ADVANCED SEISMIC ATTRIBUTE ANALYSIS: DEEP LEARNING

Keith R. Holdaway, SAS Institute

Company Confidential - For Internal Use Only
Copyright © 2012, SAS Institute Inc. All rights reserved.

AGENDA

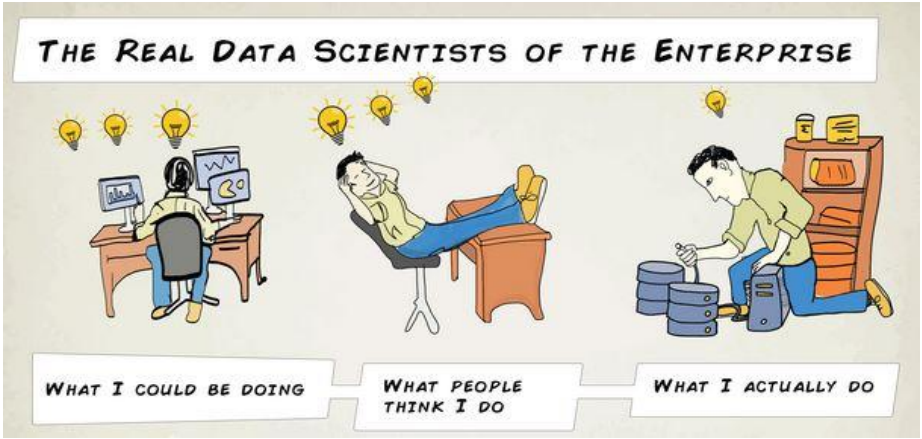
- Data Mining: What is it?
- Data Mining Virtuous Cycle
- Data Mining: O&G Input Space
- Data-Driven Analytics:
  - Artificial Intelligence & Deep Learning
- Case Studies:
  - Seismic Attribute Analysis
  - Seismic Image Analysis

"THAT'S your Ark for the Big Data flood? Noah, you will need a lot more storage space!"

Company Confidential - For Internal Use Only
Copyright © 2012, SAS Institute Inc. All rights reserved.

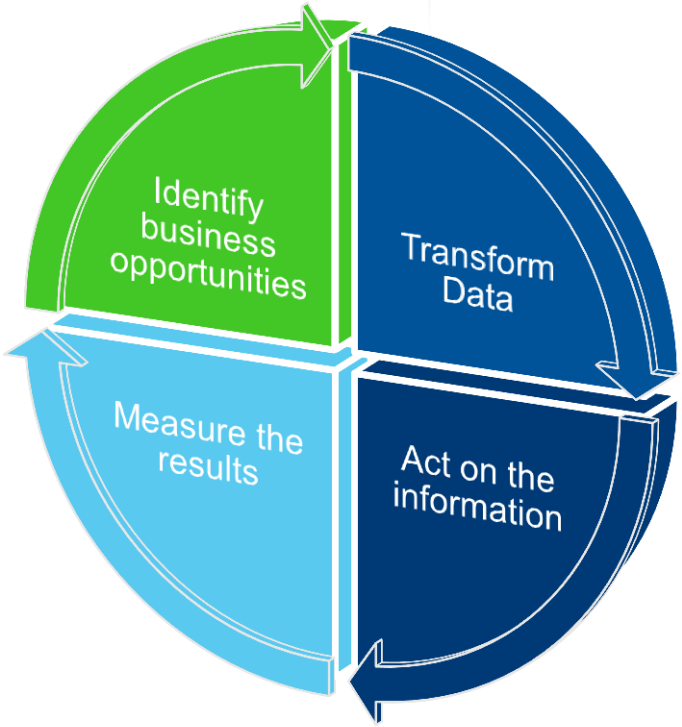
DATA MINING: WHAT IS IT?

- Data Mining Styles
  - Hypothesis Testing
  - Directed Data Mining
  - Undirected Data Mining



Company Confidential - For Internal Use Only
Copyright © 2012, SAS Institute Inc. All rights reserved.

DATA MINING VIRTUOUS CYCLE

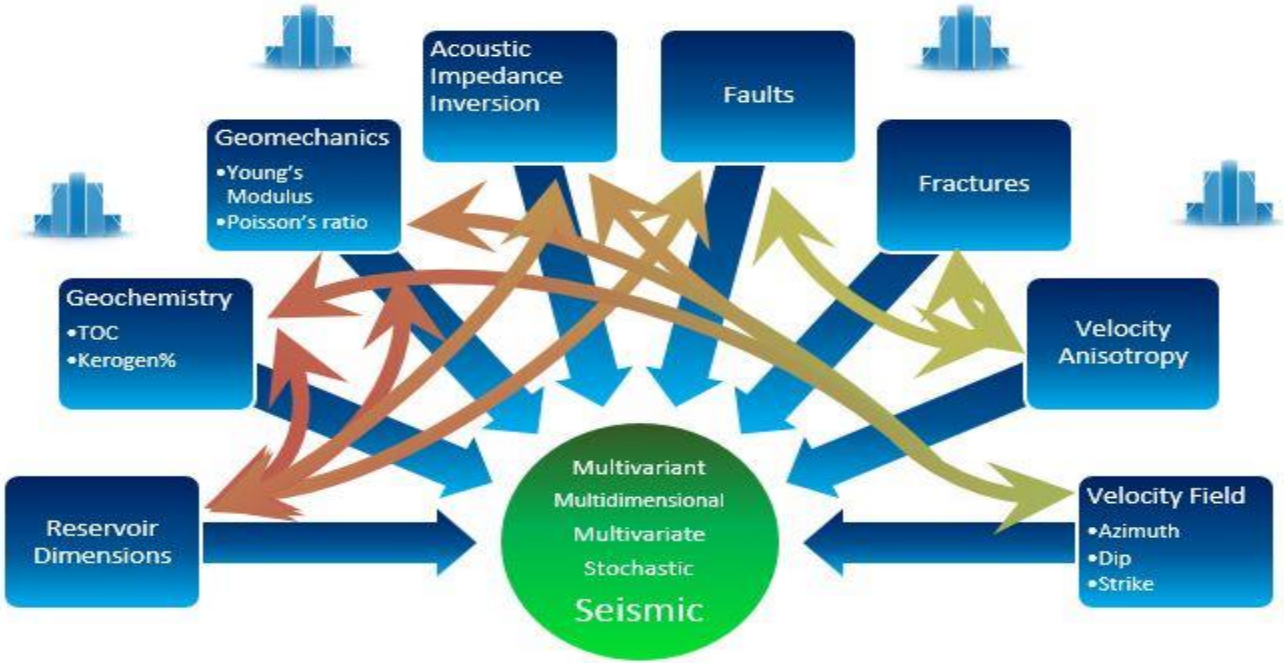


"Those who do not learn from the past are condemned to repeat it."

George Santayana

Company Confidential - For Internal Use Only
Copyright © 2012, SAS Institute Inc. All rights reserved.

DATA MINING: O&G INPUT SPACE



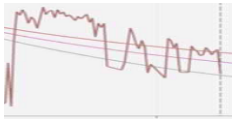
Company Confidential - For Internal Use Only
Copyright © 2012, SAS Institute Inc. All rights reserved.

DETERMINISTIC TO PROBABILISTIC

Data
- Historical
- Real-time

Deterministic analysis
- Experience

Outcomes
- Situation A
- Situation B
- Situation C



Data
- Historical
- Real-time

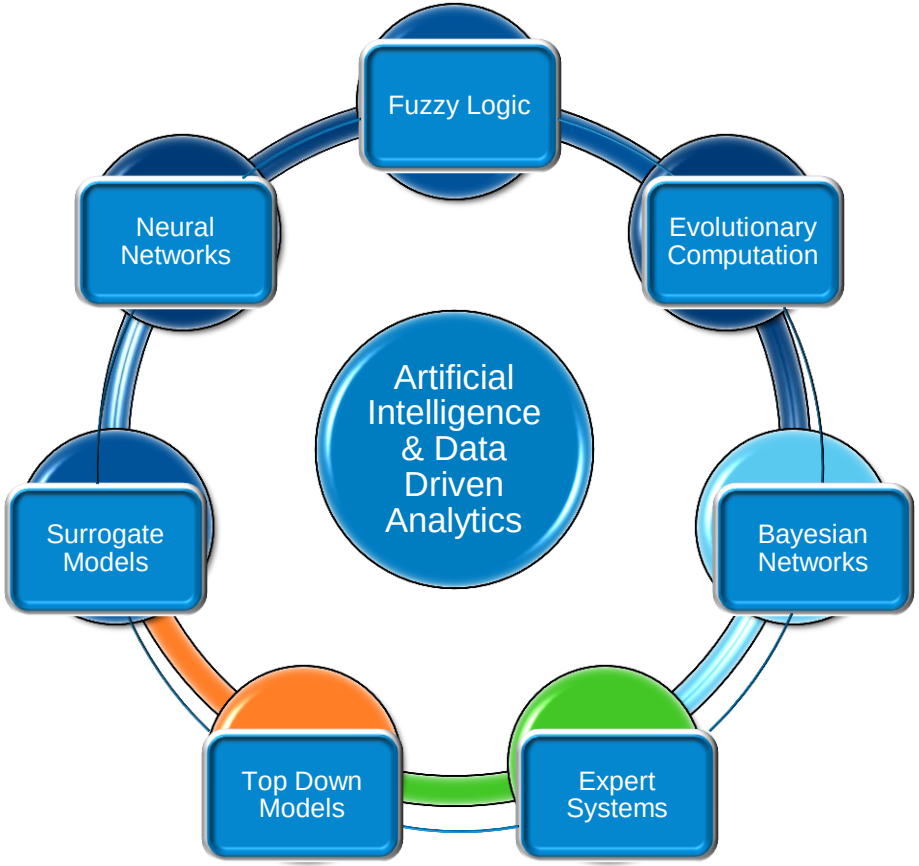
Probabilistic analysis
- Experience
- Variability
- Complex relationships

Predictive Outcomes
- Situation A 95%
- Situation B 22%
- Situation C 36%

Actionable workflows
- Workflow A
- Workflow B
- Workflow C

Company Confidential - For Internal Use Only
Copyright © 2012, SAS Institute Inc. All rights reserved.

ARTIFICIAL INTELLIGENCE & DEEP LEARNING



Company Confidential - For Internal Use Only
Copyright © 2012, SAS Institute Inc. All rights reserved.

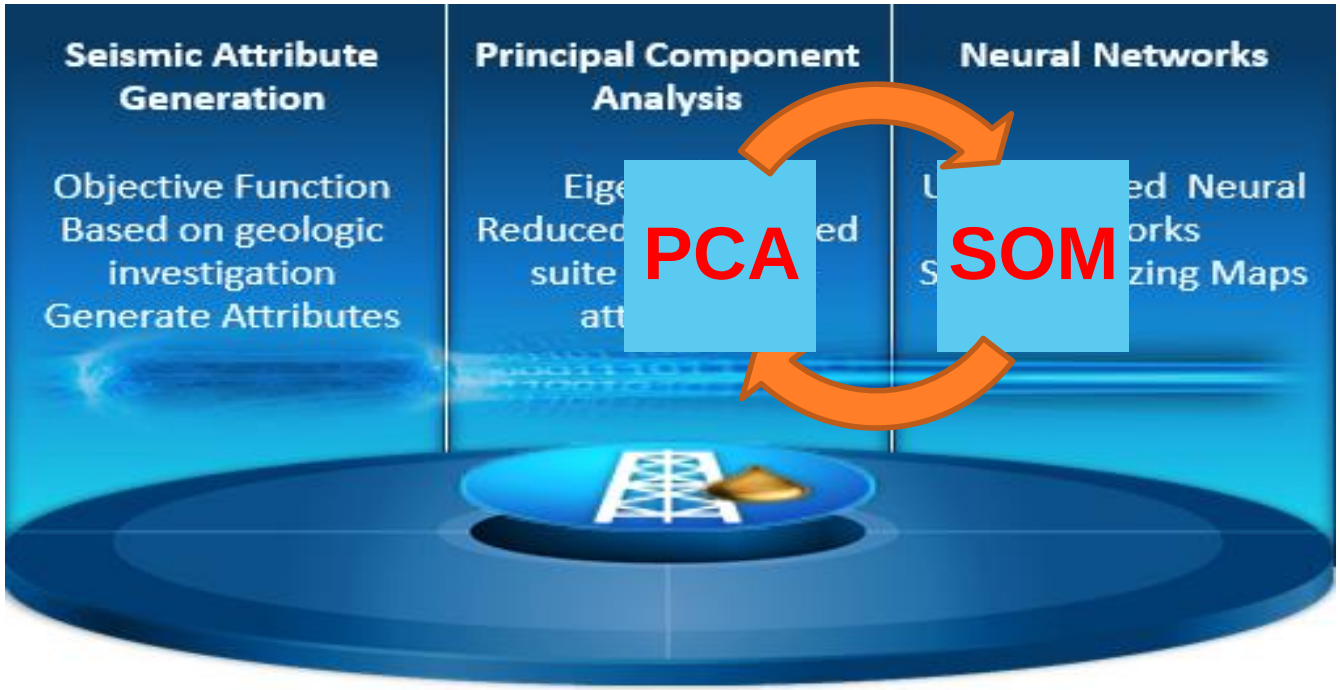
SEISMIC ATTRIBUTE ANALYSIS

METHODOLOGY

Company Confidential - For Internal Use Only
Copyright © 2012, SAS Institute Inc. All rights reserved.

SEISMIC ATTRIBUTE ANALYSIS

PRINCIPAL COMPONENT ANALYSIS AND SELF-ORGANIZING MAPS



Company Confidential - For Internal Use Only
Copyright © 2012, SAS Institute Inc. All rights reserved.

SELF-ORGANIZING MAPS

CLASSIFYING MULTIPLE SEISMIC ATTRIBUTES

- Identify natural clusters of attributes associated to each neuron
- Neurons have geologic significance
- Generate 2-Dimensional maplets
- Adapt seismic attributes in a multidimensional lattice

- Discriminate geologic and stratigraphic features
- Expose Direct Hydrocarbon Indicators (DHIs)
- Risk reduction through additional insights to complement interpretation

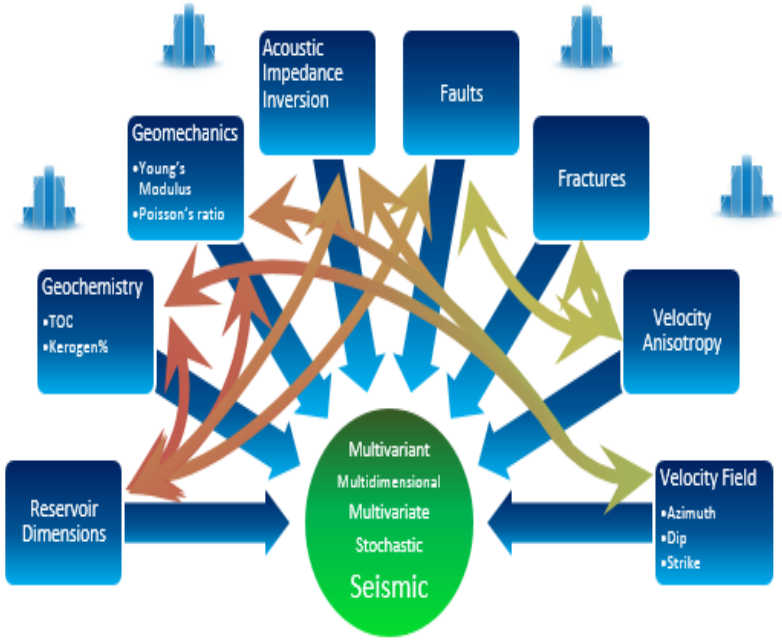
Company Confidential - For Internal Use Only
Copyright © 2012, SAS Institute Inc. All rights reserved.

sas THE POWER TO KNOW.

SEISMIC ATTRIBUTE ANALYSIS

ANALYSIS OF UNCONVENTIONAL RESOURCE PLAYS

- Reservoir geology
  - Thickness and Lateral extent
  - Mineralogy
  - Porosity and Permeability
- Geochemistry
  - Total Organic Content (TOC)
  - Maturity and Kerogen Richness
- Geomechanics
  - Acoustic impedance inversion
  - Young's Modulus
  - Poisson's Ratio (Vp/Vs)
- Faults, Fractures and Stress regimes
  - Coherency and Curvature
  - Fault Volumes
  - Velocity Anisotropy
  - Stress maps

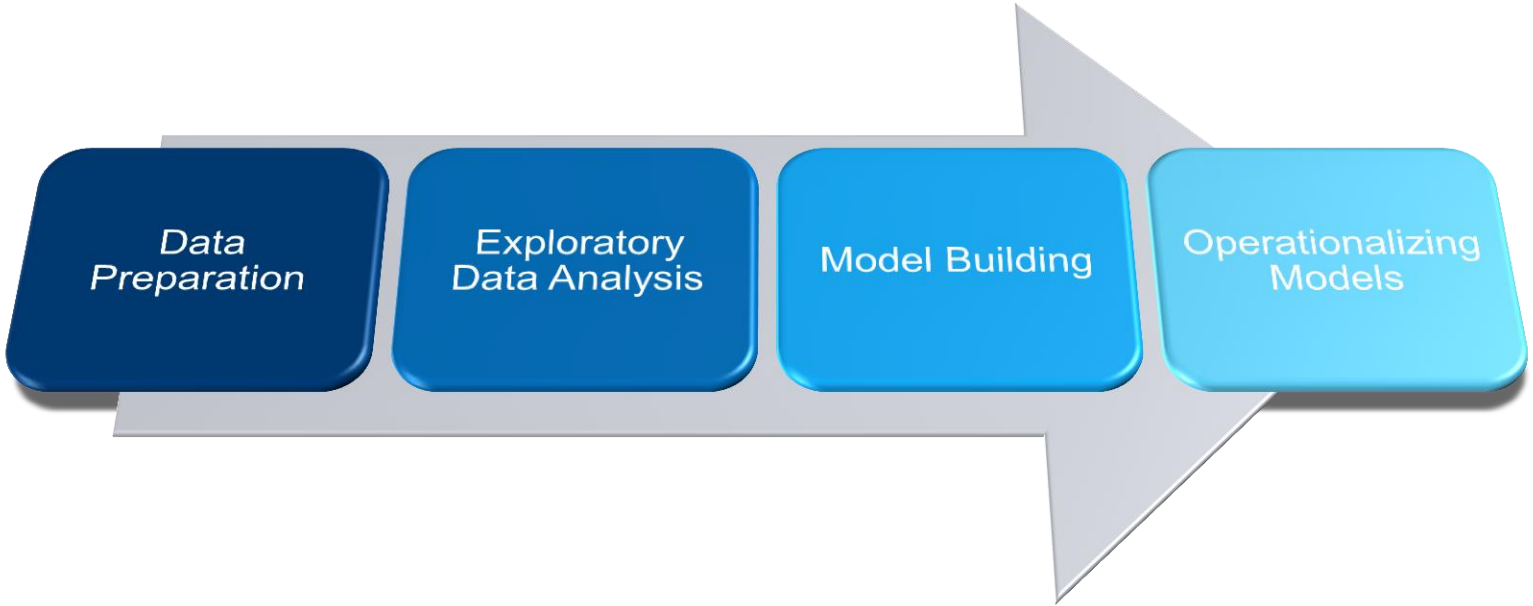


Company Confidential - For Internal Use Only
Copyright © 2012, SAS Institute Inc. All rights reserved.

sas THE POWER TO KNOW.

SEISMIC ATTRIBUTE ANALYSIS

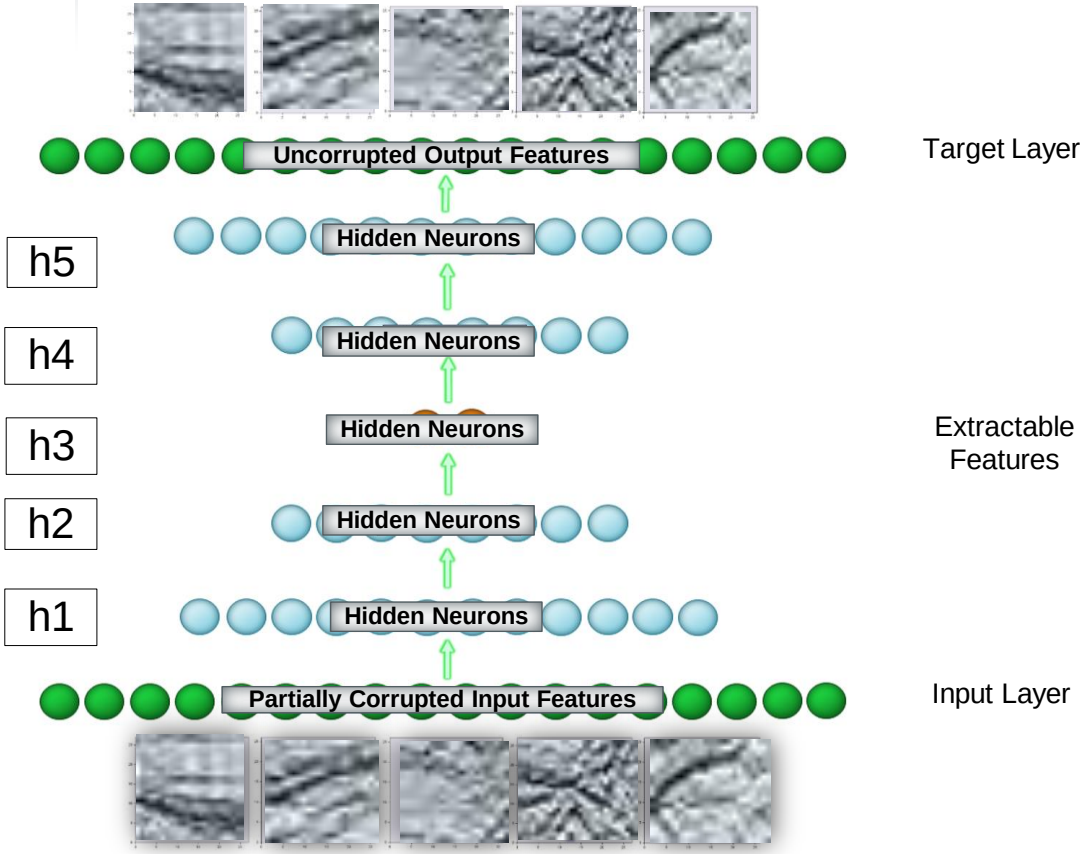
METHODOLOGY FOR IMAGE AND VIDEO ANALYTICS (IVA)



Company Confidential - For Internal Use Only
Copyright © 2012, SAS Institute Inc. All rights reserved.

SEISMIC ATTRIBUTE ANALYSIS

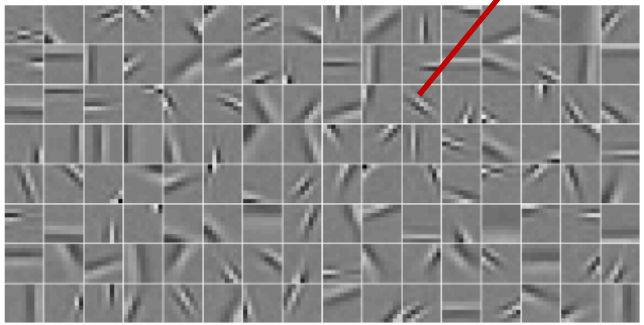
DEEP LEARNING WITH NEURAL NETWORKS



Company Confidential - For Internal Use Only
Copyright © 2012, SAS Institute Inc. All rights reserved.

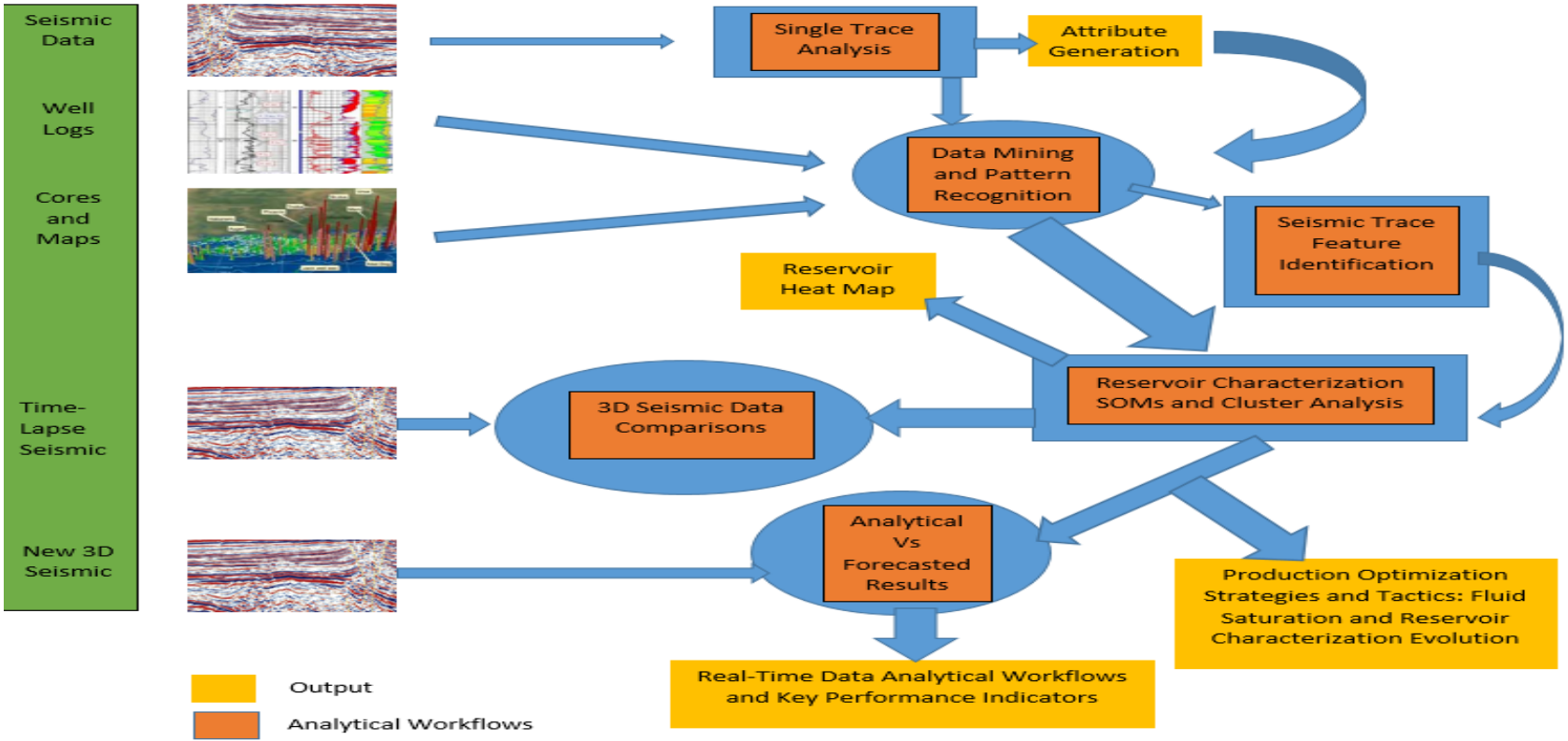
SEISMIC ATTRIBUTE ANALYSIS

DICTIONARY LEARNING



Company Confidential - For Internal Use Only
Copyright © 2012, SAS Institute Inc. All rights reserved.

MAPPING DISPARATE UPSTREAM DATA TO RESERVOIR CHARACTERIZATION



Company Confidential - For Internal Use Only
Copyright © 2012, SAS Institute Inc. All rights reserved.

Q&A

SAS DAY 2014

Company Confidential - For Internal Use Only
Copyright © 2012, SAS Institute Inc. All rights reserved.