Amalgamation of Diverse Data Types and Sources to Facilitate Data Analytics of Engineering Interpretation and Historical Data*

Cesar Velasquez¹, Ivan Olea¹, and Russell Roundtree¹

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Abstract

Field development planning of unconventional assets can benefit from learnings from historical completion practices and their production performance results. For this, it is necessary to have a consistent, integrated data source. The Oil and Gas business has been challenged for decades to have industry standard data schemas adopted across the entire industry when consensus on those data elements lags the need to capture new data types. In the age of “if it can be digitized, it will be digitized”, proliferation of data types and data volumes are outpacing our historical ability to respond. As our industry becomes ever more “data driven”, the need to efficiently use diverse data types from many sources and make these data available to a host data analytics tools to extract information and knowledge from those data requires a new approach. This work outlines a general procedure to create an integrated data management solution with the aim of implementing a customizable schema and rules-based engine. The challenge is to validate, manage and consolidate the data with different sources and formats into a standardized single trusted version. Once the fundamental Data Engineering task is done a wealth of data analysis techniques were applied to establish the relationship between well completion parameters and long-term production of an unconventional asset. Different databases of an unconventional play in North America were used, facilitating the interconnection between tables due to the standardization in most column names, primary key parameters, etc. However, this process involved a dynamic workflow to load and inspect the quality and representativeness of the data each time new information was loaded, using business rules specifically created for each attribute. Once the standardized product was generated (SQL database), it was connected to the data analytics tool to evaluate the EUR and its relationship with completion parameters. In most Upstream data analytics projects, it is common to spend more time preparing the data than analyzing it. Therefore, the integrated solution recommended here was extremely useful to facilitate the analysis, adding a high level of confidence, consistency, and representativeness on the analysis performed. This approach can be used as a guide to improve the field development plan of a play and can also be extended to host training data for Artificial Intelligence and Machine Learning techniques.
Amalgamation of Diverse Data Types and Sources to Facilitate Data Analytics of Engineering Interpretation and Historical Data

Authors: Cesar Velasquez, Ivan Olea, Russell Roundtree
Introduction

In the age of “if it can be digitized, it will be digitized”, proliferation of data types and data volumes are outpacing our historical ability to respond. As our industry becomes ever more “data driven”, the need to efficiently use diverse data types from many sources and make these data available to a host data analytics tools to extract information and knowledge from those data requires a new approach.
Outline

• Objective

• Standard Data Management Workflow:
  • Pre-Match Processing.
  • Match Processing.
  • Post-Match Processing.

• Unconventional Reservoir - Visualization / Data Analysis

• Conclusions
Objective

This work outlines a general procedure to create an integrated data management solution with the aim of implementing a customizable schema and rules-based engine. The challenge is to validate, manage and consolidate the data with different sources and formats into a standardized single trusted version. Once the fundamental Data Engineering task is done a wealth of data analysis techniques were applied to establish the relationship between well completion parameters and long-term production of an unconventional asset.
Standard Data Management Workflow

Incoming data sources → Load → Transformation, Normalization and Validation → Match → Master → Visualization / Analytics → Export to data destination systems

Standardized Copy
Sources to be interconnected

IHS Markit / Harmony Enterprise

Production Database
Production history
Cumulative production (3, 6, 12, 18, 36 months)
DCA - Decline Curve Analysis
EUR – Estimated Ultimate Recovery
SQL database

IHS Markit / Kingdom

Geological Model
LogData
Surface / Zone selected
Structural model
Petrophysical model
SQL Database

Completion Database
Historical well Completions
Perforation
Material
Casing/Tubing
Public Data
CSV Files

Additional Sources
Well spacing
Statistical analysis
Cost models
Reservoir properties:
• TOC
• Porosity
• Thickness
• Fluid saturation
CSV Files
Technical Workflow / Schematic

Master Well Header

Core Matcher

AccuMap
Well Header
- Quantities
- Production
- Frac._Material
- Completion
- Frac._Perforations

Additional Sources
Well Header
- Cost
- TOC
- Statistical Analysis
- Well Spacing

1. Harmony Enterprise
2. Well Header
- Reserves
- Production
- Entity
- Analysis
- RTA
- Hybrid_Model
- Flowing_Material_Balance
- Unconventional_Res_Model

Kingdom
Well Header
- Petrophysical_data
- Entity
- Survey_data
- Analysis

Pre-Match Transformation, Normalization and Validation
Pre-Match Process

Process Monitor Table
- Failed Cases
- Successful Cases

Exception Load Table

Successful Files are Archived

Data Flow Process
- Update AccuMap System Casing Cements
- Archive AccuMap System Casing Cements

Business Rules, Transformation and Validation

SQL Server
ORACLE
CSV
XML
Pre-Match Process

<table>
<thead>
<tr>
<th>Attribute Name</th>
<th>Data Type</th>
<th>Exception Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>UWI</td>
<td>NVARCHAR</td>
<td>Field Length Exceeded</td>
</tr>
<tr>
<td>TUBING_ID</td>
<td>INT</td>
<td>Invalid Integer</td>
</tr>
<tr>
<td>RIG_RELEASE_DATE</td>
<td>DATETIME</td>
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</tr>
<tr>
<td>WATER_SATURATION</td>
<td>NUMBER</td>
<td>Invalid Number</td>
</tr>
</tbody>
</table>
Pre-Match Process

Business Rule

Left({INPUT}.[Input UWI],3)+'/'+substring({INPUT}.[Input UWI],4,2)+'-' +substring({INPUT}.[Input UWI],6,2)+'-'+substring({INPUT}.[Input UWI],8,3)+'/'+substring({INPUT}.[Input UWI],11,4)
## Pre-Match Process

**Business Rule**

Filter = IF {INPUT},[INPUT Value] IS NULL THEN 0 Else = 1

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<tr>
<th>PRE_FRAC_COST</th>
<th>PRE_FRAC_COST_PER_STAGE</th>
<th>FRAC_COST</th>
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</tr>
<tr>
<td>8306749</td>
<td>56856.78</td>
<td>2059599</td>
</tr>
</tbody>
</table>

**Data Layout**

<table>
<thead>
<tr>
<th>PRE_FRAC_COST</th>
<th>PRE_FRAC_COST_PER_STAGE</th>
<th>FRAC_COST</th>
</tr>
</thead>
<tbody>
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</tr>
<tr>
<td>8306749</td>
<td>56856.78</td>
<td>2059599</td>
</tr>
</tbody>
</table>
### Matching Attributes

**Wellbore ID**
- 100/01-06-01-18W5/0
- 100/01-06-01-20W5/0
- 100/01-06-02-24W5/0
- 100/01-06-04-05W5/2

**License Number**
- Deeper-pool Test
- Development

**Lahee Name**
- Tony Creek North
- Kaybob South
- Two Creek
- Kaybob

**Cost Center**
- Shell Canada Energy
- Husky Oil Operations Limited
- Encana Corporation

**Well ID**
- 0032484A-B09E-439F-A4CF-04330EAAC9E0 (Tony Creek North)
- 005EC69D-AAD4-45FF-B434-1E79FBDB1989 (Kaybob South)
- 0061B2AD-52D0-4B30-89FA-8CFBAE74686C (Two Creek)
- 00703C37-A53D-42E9-A8B6-B63C7BB7FD11 (Kaybob)

**Field Name**
- Tony Creek North
- Kaybob South
- Two Creek
- Kaybob

**Data Illustrator**

<table>
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<th>Field Name</th>
<th>Illustrated Name</th>
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<tr>
<td>API</td>
<td>UWI</td>
</tr>
<tr>
<td>DLS</td>
<td>UWI</td>
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<tr>
<td>NAME</td>
<td>UWI</td>
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</tbody>
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### Matching Process

**Wellbore ID**
- 0032484A-B09E-439F-A4CF-04330EAAC9E0 (Tony Creek North)
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**Lahee Name**
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- Two Creek
- Kaybob

**Cost Center**
- Shell Canada Energy
- Husky Oil Operations Limited
- Encana Corporation
Matching Process

Harmony Well Header

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<thead>
<tr>
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<tr>
<td>1002</td>
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<tr>
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AccuMap Well Header

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<th>UI</th>
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<tbody>
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<td>1000</td>
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<tr>
<td>1005</td>
<td>UWI</td>
<td>Development SHELL CANADA ENERGY</td>
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<tr>
<td>1006</td>
<td>UWI</td>
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<td>UWI</td>
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Kingdom Well Header

<table>
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<tr>
<th>UI</th>
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<th>WELLNUMBER</th>
<th>SURFACELOCX</th>
<th>SURFACELOCY</th>
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<tbody>
<tr>
<td>1008</td>
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<tr>
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Well Spacing Header

<table>
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<th>DISTANCE_M</th>
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<tr>
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<tr>
<td>1009</td>
<td>UWI</td>
<td>ECA HZ WAHIGAN 1-4-62-24</td>
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</tr>
<tr>
<td>1005</td>
<td>UWI</td>
<td>CHEVRON HZ KAYBOBS 1-6-62-20</td>
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<td>418</td>
</tr>
</tbody>
</table>
### Matching Process

**Harmony Well Header**

<table>
<thead>
<tr>
<th>UI</th>
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<td>Oil</td>
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**AccuMap Well Header**

<table>
<thead>
<tr>
<th>UI</th>
<th>UWI</th>
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<tr>
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<td>ENCANA CORPORATION</td>
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**Kingdom Well Header**

<table>
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<th>SURFACELOCX</th>
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<td>6027568.54</td>
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<td>6028579.2</td>
</tr>
<tr>
<td>1011</td>
<td>100/15-33-062-20W5/0</td>
<td>100/15-33</td>
<td>504219.07</td>
<td>6027548.62</td>
</tr>
</tbody>
</table>

**Well Spacing Header**

<table>
<thead>
<tr>
<th>UI</th>
<th>UWI</th>
<th>WELL_NAME</th>
<th>DISTANCE_M</th>
</tr>
</thead>
<tbody>
<tr>
<td>1003</td>
<td>100/10-33-063-20W5/0</td>
<td>SCL HZ FC23I KAYBOB 1-1-63-20</td>
<td>532</td>
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<td>100/01-04-062-24W5/0</td>
<td>ECA HZ WAHIGAN 1-4-62-24</td>
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<td>1011</td>
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<td>CHEVRON HZ KAYBOBS 1-6-62-20</td>
<td>418</td>
</tr>
</tbody>
</table>
Technical Workflow / Schematic

Mastering process

Master Well Header

Core Matcher

AccuMap
Well Header

Quantities
Production
Frac_Material
Completion
Frac_Perforations

Additional Sources
Well Header

Cost
TOC
Statistical Analysis
Well Spacing

1.Harmony Enterprise
2.Well Header

Reserves
Production
Entity
Analysis
RTA
Hybrid_Model
Flowing_Material_Balance
Unconventional_Res_Model

Kingdom
Well Header

Petrophysical_data
Entity
Survey_data
Analysis
# Mastering Process

## WELL HEADER - MASTER TABLE

<table>
<thead>
<tr>
<th>Harmony Well Header</th>
<th>Kingdom Well Header</th>
<th>AccuMap Well Header</th>
<th>Well Spacing Header</th>
</tr>
</thead>
<tbody>
<tr>
<td>UI</td>
<td>DLS</td>
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</table>
### Mastering Process

#### Upstream tables to be enriched

**Harmony UNCONVENTIONAL_RES_MODEL**

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<th>LINEAR_FLOW_PARAMETER</th>
<th>FRACTURE_SPACING</th>
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<th>OGIP</th>
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**AccuMap PPRODUCTION_FIRST_12_MONTHS**

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<tr>
<td>5003</td>
<td>7506.2</td>
<td>0.19</td>
<td>1.69</td>
<td>50.6</td>
<td>22.99</td>
</tr>
</tbody>
</table>
Standard Data Management Workflow

Incoming data sources → Load → Transformation, Normalization and Validation → Match → Master → Visualization / Analytics

Automatic Model updates

70 – 80%

30 - 20%

Export to data destination systems
VISUALIZATION – DATA ANALYSIS
Using public data, it is of interest to identify trends and relationships between completion practices and production performance in the play. Activity is concentrated in a few fields where the majority of the production is coming from liquid rich wells.
Unconventional Reservoir - Visualization / Data Analysis

Public production data and hydraulic fracturing completion information from more than 800+ horizontal multi-fractured shale wells was collected.

A range of TOC values was assigned per well following published maps by the Provincial Energy Regulator.
Completion practices have evolved over time by increasing the stimulated horizontal length, stage count and clusters per stage which has led to a tighter stage spacing along the horizontal section.
By changing the level of aggregation, it is possible to reduce the noisy profiles and have a clearer picture of the trend changes in completion practices over time.
Unconventional Reservoir - Visualization / Data Analysis

TOC distribution per well and its association with EUR’s trends and the stimulation technology used per year. (Kaybob field).
Unconventional Reservoir - Visualization / Data Analysis

TOC distribution per well and its association with EUR’s trends and the stimulation technology used per year. (Kaybob field).

The TOC range selected: 2.6 and 3 (wt%)
Unconventional Reservoir - Visualization / Data Analysis

TOC distribution per well and its association with EUR's trends and the stimulation technology used per year. (Kaybob field).

The TOC range selected: 3.1 and 3.5 (wt%)
Unconventional Reservoir - Visualization / Data Analysis

TOC distribution per well and its association with EUR’s trends and the stimulation technology used per year. (Kaybob field).

The TOC range selected: 3.6 and 4.0 (wt%)
Unconventional Reservoir - Visualization / Data Analysis

TOC distribution per well and its association with EUR’s trends and the stimulation technology used per year. (Kaybob field).

The TOC range selected: 4.1 and 4.5 (wt%)
Unconventional Reservoir - Visualization / Data Analysis

TOC distribution per well and its association with EUR’s trends and the stimulation technology used per year. (Kaybob field).

The TOC range selected: 4.6 and 5.0 (wt%)

This type of analysis should be considered as the preliminary step to a much detailed modeling using AI/ML techniques.
Conclusions

• The data management process commonly represents up to 80% of the execution of data analytics / AI / ML projects.

• The value and representativeness of the interpretation is based on the quality of the data.

• Completion practices have changed over time, and the EUR trend follows these changes (increasing horizontal length, number of stages and/or clusters per stage).

• This type of work can also be followed as a first step towards ML algorithms (e.g. training and validation data sets) and applications.
Thank You