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# Well Lifecycle: Workflow Automation

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## 1. Introduction

Digital transformation changes business and operational models through the exploitation of new trends in technology and data including workflow automation, data analytics, visualization, and the cloud infrastructure.

In the case of workflow automation, specifically, it enables organizations to streamline traditional manual and paper-based processes by integrating diverse systems, automating data movement, improving data quality, and standardizing notification requirements. The many benefits include: companies make better, lower-risk decisions, are more responsive, more cost-efficient, more compliant, and overall are higher performing.

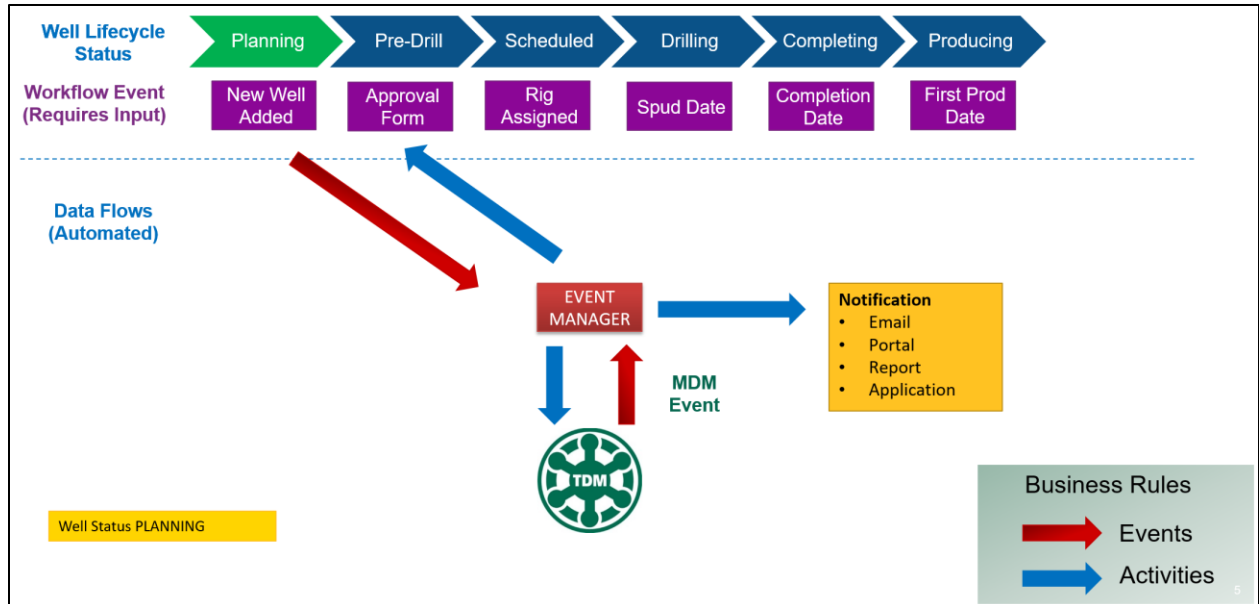
The oil and gas industry has made significant investments in the digitization of key engineering and operational areas including drilling, completion, and production, as well as around asset management. However, it still trails other industries in terms of the implementation of widespread integrated digital technology to drive workflow automation.

With the recent volatility in the industry resulting in significantly lower commodity prices and a reduction in workforce, it has become even more important for companies to become more efficient across their Well Lifecycle operations. Workflow automation is a key success factor to achieving increased efficiency. The oil and gas companies that do survive and grow will be those that most quickly learn and apply the digital transformation lessons from other sectors.

This Position Paper will explore the key components of workflow automation from a conceptual perspective as they apply to upstream oil and gas. Understanding Master Data Management (MDM) and how it fits into your data management strategy is foundational to deliver on the benefits of this type of automation. As such, this position paper includes a high-level overview of MDM and how it supports workflow activities.

## 2. Concepts and Definitions

The rest of this position paper discusses the concepts and definitions associated with workflow automation from the perspective of upstream oil and gas data management. The main components that will be discussed are workflows, business rules, events, and activities, along with the Master Data Management (MDM) functionality that ties everything together. These components are illustrated in **Figure 1.1**.



**Figure 1.1: Upstream Oil and Gas Workflow Automation Concepts**

Workflows are comprised of processes and tasks that combine to advance a Well through the different phases of the Well lifecycle. These processes and tasks are typically performed and recorded within a set of independent applications that are the responsibility of different groups across an organization. The information within these application data stores is typically not aligned in terms of structure, identification, and content definition. The individual processes and recorded information must be integrated between these applications to establish a consistent and streamlined workflow across the lifecycle.

During the execution of tasks, key workflow events are recorded such as acquiring an AFE, filing a permit, spudding a well or adding first production (plus many smaller tasks). These events then trigger a sequence of automated activities such as the synchronization of data with a corporate master store, email notification, or the generation of reports for distribution. Upon completion of these activities, the status of the Well within the Workflow remains static until the next event occurs. These events and activities are defined within Business Rules.

One of the key concepts that will be referred to in this position paper is the difference between 'above the line' events and 'below the line' activities. Above the line, nothing happens from a workflow perspective until a key event occurs through the manual entry of data or input from an external source. Below the line, all activities triggered by a workflow event including data movement, processing and notification are fully automated and continue to completion at which point control moves back above the line waiting for the next workflow event to be recorded.

The foundation of workflow automation is Master Data Management. This is the definition and application of Business Rules applied to a set of lifecycle critical attributes established through data governance. It is not practical to track changes to all of the thousands of attributes involved in typical Well Lifecycle processes and so it is necessary to identify those

key features that trigger additional activity and need to be synchronized across all relevant applications.

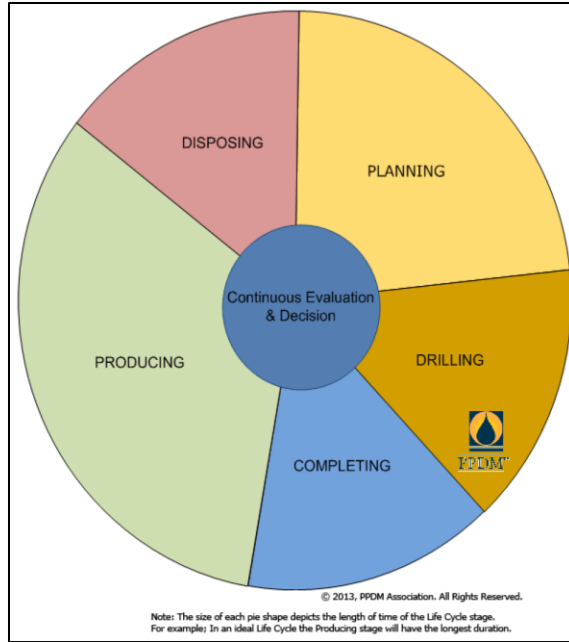
### 3. Workflow

A workflow is a sequence of tasks that complete a business process.

Within the Well Lifecycle, workflows are aligned with phases of the Well Lifecycle and comprise a number of business processes and sub-processes that advance the status of the well in an ordered fashion. Within each business process, there are a series of tasks that must be executed in a sequential order to complete the work. Typically, the completion of tasks will generate events that, in turn, trigger automated activities.

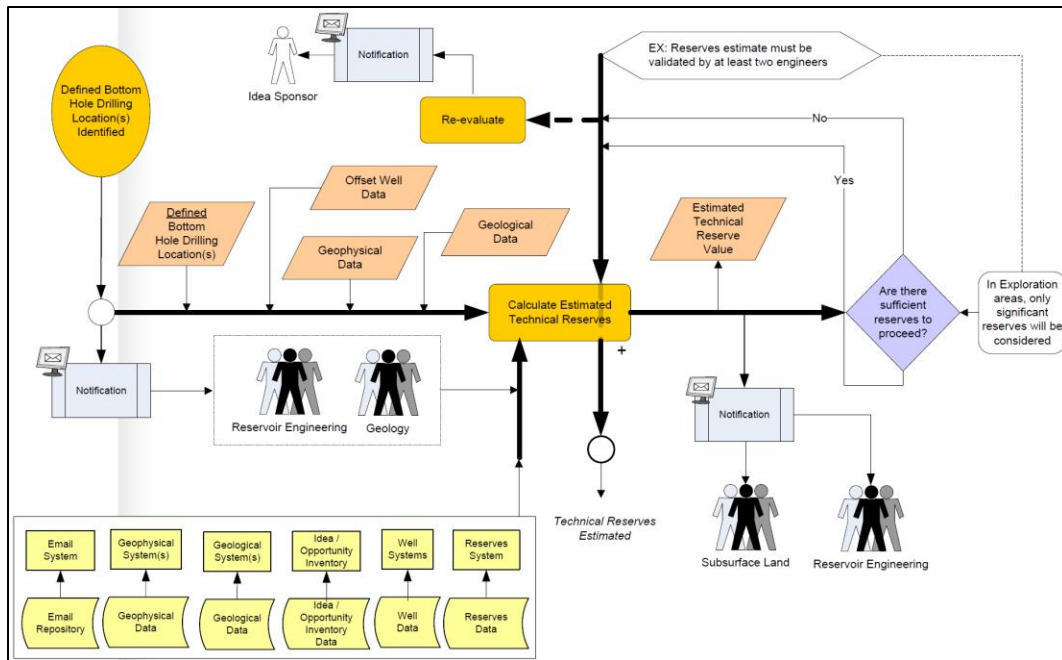
An example of this would be where a reservoir engineering group follows a prescribed workflow to evaluate alternative scenarios for developing a prospect. Upon completion of the analysis, they will identify a set of Wells and locations that they recommend drilling. At this juncture, each Well in the drilling set is advanced to the Planning phase of the Well Lifecycle. This event triggers a series of automated activities that change the status of the Well in the master data store, synchronize the Well Status with subscribing applications, create a new Well entry in RigView, and, finally, email the Land group to initiate the permitting process.

The PPDM Association delivers a course that breaks down the Well or Business Lifecycle of a Well from idea through to production and, ultimately, disposition. In the PPDM definition, there are five primary business phases of a well: Planning, Drilling, Completing, Producing, and Disposing. Each phase has unique characteristics and the focus of business activities changes depending on the current point reached within the lifecycle. **Figure 1.2** illustrates the phases of the Well Lifecycle as presented by the PPDM Association.



**Figure 1.2: PPDM Business Lifecycle Phases**

Within each phase of the Business Lifecycle of a Well, a series of processes and sub-processes are defined that break down into tasks as illustrated in **Figure 1.3**. Note that the diagram also illustrates the movement of data resulting from the business activities.



**Figure 1.3: PPDM Business Process Breakdown**

It is not the purpose of this paper to discuss the detailed workflows associated with the Well Lifecycle, but to illustrate the relationship between workflows, the processes, and the

component tasks that generate events to trigger a set of automated activities defined within Business Rules.

## 4. Business Rules

A Business Rule is comprised of an event and a set of associated activities together with the required data quality checks and ownership. In this definition, we will focus on Business Rules associated with changes to master attributes. Although it is worth noting that TDM will support Business Rules that are tied to events associated with non-mastered attributes. This could include the events tied to the addition of a new directional survey or an LAS file that failed to load.

Events have a 1:1 relationship with the MDM Hierarchy and include information such as the System of Record, ownership, and audit configuration. Activities have a 1:Many relationship with events and, consequently, the level of the MDM Hierarchy.

**Figure 1.4** illustrates some of the concepts that will be discussed in terms of event and activity definition. This is a very valuable grid as it identifies the:

- Master attributes
- Level of the Well hierarchy at which they are relevant
- Key lifecycle phases (MDM Hierarchy)
- Applications that are involved at each phase
- The System of Record (SOR) at each phase
- The applications that subscribe to the SOR at each phase

ID	Master Attribute	Well Level	MDM Hierarchy								
			Planning			Drilling			Completing		
			SOR 1	SOR 2	SOR 3	SOR 1	SOR 2	SOR 3	SOR 1	SOR 2	SOR 3
1	Well ID	Origin	Pub	Sub		Pub	Sub		Sub	Pub	
2	UWI	Origin	Pub	Sub		Pub	Sub		Pub	Sub	
3	WELL NAME	Origin	Pub	Sub		Pub	Sub		Pub	Sub	
4	COUNTRY CODE	Origin	Pub	Sub		Pub	Sub		Pub	Sub	
5	PROVINCE CODE	Origin	Pub	Sub	Sub	Pub	Sub	Sub	Pub	Sub	Sub
6	SOURCE	Origin	Pub	Sub		Pub	Sub		Sub	Pub	
7	COST CENTER	Origin	Pub	Sub	Sub	Pub	Sub		Sub	Pub	
8	BOTTOM HOLE LATITUDE	Completion	Sub	Sub	Pub	Sub	Sub	Pub		Sub	Pub
9	BOTTOM HOLE LONGITUDE	Completion	Sub	Sub	Pub	Sub	Sub	Pub		Sub	Pub
10	BOTTOM HOLE DATUM	Completion	Sub	Sub	Pub	Sub	Sub	Pub		Sub	Pub

**Figure 1.4: MDM Trust Matrix**

The implementation of this matrix defines the events, and the subscription activities across the Well Lifecycle. This combined with the ownership and data quality definitions establishes the Business Rules for MDM which are the foundation of Data Governance.

### 4.1. Events

There are many different events that occur across the Well Lifecycle as a result of completing processes within a workflow. In this position paper, the focus is on those events that result in changes to business-critical data that trigger automated data based activities

including notification, synchronization, and transformation either within a master data store or to external applications, groups, and processes. There are essentially two event types:

- **Workflow Events:** These occur external to the master store and trigger activities to update the corporate master store
- **MDM Events:** These occur within the master store either through direct input or by processing workflow events that trigger a set of externally focused activities

In this section, baseline definitions are provided for events that establishes context and scope within the EnergyIQ suite of applications. Note that when we discuss changes to critical attributes in this context, it also includes the creation and deletion of those attributes.

### **Master Data**

Master data refers to a set of attributes that are critical to the business and must be tracked across multiple applications and data stores to detect changes.

**In the EnergyIQ definition, changes to master attributes generate events.**

A change to a master attribute is recorded as an event in the Master Data Management system that will typically trigger a sequence of additional activities. If it doesn't, then we would question whether it is truly a master data attribute that is critical to the business. The event will be recorded in a Message Queue for further processing.

The key features of master data and Master Data Management solutions are described in more detail later in this section; the concepts are introduced here as they are the trigger for events and activities.

### **Definitions**

This section provides definitions for events, how they occur and are recorded, and then what happens when they are processed.

**What is an event?** An event is a change to a mastered attribute either across the Well Lifecycle in an integrated application or within the corporate master store. It triggers a series of automated activities that, when complete, pause the workflow to wait for the next event.

- Workflow events advance the Well through the Well Lifecycle and result in a change to the status of the Well. This results in master data synchronization activities and may advance the overall status of the Well.
- MDM events trigger activities that are externally focused including creating or updating records in subscribing systems, notification, and reporting.
- All events should result in some additional activity, otherwise the associated attribute should not be defined as a master attribute.
- Events are independent of one another. The activities associated with one event should be processed without influence from another event.
- **What causes an event to occur?** An event occurs due to input from an individual (manual) or from another process (automated).
  - An event requires input from something external to the system to occur and, until that input is provided, nothing happens within the workflow.



- As an example, the event could be generated by first production data being reported from a Well site, a daily report being received, or authorization for an AFE being granted.
- **How does an event get defined?** A change to any master attribute is an event.
  - When an attribute is mastered, it applies at a system wide level and does not change across the Well Lifecycle. Therefore, events do not change across the Well Lifecycle and they are always recorded regardless of the phase of the Lifecycle or the geographic location of the Well, for example.
  - A mastered attribute is not tied to a specific source. Therefore, events are also data source agnostic. When a master attribute changes, an event is recorded, regardless of the source of the change or the application that it was made in.
- **How does an event get captured?** Master attributes must be continuously (or regularly) monitored across all sources. When a change is detected, an event will be added to a Message Queue for further processing by a listening agent.
  - There can be one or more Message Queues in an implementation
  - There can one or more listening agents for each Message Queue
  - In the case of the EnergyIQ TDM solution, a change to a master attribute is captured within the audit tables. A process that monitors the audit tables determines whether the change is within SOR and, if so, it writes a record to the outbound Message Queue for processing by a listening agent.
- **What happens when an event occurs?** An event that is recorded within the Well Lifecycle will initiate a change to the master data store. Once this has been processed, then any number of further activities can be triggered by the event.
  - This can include activities such as data synchronization, transformation, and notification or can be custom activities defined by the client
  - The activities are defined within a table that is linked to the event
  - When the event occurs, each of the activities gets processed either independently or they could be grouped and processed collectively by the listening agent.

## 4.2. Activities

An activity is the automated response to an event taking place. This section discusses the definition of activities and how they get executed.

### Definitions

- **What is an Activity?** An activity is the automated response to an event taking place.
- **What types of activities are there?** There can be any number of different activities including email notification, data synchronization through subscriptions, reporting etc.
  - The MDM system should not be restricted to a defined set of activities. The client must be able to define and create their own activities in response to an event. The key is that the activity must be automated and have a definitive end-point.
  - From an EnergyIQ perspective, the solution will be focused on automated data movement, data derivation, notification via email and reporting initially.
- **How is an activity defined?** There can be more than one activity associated with an event and each one could be of a different type. The different types of activities will be

defined independently and maintained within a database table. However, they will all be associated with the MDM Hierarchy through the parent event.

- In the case of automated data movement, the activities will be tied with the subscription matrix. The subscription matrix identifies those applications that will be kept synchronized with the golden record version of the attribute within the master store. This is illustrated in **Figure 1.4**.
  - In the case of email notification, the activity table identifies the group or groups that will be notified when a master attribute changes.
  - In the case of data derivation activities, the activity will include the SQL statement to be applied or stored procedure to be called when the golden attribute changes. An example of this would be to recalculate the plot symbol if the fluid type changes.
  - Clients may create their own activities and associate them with events across the MDM Hierarchy.
- **How are activities executed?** When an event is recorded, a monitor will post an entry to the Message Queue for each activity made up of the activity definition and the data object associated with the changed master attribute.
    - A Message Queue will have one or more listeners that will each execute specific activities when the activity is added to the queue.
    - In the case of automated data movement, the listener will gather the data that changed from the event and then make a call to the associated agent to write the data to the target.

## 5. Master Data Management

Master Data Management involves the definition and application of business rules for the management of attributes that are critical to the process of advancing a Well across the Well Lifecycle.

Master Data Management includes the following key features:

- MDM Hierarchy
- Master attribute definition
- System of Record
- Ownership
- Business Rules and Data Objects

These are discussed in more detail within this section along with a brief review of how Master Data Management and governance are aligned.

### 5.1. MDM Hierarchy

While master attributes are consistent across the Well Lifecycle, the Business Rules that define what activities will be performed in response to an event will vary. In addition, the Business Rules may vary depending on whether the Well is operated or non-operated and even depending upon its geographic location. The MDM hierarchy establishes the

hierarchical relationships between classification categories so that different sets of Business Rules can be applied depending on the status of the Well.

## 5.2. Master Attributes

Master data attributes are those that are critical for an enterprise, and foundational to key business processes and workflows.

### Key assumptions:

- Only master attributes can be included in the definition of the MDM hierarchy.
- Each master attribute will have a System of Record (SOR) defined at each level of the MDM hierarchy.
- Only master attribute changes trigger events. These events only initiate activities when the source changed has the highest priority of the populated sources.
- Only master attributes will be synchronized bi-directionally based upon workflow events and the Subscription Matrix.
- The master attribute SOR must have the highest preference in the associated Source Preference List (SPL) for data blending purposes.
- Master attributes can exist at multiple levels of the Well Hierarchy, and so events must be tied to a specific level within the Well Hierarchy.

Within the EnergyIQ definition, master attributes are established at the system-wide level; the set of mastered attributes does not change according to location or phase of the Well Lifecycle, for example.

## 5.3. System of Record

Each master attribute will be represented within any number of applications across the Well Lifecycle. The multiple different sources of data will be gathered within the master data store, and then a golden record created based upon a source preference list that identifies the order which source takes precedence from highest to least. The highest priority source attributes are promoted to the golden record, which in turn is made available for enterprise consumption.

The System of Record (SOR) identifies the definitive source of data for a given master attribute. If this is populated, then it takes precedence over all other sources and is promoted to the golden record within the master data store. There is some debate as to whether a source that is not the SOR should be promoted to the golden record if the SOR is null. The decision will depend to a large degree as to whether the master attributes will be synchronized across all of the applications associated with the Well Lifecycle in a given solution. If they are to be synchronized, then it makes sense to promote non-SOR attributes to the golden record to maintain consistency across the enterprise. In some organizations, the SOR is not permitted to be null for the current or an earlier phase of the Well Lifecycle. This is a business rule that must be supported by the implementation.

The SOR for a given master attribute can change based upon the phase of the Well Lifecycle or some other level within the MDM Hierarchy (see MDM below). Therefore, a matrix needs to be maintained that defines the SOR for a given master attribute at each

phase of the Well Lifecycle and for each level of the MDM Hierarchy. An example matrix is illustrated in **Figure 1.4**.

#### 5.4. Ownership

One key aspect of data governance is being able to define the ownership of data across the Well Lifecycle. As with the SOR, ownership can change as the Well advances across the lifecycle, and the responsibilities of ownership may also change.

#### 5.5. Business Rules

Business Rules were discussed in detail in the previous section so the information will not be repeated here.

It should be noted that the business rules that get executed can vary according to the phase of the Well Lifecycle or even geographic location. Consequently, it is important that any implementation has the flexibility to configure the rules based upon variable parameters.

##### Subscription Matrix

The Subscription Matrix is a particular type of activity within a Business Rule that also varies according to the phase of the Well Lifecycle. When a master attribute changes and it is the SOR or the highest priority source if the SOR is null, typically, the change will be synchronized with the other sources that subscribe to that master attribute to ensure consistency.

The Subscription Matrix defines which data sources subscribe to a change in the SOR for a master attribute. **Figure 1.4** provides an illustration of a Subscription Matrix across the Well Lifecycle.

#### 5.6. Governance

It is not the intent of this Position Paper to provide an in-depth discussion of Data Governance. However, it is worth pointing out that many of the requirements of enterprise data governance are addressed by the components outlined here.

Defining master attributes that are critical to the business together with the Business Rules that establish ownership, the System of Record source, the Subscription Matrix together with miscellaneous activities covers many of the requirements of Data Governance. When this is tied back to Data Objects and the associated data quality rules, then many of the fundamental requirements of Data Governance are addressed.

## 6. Summary

Workflow automation is prevalent in many industries, but has been slowly adopted by the oil and gas industry. As the companies look to reduce costs, preserve capital, and compete more effectively, workflow automation must be addressed and implemented as a strategic initiative to enable the enterprise with increased efficiencies across the business.

By automating critical workflows, E&P companies make better, lower-risk decisions, are more responsive, more cost-efficient, more compliant, and overall are higher performing. Additionally, because this type of automation provides access to higher quality and more comprehensive data, the benefits apply to all facets of business that are influenced or supported by enhanced analytics.

To gain a deeper understanding for the technology in support of automation as described in this paper, and how it is being applied within the E&P industry, please contact EnergyIQ for a companion paper: [Implementing Workflow Automation](#). The EnergyIQ companion paper describes how the concepts identified here are implemented through the EnergyIQ suite of products. The companion paper presents the technology that enables workflow automation, integrating diverse systems, automating data movement, improving data quality, and standardizing notification requirements.