCLP	DCLP	F	4	M3	BBL
24	DST Cum Gas Production	DSTCGP	DCGP	F	4	MCM	MCF
25	DST Cum Total Production	DSTCTP	DCTP	F	4	M3	BBL
26	Hydrogen Sulfide (avg)	HSA	HSA	L	4	PPM	PPM
27	< SPARE 1 >	SPARE1	SPR1	F	4	----	----
28	< SPARE 2 >	SPARE2	SPR2	F	4	----	----
29	< SPARE 3 >	SPARE3	SPR3	F	4	----	----
30	< SPARE 4 >	SPARE4	SPR4	F	4	----	----
31	< SPARE 5 >	SPARE5	SPR5	F	4	---	----

7.4.16 RECORD # 19: CONFIGURATION

WITS Record ID 19	**Logical Record Type 169**	**Auto/Manual MANUAL**
Trigger [EVENT] Transmission is operator-initiated		
Data Source Manually-entered data. Record is sent when new data values are available		

Item	Description	Long Mnemonic	Short Mnemonic	Type	Length	Metric Units	FPS Units
1	Well Identifier	WELLID	WID	A	16	----	----
2	Sidetrack/Hole Sect No.	STKNUM	SKNO	S	2	----	----
3	Record Identifier	RECID	RID	S	2	----	----
4	Sequence Identifier	SEQID	SQID	L	4	----	----
5	Date	DATE	DATE	L	4	----	----
6	Time	TIME	TIME	L	4	----	----
7	Activity Code	ACTCOD	ACTC	S	2	----	----
8	Depth Hole (meas)	DEPTMEAS	DMEA	F	4	M	F
9	Depth Hole (vert)	DEPTVERT	DVER	F	4	M	F
10	No. Drill String Sections	DSNUM	DSNO	S	2	----	----
11	DS Section 1 OD	DS1OD	D1OD	F	4	MM	IN
12	DS Section 1 ID	DS1ID	D1ID	F	4	MM	IN
13	DS Section 1 Tool Joint ID	DS1JID	D1JI	F	4	MM	IN
14	DS Section 1 Tool Joint OD	DS1JOD	D1JO	F	4	MM	IN
15	DS Section 1 Mass/Length	DS1MASS	D1MA	F	4	KG/M	LB/F
16	DS Section 1 Length	DS1LEN	D1LE	F	4	M	F
17	DS Section 2 OD	DS2OD	D2OD	F	4	MM	IN
18	DS Section 2 ID	DS2ID	D2ID	F	4	MM	IN
19	DS Section 2 Tool Joint ID	DS2JID	D2JI	F	4	MM	IN
20	DS Section 2 Tool Joint OD	DS2JOD	D2JO	F	4	MM	IN
21	DS Section 2 Mass/Length	DS2MASS	D2MA	F	4	KG/M	LB/F
22	DS Section 2 Length	DS2LEN	D2LE	F	4	M	F
23	DS Section 3 OD	DS3OD	D3OD	F	4	MM	IN
24	DS Section 3 ID	DS3ID	D3ID	F	4	MM	IN
25	DS Section 3 Tool Joint ID	DS3JID	D3JI	F	4	MM	IN
26	DS Section 3 Tool Joint OD	DS3JOD	D3JO	F	4	MM	IN
27	DS Section 3 Mass/Length	DS3MASS	D3MA	F	4	KG/M	LB/F
28	DS Section 3 Length	DS3LEN	D3LE	F	4	M	F
29	DS Section 4 OD	DS4OD	D4OD	F	4	MM	IN
30	DS Section 4 ID	DS4ID	D4ID	F	4	MM	IN
31	DS Section 4 Tool Joint ID	DS4JID	D4JI	F	4	MM	IN

32	DS Section 4 Tool Joint OD	DS4JOD	D4JO	F	4	MM	IN
33	DS Section 4 Mass/Length	DS4MASS	D4MA	F	4	KG/M	LB/F
34	DS Section 4 Length	DS4LEN	D4LE	F	4	M	F
35	DS Section 5 OD	DS5OD	D5OD	F	4	MM	IN
36	DS Section 5 ID	DS5ID	D5ID	F	4	MM	IN
37	DS Section 5 Tool Joint ID	DS5JID	D5JI	F	4	MM	IN
38	DS Section 5 Tool Joint OD	DS5JOD	D5JO	F	4	MM	IN
39	DS Section 5 Mass/Length	DS5MASS	D5MA	F	4	KG/M	LB/F
40	DS Section 5 Length	DS5LEN	D5LE	F	4	M	F
41	DS Section 6 OD	DS6OD	D6OD	F	4	MM	IN
42	DS Section 6 ID	DS6ID	D6ID	F	4	MM	IN
43	DS Section 6 Tool Joint ID	DS6JID	D6JI	F	4	MM	IN
44	DS Section 6 Tool Joint OD	DS6JOD	D6JO	F	4	MM	IN
45	DS Section 6 Mass/Length	DS6MASS	D6MA	F	4	KG/M	LB/F
46	Kelly ID	KELLYID	KID	F	4	MM	IN
47	Kelly Length	KELLYLEN	KLEN	F	4	M	F
48	Drill Pipe Stand Length	DPSTDLEN	SLEN	F	4	M	F
49	No. Joints/Stand	DPSTDJNT	SJNT	S	2	----	----
50	No. Hole Sections	HOLENUM	HLNO	S	2	----	----
51	Hole Section 1 Diam	HL1DIAM	H1DI	F	4	MM	IN
52	Hole Section 1 Length	HL1LEN	H1LE	F	4	M	F
53	Hole Section 2 Diam	HL2DIAM	H2DI	F	4	MM	IN
54	Hole Section 2 Length	HL2LEN	H2LE	F	4	M	F
55	Hole Section 3 Diam	HL3DIAM	H3DI	F	4	MM	IN
56	Hole Section 3 Length	HL3LEN	H3LE	F	4	M	F
57	Hole Section 4 Diam	HL4DIAM	H4DI	F	4	MM	IN
58	Hole Section 4 Length	HL4LEN	H4LE	F	4	M	F
59	Hole Section 5 Diam	HL5DIAM	H5DI	F	4	MM	IN
60	Pump 1 Capacity	PUMP1CAP	P1CA	F	4	M3ST	B/ST
61	Pump 1 Efficiency	PUMP1EFF	P1EF	S	2	%	%
62	Pump 2 Capacity	PUMP2CAP	P2CA	F	4	M3ST	B/ST
63	Pump 2 Efficiency	PUMP2EFF	P2EF	S	2	%	%
64	Pump 3 Capacity	PUMP3CAP	P3CA	F	4	M3ST	B/ST
65	Pump 3 Efficiency	PUMP3EFF	P3EF	S	2	%	%
66	Rig Operating Cost/Hour	RIGCOST	RIGC	S	2	----	$
67	Trip Rate (Dist/Time)	TRIPRATE	TRRT	F	4	KPH	KF/H
68	Kill Line ID	KILLID	KLID	F	4	MM	IN
69	Kill Line Joint ID	KILLJID	KLJD	F	4	MM	IN
70	Kill Line Joint Fraction	KILLJF	KLJF	S	2	%	%
71	Kill Line Length	KILLLEN	KLLE	F	4	M	F
72	Choke Line ID	CHKID	CHID	F	4	MM	IN
73	Choke Line Joint ID	CHKJID	CHJD	F	4	MM	IN
74	Choke Line Joint Fraction	CHKJF	CHJF	S	2	%	%
75	Choke Line Length	CHKLEN	CHLE	F	4	M	F
76	Depth Casing Shoe (meas)	DEPTCSGM	DCGM	F	4	M	F
77	Depth Casing Shoe (vert)	DEPTCSGV	DCGV	F	4	M	F
78	Depth PIT (meas)	DEPTPITM	DPTM	F	4	M	F
79	Depth PIT (vert)	DEPTPITV	DPTV	F	4	M	F
80	Frac Pressure Grad at PIT	FPGPIT	FPIT	F	4	KGM3	PPG
81	Drilling Contractor	DRLGCONT	CONT	A	16	----	----
82	Rig Name	RIGNAME	RIG	A	16	----	----
83	Rig Type	RIGTYPE	RTYP	A	16	----	----
84	Vendor 1 Name/Service	VENDOR1	VEN1	A	32	----	----
85	Vendor 2 Name/Service	VENDOR2	VEN2	A	32	----	----

86	Vendor 3 Name/Service	VENDOR3	VEN3	A	32	----	----
87	Vendor 4 Name/Service	VENDOR4	VEN4	A	32	----	----
88	Vendor 5 Name/Service	VENDOR5	VEN5	A	32	----	----
89	Vendor 6 Name/Service	VENDOR6	VEN6	A	32	----	----
90	< SPARE 1 >	SPARE1	SPR1	F	4	----	----
91	< SPARE 2 >	SPARE2	SPR2	F	4	----	----
92	< SPARE 3 >	SPARE3	SPR3	F	4	----	----
93	< SPARE 4 >	SPARE4	SPR4	F	4	----	----
94	< SPARE 5 >	SPARE5	SPR5	F	4	---	----

7.4.17 RECORD # 20: MUD REPORT

WITS Record ID 20	**Logical Record Type 170**	**Auto/Manual MANUAL**
Trigger [EVENT] Transmission is operator-initiated		
Data Source Manually-entered data for each mud report. Record is sent when new data values are available		

Item	**Description**	**Long Mnemonic**	**Short Mnemonic**	**Type**	**Length**	**Metric Units**	**FPS Units**
1	Well Identifier	WELLID	WID	A	16	----	----
2	Sidetrack/Hole Sect No.	STKNUM	SKNO	S	2	----	----
3	Record Identifier	RECID	RID	S	2	----	----
4	Sequence Identifier	SEQID	SQID	L	4	----	----
5	Date	DATE	DATE	L	4	----	----
6	Time	TIME	TIME	L	4	----	----
7	Activity Code	ACTCOD	ACTC	S	2	----	----
8	Mud Rept Depth (meas)	MREPDM	MRDM	F	4	M	F
9	Mud Rept Depth (vert)	MREPDV	MRDV	F	4	M	F
10	Mud Rept Number	MREPNUM	MNUM	S	2	----	----
11	Mud Rept Mud Type	MRMTYPE	MTYP	A	16	----	----
12	Mud Rept Sample Location	MRSLOC	MLOC	A	8	----	----
13	Mud Rept Sample Date	MRSDATE	MDAT	L	4	----	----
14	Mud Rept Sample Time	MRSTIME	MTIM	L	4	----	----
15	Mud Rept Mud Density	MRDENS	MDEN	F	4	KGM3	PPG
16	Mud Rept Funnel Vis	MRFVIS	MFV	S	2	S/L	S/QT
17	Mud Rept Funnel Vis Temp	MRFVIST	MFVT	F	4	DEGC	DEGF
18	Mud Rept Plastic Vis	MRPV	MPV	F	4	CP	CP
19	Mud Rept Yield Point	MRYP	MYP	F	4	PA	PHSF
20	Mud Rept Gel - 10 sec	MRGEL10S	MGL1	F	4	PA	PHSF
21	Mud Rept Gel - 10 min	MRGEL10M	MGL2	F	4	PA	PHSF
22	Mud Rept Gel - 30 min	MRGEL30M	MGL3	F	4	PA	PHSF
23	Mud Rept Filtrate	MRFILT	MFIL	F	4	C/30	C/30
24	Mud Rept Filter Cake	MRCAKE	MCAK	S	2	MM	I/32
25	Mud Rept HTHP Temp	MRHT	MHT	F	4	DEGC	DEGF
26	Mud Rept HTHP Pressure	MRHP	MHP	F	4	KPA	PSI
27	Mud Rept HTHP Filtrate	MRHFILT	MHFI	F	4	C/30	C/30
28	Mud Rept HTHP Filter Cake	MRHCAKE	MHCK	S	2	MM	I/32
29	Mud Rept Solids % (retort)	MRSOLRET	MSOL	F	4	%	%
30	Mud Rept Water % (retort)	MRWATRET	MWAT	F	4	%	%
31	Mud Rept Oil % (retort)	MROILRET	MOIL	F	4	%	%
32	Mud Rept Sand %	MRSAND	MSAN	F	4	%	%
33	Mud Rept Low Grav Sol %	MRLGSOL	MLGS	F	4	%	%
34	Mud Rept Solids % (calc)	MRSOLCAL	MSCA	F	4	%	%
35	Mud Rept Barite content	MRBARITE	MBRT	F	4	%	%

36	Mud Rept LCM content	MRLCM	MLCM	F	4	KGM3	PPB
37	Mud Rept MBT capacity	MRMBT	MMBT	F	4	KGM3	PPB
38	Mud Rept pH	MRPH	MPH	F	4	----	----
39	Mud Rept pH sample temp	MRPHT	MPHT	F	4	DEGC	DEGF
40	Mud Rept Pm	MRPM	MPM	F	4	MLML	MLML
41	Mud Rept Pf	MRPF	MPF	F	4	MLML	MLML
42	Mud Rept Mf	MRMF	MMF	F	4	MLML	MLML
43	Mud Rept P1	MRP1	MRP1	F	4	MLML	MLML
44	Mud Rept P2	MRP2	MRP2	F	4	MLML	MLML
45	Mud Rept Chlorides	MRCHLOR	MCHL	F	4	MG/L	MG/L
46	Mud Rept Calcium	MRCALC	MCAL	F	4	MG/L	MG/L
47	Mud Rept Magnesium	MRMAG	MMAG	F	4	MG/L	MG/L
48	Mud Rept Potassium	MRPOT	MPOT	F	4	MG/L	MG/L
49	Mud Rept Rheometer temp	MRRHETEM	MRHT	F	4	DEGC	DEGF
50	Mud Rept Viscom 3 rpm	MRVIS3	M3	F	4	----	----
51	Mud Rept Viscom 6 rpm	MRVIS6	M6	F	4	----	----
52	Mud Rept Viscom 100 rpm	MRVIS100	M100	F	4	----	----
53	Mud Rept Viscom 200 rpm	MRVIS200	M200	F	4	----	----
54	Mud Rept Viscom 300 rpm	MRVIS300	M300	F	4	----	----
55	Mud Rept Viscom 600 rpm	MRVIS600	M600	F	4	----	----
56	Mud Rept Brine %	MRBRINE	MBRI	F	4	%	%
57	Mud Rept Alkalinity	MRALK	MALK	F	4	MLML	MLML
58	Mud Rept Lime content	MRLIME	MLIM	F	4	KGM3	PPB
59	Mud Rept Elect. Stability	MRELECST	MELS	F	4	V	V
60	Mud Rept CaCl, Wt %	MRCACL	MCCL	F	4	%	%
61	< SPARE 1 >	SPARE1	SPR1	F	4	----	----
62	< SPARE 2 >	SPARE2	SPR2	F	4	----	----
63	< SPARE 3 >	SPARE3	SPR3	F	4	----	----
64	< SPARE 4 >	SPARE4	SPR4	F	4	----	----
65	< SPARE 5 >	SPARE5	SPR5	F	4	---	----

7.4.18 RECORD # 21: BIT REPORT

WITS Record ID 21	Logical Record Type 171	Auto/Manual MANUAL
Trigger [EVENT] Transmission is operator-initiated		
Data Source Manually-entered data at the start and end of each bit run. Record is sent when new data values are available		

Item	Description	Long Mnemonic	Short Mnemonic	Type	Length	Metric Units	FPS Units
1	Well Identifier	WELLID	WID	A	16	----	----
2	Sidetrack/Hole Sect No.	STKNUM	SKNO	S	2	----	----
3	Record Identifier	RECID	RID	S	2	----	----
4	Sequence Identifier	SEQID	SQID	L	4	----	----
5	Date	DATE	DATE	L	4	----	----
6	Time	TIME	TIME	L	4	----	----
7	Activity Code	ACTCOD	ACTC	S	2	----	----
8	Bit Number	BTNUM	BNUM	A	8	----	----
9	Bit Diameter	BTDIAM	BDIA	F	4	MM	IN
10	Bit Manufacturer	BTMANUF	BMAN	A	16	----	----
11	Bit Name	BTNAME	BNAM	A	16	----	----
12	Bit IADC Code	BTCODE	BCOD	A	8	----	----
13	Bit Serial Number	BTSERNUM	BSER	A	16	----	----

14	Bit Cost	BTCOST	BCST	F	4	$	$
15	Bit Jet 1 Diameter	BTJET1	BJT1	F	4	MM	I/32
16	Bit Jet 2 Diameter	BTJET2	BJT2	F	4	MM	I/32
17	Bit Jet 3 Diameter	BTJET3	BJT3	F	4	MM	I/32
18	Bit Jet 4 Diameter	BTJET4	BJT4	F	4	MM	I/32
19	Bit Center Jet Diameter	BTJETCEN	BJTC	F	4	MM	I/32
20	Bit Total Flow Area	BTTFA	BTFA	F	4	MM2	SQIN
21	Bit Starting Depth (In)	BTDEPIN	BDPI	F	4	M	F
22	Bit Ending Depth (Out)	BTDEPOUT	BDPO	F	4	M	F
23	Bit Run Drilled Distance	BTDDIST	BDDI	F	4	M	F
24	Bit Run Drilled Time	BTDTIME	BDTI	F	4	HR	HR
25	Bit Run Reamed Time	BTRTIME	BRTI	F	4	HR	HR
26	Bit Penetration Rate (avg)	BTROPA	BRPA	F	4	M/HR	F/HR
27	Bit Weight-on-Bit (avg)	BTWOBA	BWBA	F	4	KDN	KLB
28	Bit Weight-on-Bit (max)	BTWOBX	BWBX	F	4	KDN	KLB
29	Bit Rotary Speed (avg)	BTRPMA	BRMA	S	2	RPM	RPM
30	Bit Rotary Speed (max)	BTRPMX	BRMX	S	2	RPM	RPM
31	Bit Mud Flow Rate (avg)	BTMFA	BMFA	F	4	L/M	GPM
32	Bit Mud Density (avg)	BTMDA	BMDA	F	4	KGM3	PPG
33	Bit Standpipe Pressure (avg)	BTSPPA	BSPA	F	4	KPA	PSI
34	Bit Reason Run	BTRUN	BRUN	A	16	----	----
35	Bit Reason Pulled	BTPULL	BPUL	A	16	----	----
36	Bit Grade In	BTGRDIN	BGI	A	16	----	----
37	Bit Grade Out	BTGRDOUT	BGO	A	16	----	----
38	Bit Shock Sub Used ?	BTSHKSUB	BSHK	A	1	----	----
39	Bit Mud Motor Used ?	BTMUDMOT	BMM	A	1	----	----
40	Bit Comments	BTCOMM	BCOM	A	128	----	----
41	< SPARE 1 >	SPARE1	SPR1	F	4	----	----
42	< SPARE 2 >	SPARE2	SPR2	F	4	----	----
43	< SPARE 3 >	SPARE3	SPR3	F	4	----	----
44	< SPARE 4 >	SPARE4	SPR4	F	4	----	----
45	< SPARE 5 >	SPARE5	SPR5	F	4	---	----
46	< SPARE 6 >	SPARE6	SPR6	F	4	----	----
47	< SPARE 7 >	SPARE7	SPR7	F	4	----	----
48	< SPARE 8 >	SPARE8	SPR8	F	4	----	----
49	< SPARE 9 >	SPARE9	SPR9	F	4	---	----

7.4.19 RECORD # 22: REMARKS

WITS Record ID 22	Logical Record Type 172	Auto/Manual MANUAL
Trigger [EVENT] Transmission is operator-initiated		
Data Source Manually-entered data		

Item	Description	Long Mnemonic	Short Mnemonic	Type	Length	Metric Units	FPS Units
1	Well Identifier	WELLID	WID	A	16	----	----
2	Sidetrack/Hole Sect No.	STKNUM	SKNO	S	2	----	----
3	Record Identifier	RECID	RID	S	2	----	----
4	Sequence Identifier	SEQID	SQID	L	4	----	----
5	Date	DATE	DATE	L	4	----	----
6	Time	TIME	TIME	L	4	----	----
7	Activity Code	ACTCOD	ACTC	S	2	----	----
8	Depth Hole (meas)	DEPTMEAS	DMEA	F	4	M	F

9	Depth Hole (vert)	DEPTVERT	DVER	F	4	M	F
10	Comments	COMM	COMM	A	256	----	----

7.4.20 RECORD # 23: WELL IDENTIFICATION

WITS Record ID 23	Logical Record Type 173	Auto/Manual MANUAL
Trigger [EVENT] Transmission is operator-initiated		
Data Source Manually-entered data. Record is sent when new data values are available		

Item	Description	Long Mnemonic	Short Mnemonic	Type	Length	Metric Units	FPS Units
1	Well Identifier	WELLID	WID	A	16	----	----
2	Sidetrack/Hole Sect No.	STKNUM	SKNO	S	2	----	----
3	Record Identifier	RECID	RID	S	2	----	----
4	Sequence Identifier	SEQID	SQID	L	4	----	----
5	Date	DATE	DATE	L	4	----	----
6	Time	TIME	TIME	L	4	----	----
7	Activity Code	ACTCOD	ACTC	S	2	----	----
8	Well Name	WELLNAME	WELL	A	32	----	----
9	Well Identification Number	WELLNUM	WNUM	A	16	----	----
10	Operator	OPERATOR	OPER	A	32	----	----
11	Well Classification (Lahee)	WELLCLAS	WCLS	A	16	----	----
12	Well Location	LOCATION	WLOC	A	32	----	----
13	Well Univ.Tran.Mercator	WELLUTM	WUTM	A	16	----	----
14	Well Surface Latitude	WELLLAT	WLAT	A	16	----	----
15	Well Surface Longitude	WELLLON	WLON	A	16	----	----
16	Field Name	FIELD	FLD	A	32	----	----
17	Elev : Datum-MSL	ELEVDP	ELDP	F	4	M	F
18	Elev : Kelly Bushing-MSL	ELEVKB	ELKB	F	4	M	F
19	Elev : Ground Level-MSL	ELEVGL	ELGL	F	4	M	F
20	Water Depth (mean)	WATDEPT	WDPM	F	4	M	F
21	Spud Date	SPUDDATE	SPDT	L	4	----	----
22	Custom Field 01 Identifier	CUS1	CUS1	A	32	----	----
23	Custom Field 02 Identifier	CUS2	CUS2	A	32	----	----
24	Custom Field 03 Identifier	CUS3	CUS3	A	32	----	----
25	Custom Field 04 Identifier	CUS4	CUS4	A	32	----	----
26	Custom Field 05 Identifier	CUS5	CUS5	A	32	----	----
27	Custom Field 06 Identifier	CUS6	CUS6	A	32	----	----
28	Custom Field 07 Identifier	CUS7	CUS7	A	32	----	----
29	Custom Field 08 Identifier	CUS8	CUS8	A	32	----	----
30	Custom Field 09 Identifier	CUS9	CUS9	A	32	----	----
31	Custom Field 10 Identifier	CUS0	CUS0	A	32	----	----
32	Units Type used	UNIT	UNIT	A	8	----	----
33	Time Zone Offset	TOFFSET	TOFF	L	4	----	----
34	< SPARE 1 >	SPARE1	SPR1	F	4	----	----
35	< SPARE 2 >	SPARE2	SPR2	F	4	----	----
36	< SPARE 3 >	SPARE3	SPR3	F	4	----	----
37	< SPARE 4 >	SPARE4	SPR4	F	4	----	----

7.5 Objects definition from collected data

A BIM object is a combination of many types of information. Within the AEC industry it can be used to define a product and geometry that represents that product's physical features.

Visualisation data give the object a recognisable appearance. Behavioural data, such as detection zones, allows the object to be positioned or to behave in the same way as the product itself.

There are two primary types of object: 'component' and 'layered'.

- The component objects are building products that have fixed geometrical shapes such as windows, doors, boilers etc;
- The layered objects are building products that do not have a fixed shape or size such as carpets, roofing, walls and ceilings.

Objects may also be said to be 'generic' or 'specific':

- Generic objects, often called library objects, are used during the initial design phase as placeholders as a visual expression of the need for a specific object to be selected at a later stage;
- Specific objects, often called manufacturer objects, are those objects that represent a manufacturer's specific products.

BIM objects can be made available in a range of file formats, suitable for use in software like Revit Architecture, Bentley AECOsim, Nemetscheck Vectorworks and Graphisoft ArchiCAD.

BIM objects can also be provided in open exchange, platform-neutral formats, like IFC. This is important as projects will be worked on by designers using multiple platforms, and will be analysed by contractors, quantity surveyors and facilities managers also using different platforms, making interoperability very important [6].

Data collected from the drilling process may help to build objects related to bores and wells which will be further used to install underground geo heat exchanger types (GHEX) systems. Visualization tools need also objects created in object modelling software under standards for borehole digitisation. Some subsurface modelling methodologies require subsurface geological data in the form of depths below ground level of points corresponding to the top and base of each geological unit that has been intersected during well/borehole drilling or trial pit excavation.

8 Use case definition

In order to align with the objectives of this deliverable and the GEOFIT project requirements, the definition of a use case for an IDM for drilling process will determine the specific scope of the business processes to be supported. The intention is then to capture information exchange needs from a drilling process in environments considered as retrofitting cases, with the specific challenges it imposes, but also procuring a flexible solution for similar drilling project scenarios.

The use case statement aligned with the GEOFIT project scope would be to develop an IDM that provides ***integration reference to a GEOBIM platform of the discrete processes undertaken within drilling processes for geothermal construction***.

For this specific development the following key aspects must be considered:

- As the main objective is to integrate drilling process data into the GEOBIM platform, the same conceptual principles will be applied, aiming at a comprehensive, integrated decision support platform on geothermal retrofitting projects, with multi-scale, multi-criteria analysis features for better planning.

- IDM must align with IDDS concepts, therefore specially focused towards **information** and **data** exchange.
- GEOBIM integration implies this information and data is also supported by Building Information Modelling solutions and BIM integrated Geographic information.
- The IDM solution shall support the business process of a drilling project in the cases where it adds value to the current process and to the overall GEOBIM platform objectives depicted above.
- The IDM shall consider the drilling process and identify very clearly the starting and ending events. All processes included to describe the drilling process sequence shall contribute to meet the workflow objectives.
- The process shall also prioritize stakeholders or actors directly involved with drilling specific activities or assume major responsibility of the drilling risks.
- Drilling processes to be supported shall also consider the specific challenges of retrofitting scenarios in which information, data and characterization of existing site conditions are relevant.

With these considerations in place, the next steps will be to describe the business process to support using a process map diagram approach.

The use cases will be studied in detail in the different demo sites as follows:

8.1 Sant Cugat

Vertical drilling (13+9 borehole 120m deep) + Horizontal Directional Drilling (HDD)

The drilling site is a ground soccer field situated below the school level, near the creek.

8.2 Bordeaux

Basket HEX (excavation) has been proposed

8.3 Perugia

Slinky HEX (excavation) has been proposed

8.4 Galway

Vertical drilling has been proposed

8.5 Aran

Vertical drilling has been proposed

9 Process map

As part of the established IDM development methodology the process map is a crucial step in understanding the information exchange needs of the business process to be supported. In this case, the process of a drilling project for geothermal retrofitting projects with the added requirements of establishing a GEOBIM support platform for enhancing the information exchange needed to complete de specific tasks of the complete geothermal system.

The purpose of the process map is to understand the business process through these key aspects:

- **Tasks** or activities performed in order to complete the process;

- Task **sequence** and priorities;
- **Actors**/Stakeholders involved in the process;
- **Information** that is exchanged between actors for completing tasks or produced at the completion of those tasks.

As mentioned before, it is important to identify the start and the end of the process, the events or milestones and the decisions.

Due to the complexity of drilling processes, the suggested approach is to develop two levels of process definition. The first level will consider the high-level process to correctly identify the scope of the process, actors and sequence. Then a more discrete approach will be used for detailing the specific data exchanges that will be compiled as an information requirements table. These two levels are described next:

LEVEL 1 General Process Definition

Process Name: Geothermal Drilling Project

Actors

- **Project Manager** (Specific to the drilling project)
- **Rig and Well Design / Civil engineer and/or geologist** (Internal expert)
- **Drilling Contractor** (Contractor)
- **Other Contractors** (Contractors involved in installing heat collectors) Generic civil works will be included here.
- **Information Model** (As a common IDM practice, the data model will be represented as an actor with its own LANE in the process diagram, this way all data objects (Information inputs/outputs) that usually sit within the lane of the originator (other actors) will be all stored in the integrated data model for all actors to access.

Tasks

Tasks can only be assigned to one actor:

- Target Site selection for Well
- Rig and Well Design
- Site Access Design (Civil Works)
- Drilling Tender
- Civil Works Tender
- Site Access Execution
- Drill Pad Execution
- Drilling and Well Execution
- Other works
- Well Handover (Contractor signoff)
- Operations Handover

Information

As information is required for completing specific tasks, it is first advised to determine the appropriate actor and task list in order to determine information requirements needed to complete those tasks.

- Design Requirements Document
- Existing Site Information/Existing Conditions
- Reg and Well Design
- Civil/Site Design
- Site Work Progress/Monitoring
- Drilling Progress/Ground Monitoring
- As-Built Project and Handover Documentation

Level 1 Process Map:

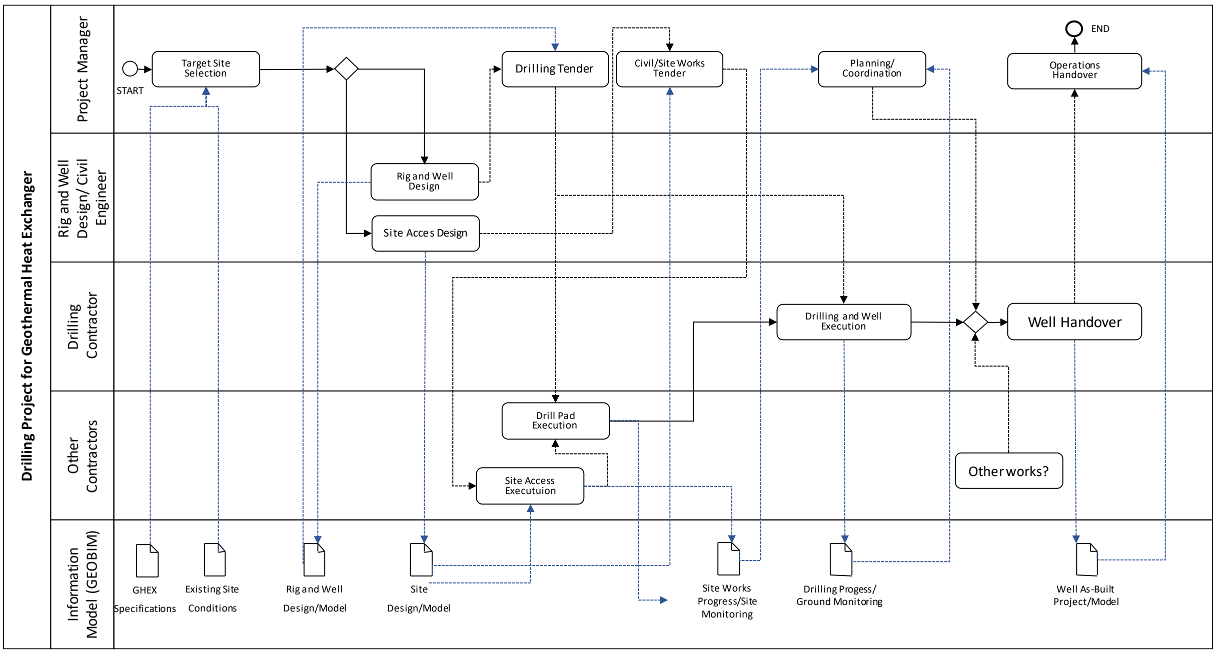

Figure 7. Process map for GEOFIT drilling in a level 1 of detail. Source: own elaboration based on the current data available

LEVEL 2 Detailed Process Definition

The following tables are used to define the specifications for each element within the process map. The considered elements will be the following. These four elements are further developed in chapter 10:

- Process Overview
- Processes and Tasks Specifications
- Data Objects Specifications
- Information Requirements Specifications

10 Information Exchange Requirements

In the BIM context, information exchange requirements (IER) are defined as a set of information units that needs to be exchanged to support a particular business requirement at a particular process phase (or phases)/stage (or stages). The specifications of IER are contained in EN ISO 29481-1:2016, previously described in section 4.4.

IDM forms the first part of a complete framework that meets the information definition and exchange requirements of both users and software solution providers. This also includes a technology element that allows for configuration according to purpose, time and location.

Each exchange requirement has a name that consists of three parts:

- The first part is the prefix "er" which identifies that this component is an exchange requirement;
- The second part of the name is an action (or activity) required and is expressed as a verb. All exchange requirements have the action "exchange" thus, the first part of the name of an exchange requirement will always be "er_exchange_";
- The third part of the name is the subject of the exchange requirement and is expressed as a noun or noun phrase e.g.: "space_model";
    - Exchange requirements may have parameters that enable further qualification. Parameters are expressed as a list within parentheses ( ) or [ ] or { };
    - Parameters for exchange requirements typically restrict the exchange requirement by project stage and/or actor role e.g. er_exchange_space_model (outline).

Header

Name	Model, Drilling Project for Geothermal Heat Exchangers (GHEX)

Identifier	GEOFIT_IDM_001

Change Log		
08/02/2019	Created	svelasquez@idp.es

Exchange Requirements	er_exchange_drilling_process_model (design)
	er_exchange_drilling_process_model (execution monitoring)
	er_exchange_drilling_process_model (commisionning)

10.1 Overview

Processes and Task Specification

Type	Task
Name	Target Site Selection
ID	1
Documentation	Starting point of the Drilling Project, site selection comes from determining the need for a GHEX to be implemented in a specific site. This step sets will require information about the pre-selected site to be collected and processed for validating the drilling location and other aspects of the drilling design. Information of the site will be documented under the following aspects: -Site surface conditions -Site underground conditions Early information about the GHEX system requirements will help to determine the scope of the existing conditions survey. Administrative procedures and permits will also aid the overall assessment. The objective is to validate the selection of the drilling sites, based on a set of initial

	hypotheses, to engage the well design and to establish baseline information for the site, rig and well projects.

Type	Task
Name	Rig and Well Design
ID	2
Documentation	Development of the Rig and Well for the construction of the project boreholes. The design will comply with the GHEX system specification as well as the technical advice from the project designer taking into consideration the necessary conditions and hypothesis. The main objective is to validate an executive design of the drilling project. It shall determine in general terms the following aspects: - Drilling technology, means and methods - Borehole specifications and distribution/configuration - Backfilling methods - Specifications of the drilling equipment - Drilling planning and resources - Site requirements and utilities - Site utilization - Third party repercussions

Type	Task
Name	Site Accessibility Design
ID	3
Documentation	Site requirements for accessibility, utilization and utilities will be defined by the well and rig project and treated as a civil works site project depending on the works necessary to fulfil site preparation requirements for the drilling operation. It will be differentiated from the well and rig design in that the design elements will be predominantly common civil works or buildings elements that are already present in the IFC schema definitions and BIM solutions. It is therefore intended to test the capability of the drilling specific requirements to comply with information requirements for a site or civil works project.

Type	Task
Name	Site and Drill Pad Execution
ID	4
Documentation	Preparation of the site and execution drill pad according to the site design project. This process may also consider maintenance and monitoring the site maintenance and utilization. The same as with the Site Design phase, this process can be considered as a common civil works or building construction project in which the information workflows can be found to be supported by several software solutions with resolved integration requirements. The importance of this process in the drilling operation lies in that is will be considered as a task predecessor. This process is also intended to include site monitoring and recording during the construction phase right until commissioning for delivering the as-built site project.

Type	Task

Name	Drilling and Well Execution
ID	5
Documentation	This is the main objective of the drilling process since it covers the execution of the boreholes intended for the specified GHEX system and the Well design project. Drilling operations and all related services to such operations. Drilling operations will take into account all specifications from the design project such as: -Borehole depth and diameter -Backfilling materials -Borehole location, inter-distance and field configuration In addition to complying with design and specification requirements, one of the most important aspects of the drilling operations will be monitoring and recording logs to ensure site safety, risk control and optimal execution. This will include specific services such as: - Well logging - Geological logging - Mud engineering - Mud logging - Directional drilling - Running casing - Cementing With these operations in place the novelty information requirements for integrated design and delivery solutions of drilling processes will be assessed.

Type	Task
Name	GHEX Execution, Connection and Commissioning
ID	6
Documentation	This task is considered as the end event for the drilling processes. It starts with the works of executing, connecting and commissioning the GHEX system in a borehole or group of boreholes once the drilling process has resumed. The GHEX execution itself can consider several aspects from the GHEX implementation and commissioning data but in the framework of the drilling process data requirements the focus might shift to those information points that can be inherited from the finished drilling operations that will serve to validate the overall fitness of the executed well for the GHEX implementation and also information that might continue down the GHEX commissioning chain.

10.2Data objects Specification

Type	Data Object
Name	GHEX Design Specifications
Documentation	A collection of design requirements determined for the GHEX system. This will serve as a basis of design for the well design process in order to validate the hypothesis that meet design specifications. The implications of the well design and drilling operations will depend on the specifications given on the ground loop system. At this stage several options could be considered until the site, underground surveying and design processes are completed.

Type	Data Object
Name	Administrative Procedures
Documentation	Any documentation or requirements in order to get the necessary work permits for executing each of the components of the GHEX system.

10.3Exchange Requirements Specification

Type	Exchange Requirement
Name	er_exhange_existing_surface_conditions
Documentation	Model of the existing site conditions on surface derived from a site survey or other methods for surface data capture. This model can be considered as a three-dimensional topography model generated in practice by the surveying services company and given to the final user in several exchange formats. The information and model elements must include: Survey Points - These are the basis of the topographical survey and it is used to generate other 3D and 2D topographical characterizations. Survey point usually include naming, description and numbering to classify then into survey elements such as roads, utilities, buildings and vegetation. Break lines - As with the survey points, the break lines are used to join together survey points from a same group or element characterization to represent boundaries or limits such as differences in paving, building perimeters and sidewalk limits. these lines can be either 2D or 3D depending on the desired outcome. Ground Surface - It is a representation of the continues mesh of an existing ground surface that is generated from the affectation of survey points and break lines. Depending on the desired outcome, the representation of this mesh can be 2D or 3D contour lines, faceted 3D surfaces or 3D meshes.

Type	Exchange Requirement
Name	er_exhange_existing_underground_conditions
Documentation	The underground conditions model is a characterization of the relevant entities that exists below the surface that might impact the design of the ground loop of a GHEX system and its execution. In terms of well design and drilling operations there are two main aspects that need to capture: Underground survey for utilities and grids: Similar to the surface model, this model is used to characterize the existing utilities lines and grids that sit below the ground surface. These elements will be presented as 2D or 3D lines and even surfaces and meshes. Geological profiling: Several geological profiles are put together to represent the configuration of the underground terrain layers and their mechanical behaviour. This model can be represented as 3D subsurface representing the boundaries for each material layer, along with information to describe the mechanical behaviour. This information will be decisive in the design of the ground loop, drilling technologies and backfilling methods.

Type	Exchange Requirement
Name	er_exhange_well_rig
Documentation	This will be the model of the well and rig projects as required by the GHEX systems specifications and the designer's recommendations. The model captures the outcome of the design at the final stage of execution and all the required works to achieve this. This model will be the outcome of the design process for the well and rig and part of the design deliverables for tender or service procurement for the project's execution. The main aspects to be included in the project shall include: Borehole type Borehole depth Borehole diameter Backfilling materials Borehole spacing Borehole position (Coordinates and depth) Borehole field configuration Drilling works: Drilling method or technology Drilling equipment, size and weight Drilling platform

Type	Exchange Requirement
Name	er_exhange_site_design
Documentation	This will be the model of the site for implementing the GHEX system, and for the drilling works to take place. Although it might be a part of the well design, the elements designed as part of the site may be temporary measures for ensuring site access and optimal performance during the drilling process and related works. This project may also consider the site conditions that need to be restored after the drilling process is finished. The main aspects to be covered in the project shall include: Site access design Auxiliary roads or pathways Utilities needed , supply and connection Site area for rig, including protection measures Storage areas for provisions or piling material Surface connections

Type	Exchange Requirement
Name	er_exhange_site_monitoring
Documentation	This exchange model will be used to capture changes of site configuration and monitoring progress of the site works thorough the project phases. The main objective is to track continuous progress and design changes for record modelling and operations handover.

Type	Exchange Requirement
Name	er_exhange_drilling_monitoring
Documentation	

	This exchange model will be used to capture the relevant drilling records. As and exchange model, the information aspects will focus on those that serve for site works coordination gateways, safety and risk monitoring and eventually in the commissioning of the well for GHEX connection works and testing. Some of the works related to drilling entail record keeping or logging as exposed in the well execution process. This model exchange will be the outcome of such data records: - Well logging - Geological logging - Mud engineering - Mud logging - Directional drilling - Running casing - Cementing The finished drilling record model along with the site record model will be used for delivering the project record for the commissioning process.

Type	Exchange Requirement
Name	er_exhange_AsBuilt
Documentation	The record model or as built model is a combination of both site and well record models that come together for a coordination gateway for well commissioning. This process will consider the well to be handed over for GHEX systems connections and testing, when the drilling works have finalized, and the drilling contractor gets the release.

Conclusion

IDM exchange requirements have been defined as applicable to the GEOFIT project needs at the particular stage in the drilling processes. Exchange requirements have been developed by different parties that will perform their activities in different places and at different points in time. This IDM approach needs to be validated with the aim of enforcing consistency during the execution of the drilling stages in the GEOFIT project. Without such consistency, it is not possible to bring exchange requirements together within an overall information framework. Effectively, lack of consistency in stage naming leads to a 'free for all' in which everyone can name project stages their own way. This is largely the case for older plans of work and conditions of engagement within the construction industry worldwide for example. However, to allow this within a digital information environment would lead to chaos.

The standard exchange requirements published in this drilling IDM are identified against project stages defined within the Generic Process Protocol (GPP) applied to drilling processes considered as sub-project. When integrated in the GEOBIM model, drilling information exchange provides an added value layer useful for maintenance and other geothermal system lifecycle control.

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