IADC **D**aily **D**rilling **R**eport

Background

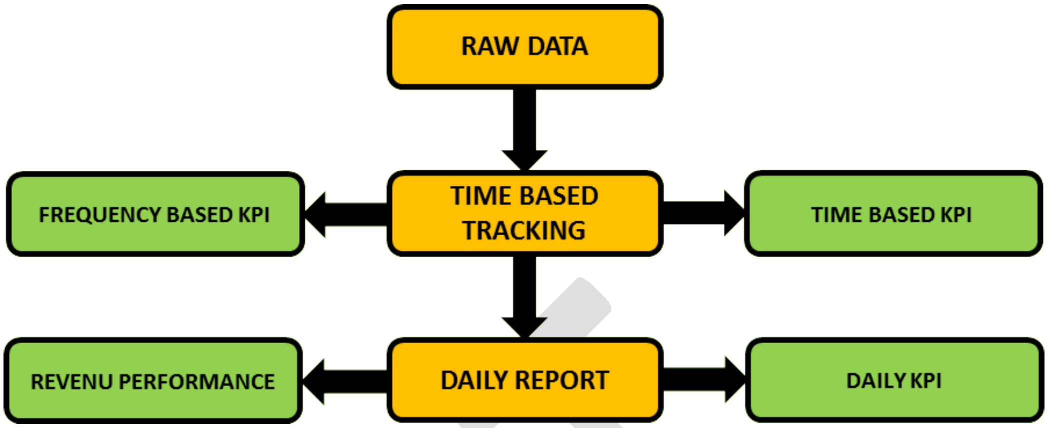
The IADC Daily Drilling Report (DDR) has been the standard in reporting activities on drilling rigs around the world for decades. Available both in paper form directly from IADC or licensed electronic formats (available through numerous commercial parties), the IADC DDR is the standard for reporting drilling performance. The IADC DDR functions in the majority of the drilling contracts as the legal standard for reporting performance, and consequently for any financial decisions.

However, there are numerous developments that necessitate a rethinking of the function, form and usage of the IADC DDR. An increased number of drilling KPI (Key Performance Indicators) are being used to assess the drilling performance often with short time intervals. The recent advantages in measuring, processing and presenting sensor data present exciting possibilities to optimize and control the drilling process.

The IADC executive committee tasked the ART (Advanced Rig Technology) group to upgrade the IADC DDR to reflect the current state of technology. Within the ART group the DCS (Drilling Control Systems) committee is acting as a lead for this project.

The first question that needs to be answered: what is the final purpose of the IADC DDR? Is the DDR the final document that acts as proof for any financial obligations, tracking performance to improve efficiency, logging drilling data, logging equipment use, a combination of all, etc. Each purpose requires specific fields, logging frequency and accuracy that might be interchangeable but often only in one direction. To gain more insight in the use of the DDR a market survey is being conducted which hopefully will provide more insight in the current and future use.

Since the IADC DDR has to fulfill multiple purposes it should be possible to transition from the format of one purpose (efficiency tracking) to another purpose format (financial obligations) in a standardized manner.



Daily Drilling Report based on Sensor Data

Based on the definition of the final purpose the optimal format can be chosen, including what fields need to be part of the IADC DDR.

Since the IADC DDR is used worldwide and has decades of usage, backward compatibility will be an important feature. This will ensure a seamless transition from the old to the new format, limiting the necessary changes in client systems.

Role of IADC

By its very nature the IADC is an impartial body, representing the entire drilling industry. As such it is well suited to maintain and verify a minimum standard for reporting performance. Especially when it comes to performance linked to revenue/cost a validated method is essential.

The minimum standards can be divided into three sections:

1. **Base sensor data standards**
   a. Manually filled in reports
   b. Automatically filled in reports

2. **Drilling report fields and transitional calculations**
   a. Manually filled in reports
   b. Automatically filled in reports

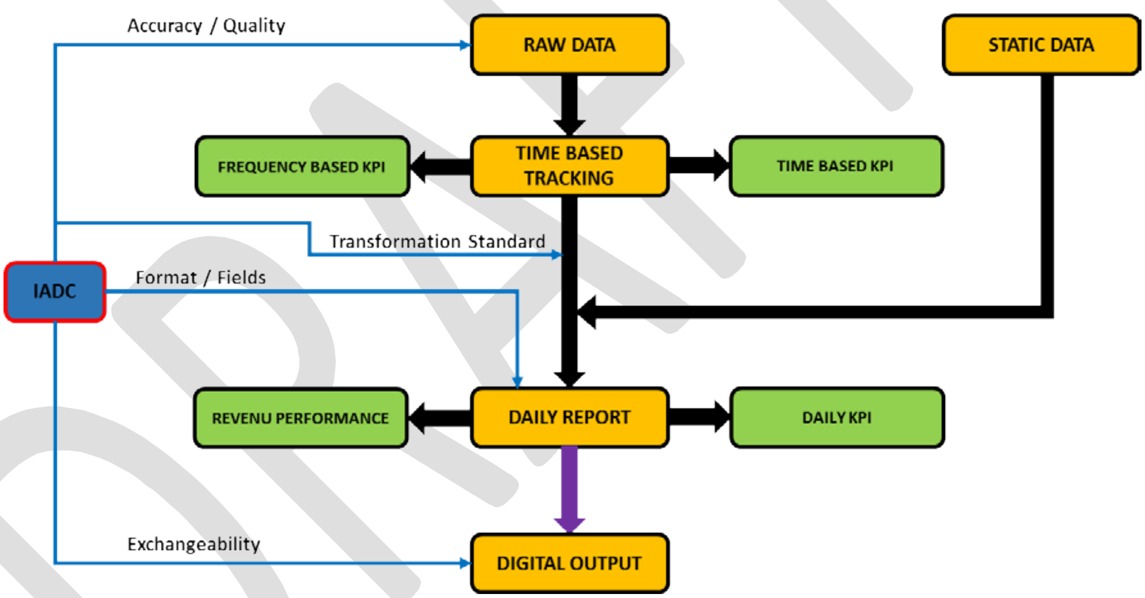
3. **Static Data (such as well name, location, etc)**
   a. Manually filled in reports
   b. Automatically filled in reports

Base Sensor Data Standards concerns mainly the automatically filled in reports, although certain standards on the sensors can be determined even in the manual case.

For the automatically filled in reports the standards could describe the following:

- Sensor location (preferred)
- Recalibration period
- Accuracy of the sensor (digits), preferred range of the sensor
- Significant digits to be maintained when sending data across networks
- Sensor sample frequency
- Calculation method to transform measured data into daily data
- Data formats

There are many systems on the market nowadays that can track sensor data and/or generic drilling data. Many programs exist that present drilling data. It would be very cumbersome to mandate/specify exactly how data is transferred and presented. Focusing on the quality of the data is a more efficient way.



However, IADC can mandate the format (or sequence/schema) once the data is in the daily drilling format. That will ensure that IADC DDR data can be freely exchanged from one party to another. It also opens the door for 3rd parties to present the data on a number of devices such as tablets, phones, etc.

So, in short, the IADC could play a steering role in 4 different areas:

- Accuracy / Quality of measured data
- Transformation Standards to go from time based to daily data
- Format / Fields of the Report
- Digital IADC DDR format (schema or otherwise)

Rig States

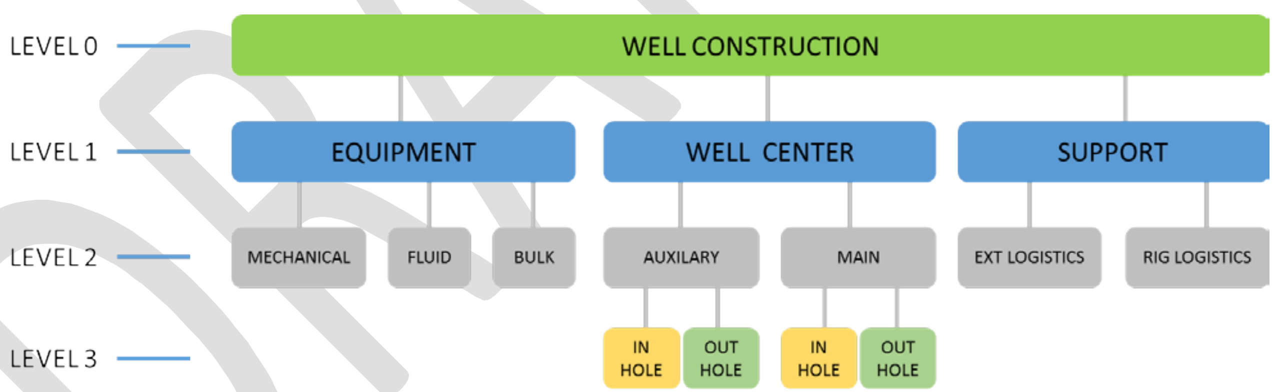
Currently the IADC DDR recognizes 23 different rig states not counting the "downtime" state. One of the activities that could be looked at is to identify the minimum sensors needed to be able to ascertain a state. A state diagram could to be developed to map those sensors to states or vice versa. It must be noted that in some instances it might not even be possible to uniquely map states to sensors.

Also, the question must be asked if all states must be kept – or different states must be introduced such as drilling with MPD, fracking, etc.

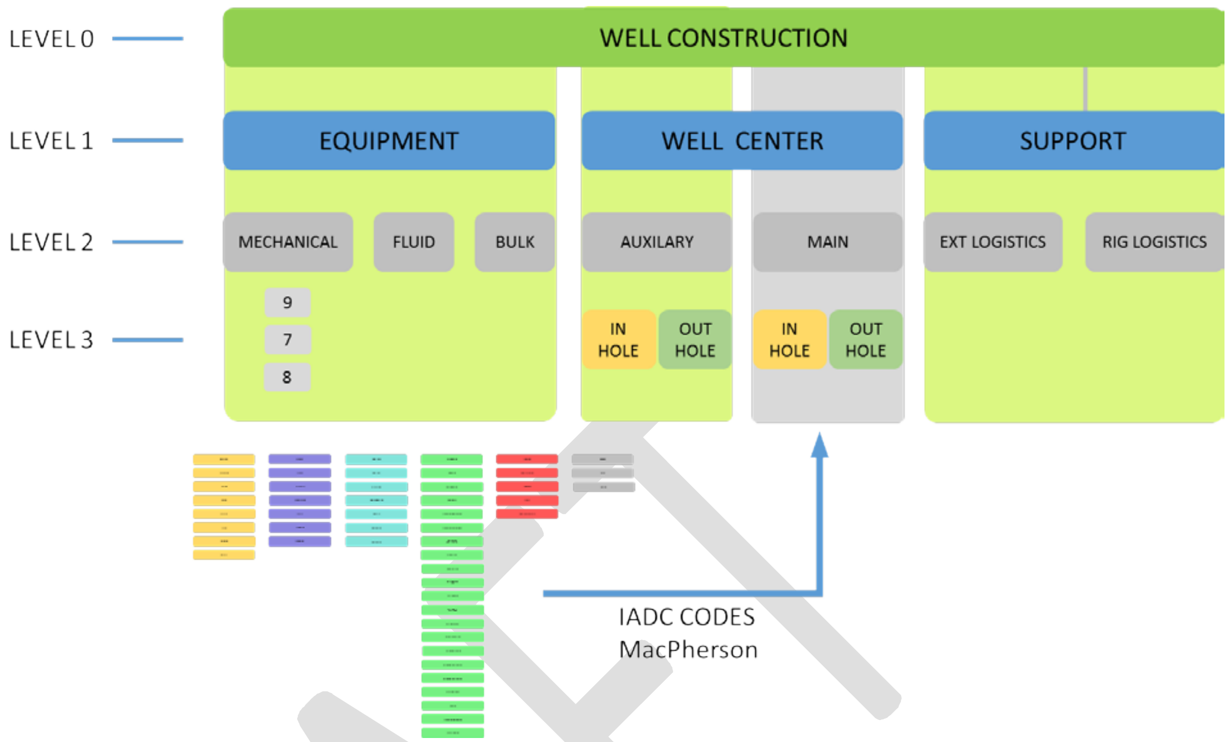
The time spent on well construction can be (arbitrarily) divided up into three main sections:

1. Equipment activities (maintenance, etc)
2. Well center (drilling activities, pipe handling, etc)
3. Support (logistics, etc)

All well center related activities can be divided up in activities using the main well center and activities using the auxiliary well center (parallel activities). A further subdivision can be made into activities related to the well bore (drilling, etc) and outside the well bore (standbuilding, etc)

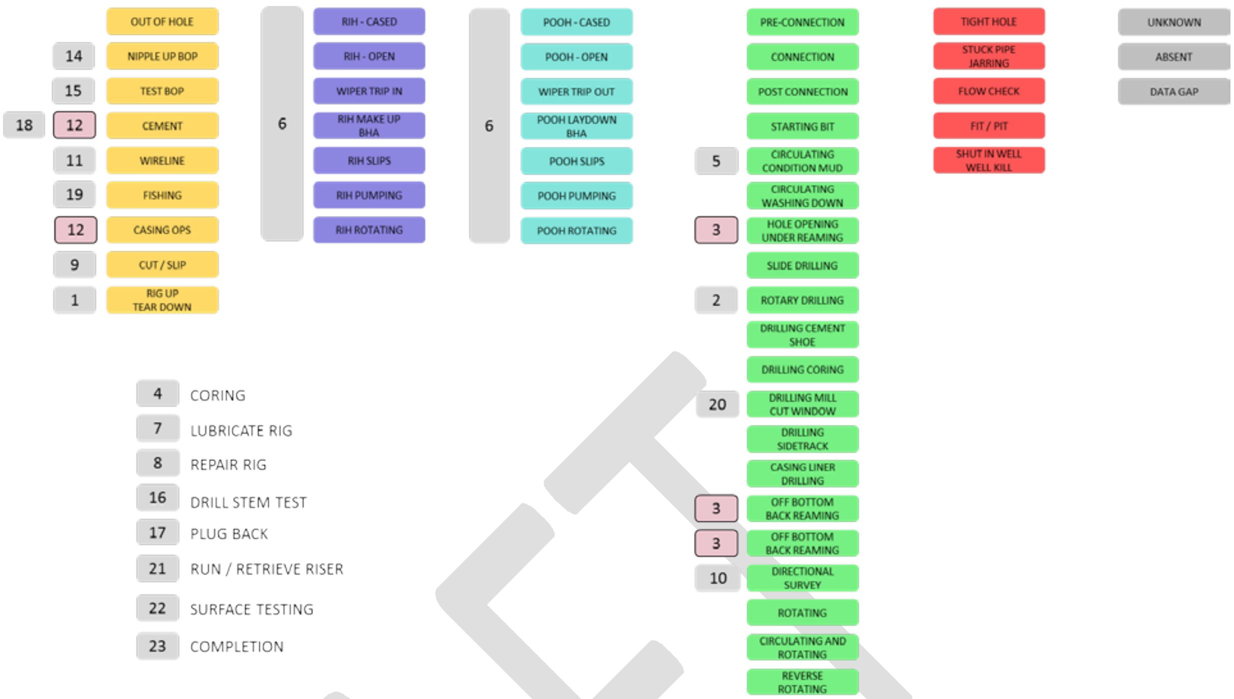


If we plot the IADC codes on this sectional view it becomes clear that a large portion of activities related to well bore construction are not captured with the IADC codes.



One of the reasons for this is that the IADC codes only related to activities that actively progress the well bore. Dual activity, preventive maintenance, loading/unloading, etc are not covered. As such the current IADC codes are not suited to track the total cost of the well construction, nor tracking of “invisible” lost time.

Zooming in on the codes themselves and using the work of MacPherson it seems that the 23 original IADC codes do not provide a very detailed level of detail in tracking the drilling operation.



The grey boxes are the IADC codes (23). The colored boxes the MacPherson codes (51). A lot of companies added their own sub-codes to the main codes to ensure the required granularity.

Code Description / Uniqueness
Regardless of the number of codes used, every code must be unique. Otherwise there can multiple activities with the same code, or multiple codes for the same activity. Any attempt to automate activity detection needs a unique set of conditions to work properly.

To provide an example:

Circulating / Condition Mud: "**off bottom circulation** event, possibly **with rotation**, circulating mud until measurements indicate mud is **in condition**"

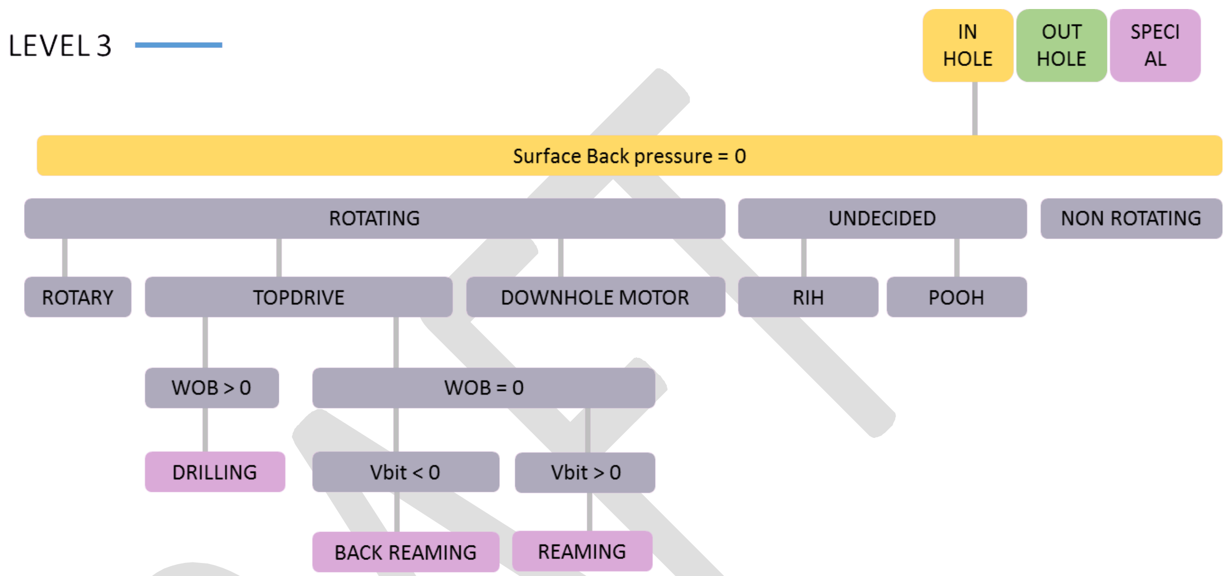
Compared to

Circulating and Rotating: "**Rotating** and **Circulating** through the drill string with the bit **off bottom**"

Based on the description there is no difference between the two states. The only difference is the quality of the mud. Therefore, to automate the detection between these two states thus requires a measurement of the condition of the mud.

Or in simple mathematical terms; if a "truth" table is used to determine states this table must be in the nxn form and have a determinant that is non-zero. If this determinant is zero, then the system has either no nontrivial solutions or an infinite number of solutions. (n being the number of states).

Presenting the states can be done via a decision tree. While visually easy to understand it becomes fairly complicated when multiple states need to be presented.



Presentation in the form of a matrix is more efficient. The below table is an excerpt from the work of MacPherson. In this case there are four different binary codes (01,10,11,00) for each parameter. Combining the codes leads to a unique number for each state. It can be seen that there are a number of activities that have the same code. For these activities, additional measurements need to be added or more than the four different codes per state/sensor.

STATE	OFF-BOTTOM	BIT VELOCITY	BIT ROT	SURF ROT	CIRC	IN SLIPS	BIN CODE	DEC CODE
DRILLING OPERATION STATES								
PRE-CONNECTION	10	11	00	00	00	01	101100000001	1038
CONNECTION	10	01	01	01	01	10	100101010110	2390
POST-CONNECTION	10	10	00	00	00	01	101000000001	1034
STARTING BIT	01	10	10	00	10	01	011010001001	1577
CIRCULATING/CONDITION MUD	10	00	00	01	10	01	100000011001	1602
CIRCULATING/WASHING DOWN	10	10	00	01	10	01	101000011001	1610
HOLE OPENING/UNDER REAMING	01	10	10	00	10	01	011010001001	1577
SLIDE DRILLING	01	10	10	01	10	01	011010011001	1641
ROTARY DRILLING	01	10	10	10	10	01	011010101001	1705
DRILLING CEMENT/SHOE	01	10	10	10	10	01	011010101001	1705
DRILLING CORING	01	10	10	10	10	01	011010101001	1705
DRILLING MILL/CUT WINDOW	01	10	10	10	10	01	011010101001	1705
DRILLING SIDETRACK OPS	01	10	10	10	10	01	011010101001	1705
CASING/LINER DRILLING	01	10	10	00	10	01	011010001001	1577
OFF BOTTOM REAMING	10	10	10	10	10	01	101010101001	1706
OFF BOTTOM BACK REAMING	10	11	10	10	10	01	101110101001	1710
DIRECTIONAL SURVEY	10	01	01	01	00	00	100101010000	86
ROTATING	10	01	10	10	00	01	100110100001	1190
CIRCULATING AND ROTATING	10	01	10	10	10	01	100110101001	1702
REVERSE ROTATION	10	00	11	10	00	01	100011100001	1202

The table uses 6 different measurements:

1.	Off Bottom	yes/no
2.	Bit Velocity	up/down
3.	Bit Rotation	positive, negative, no
4.	Surface Rotation	positive, negative, no
5.	Circulation	yes/no
6.	In Slips	yes/no

The proposal is to add the following measurements:

7.	Surface Pressure	analogue value
8.	Bit Location	analogue value
9.	Pump Pressure	analogue value
10.	Bit orientation	angle
11.	Mud Weight	analogue value

Based on the final number of states more measurements could be added.

Work ahead

There are several distinct areas where there is a need for more discussion and development.

1. Development of generic states in the equipment column and support column. How many different machines need to be included and which logistical operations need to be tracked? Since most drilling rigs do not have full sensor integration that includes equipment used for these operations/equipment, development of a "truth" table is not a priority. However, with more and more sensors on the rig this opens up an exciting new area for development and improvement of automated rig operations.

2. Development of a set of drilling states which clear and unique descriptions for each state.

3. Development of a "truth" table with a set of corresponding minimum number of sensors.

Several moderated workshops could be held to tackle each area.

It must be noted that task #2 and #3 are focused on providing <u>exact</u> and <u>clear</u> definitions for a state. How data is measured and processed is left up to the industry. If the states are not precisely defined there will be room for individual parties to come up with their own definitions which defies the purpose of a common industry standard that provides interchangeable data. With exact and clear definitions, it will be easier for IADC to check and approve products for conformance to the standard.