From Qualitative to Quantitative: How Visual Data Analytics has Transformed Downhole Video
Visual Analytics combines cutting edge visual diagnostic information with advanced computational analysis techniques to provide vivid, quantified downhole intelligence.

Visual Analytics provides:
- Quantified visual inspection
- Real-time decisions at the well site
- Integration of quantified video and log data
The world’s first array sideview camera for downhole applications:

- **360-degree** continuous side-view camera footage
- **Integrated** down-view camera
- **25 fps** sample rate
- **Real-time or memory** configuration
- **All conveyance types:** slickline, e-line, coiled tubing, e-coil and e-line tractor
- **2880 x ∞** pixel video resolution
- **>5 GigaPixels** processed per 30ft (at 15 ft/min)
Providing a complete and quantified picture to the global oilfield industry

Data acquired in collaboration with Altus
Providing a complete and quantified picture to the global oilfield industry
OPTIS INFINITY™ – VALVE

Data acquired in collaboration with Altus

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INTEGRATED VISUALIZATION

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VISUAL ANALYTICS

**Corrosion**
360° corrosion evaluation
Optimizing integrity management

**Sand**
Evaluating sand control
Optimizing clean-up

**Fish**
Real-time decision making
Fast, effective fish retrieval

**Water**
Pinpointing water entry
Effective isolation at source

**Leak**
Locate and diagnose leaks
Detailed root cause analysis

**Restriction**
Quantified evaluation
De-risking interventions

**Perforation**
Quantifying perforation geometry
Optimizing frack/stimulation

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Targeted remedial action

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PERFORATION – LIMITED ENTRY STIMULATION

Typical Well Design

- Geometric design applied on field-wide basis
- Perforation and frac design dependent on assumptions
- Diagnostics limited to stage and cluster level:
  - Micro-seismic
  - Fiber Optics (DAS/DTS)
  - Tracers
  - Production Logging

Limitations:

- All information is inferred (not a direct measure)
- Time to take information to action is high
- Critical perforation-level information missing

Limited Entry Stimulation

\[ P_{pf} = \frac{0.2369Q^2 \rho}{C_p^2 N_p^2 D^4} \]

Where

- \( P_{pf} \) = Perforation friction pressure (psi)
- \( Q \) = Total flow rate (bbl/min)
- \( \rho \) = Fluid, proppant & additives density (lb/gal)
- \( C_p \) = Perforation discharge coefficient
- \( N_p \) = Number of open perforations
- \( D \) = Perforation diameter (in)

McClain 1963 (Bernoulli theorem)
PERFORATION – CALCULATING ERODED AREA

Pre-Frac

Post-Frac

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Analysis Sequence

- Analysis suite integral to video playback application
- Auto-identification of perforation and reference blade
- Calibration of image and computation of perforation geometry
- Apply image un-distortion algorithms (lens geometry and pipe geometry)

Computed Outputs

- Diameter, Area, Perimeter, Circularity, Height, Width, Azimuthal Position
PERFORATION - SPATIAL ANALYSIS SHOWS PHASE BIAS

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Azimuthal bias with over-stimulated low-side and under-stimulated high-side

Heel-Toe bias with over-stimulated heel and under-stimulated toe

Post-frac average Entry Hole Area per 60° phase
(0° = high side)
PERFORATION – IMPROVED CLUSTER EFFICIENCY

Eroded area per perforation (in²)

Heel

1.22 in²
0.65 in²
0.39 in²
0.42 in²
0.10 in²

23%
14%
15%
4%
0%

Eroded area per cluster (in²)

19%
20%
19%
21%
21%

0.59 in²
0.53 in²
0.55 in²
0.54 in²
0.57 in²

Eroded area per perforation (in²)

Eroded area per cluster (in²)

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Perforation VA – FIELD-WIDE BENEFITS

Perforation VA helps operators to:

- Optimize the number of perforations, their spacing and azimuthal orientation
- Eliminate heel-toe bias within each cluster
- Eliminate over and under stimulation
- Optimize the number of clusters treated in each stage

Benefits

- More cost effective frac operations
- Reduced risk of frac hits and well integrity events
- Better distribution and fracture propagation

Field-wide Optimization
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**SAND VA– EROSION ANALYSIS**

No clear visual or measured evidence of erosion of base holes in screen sections

- 72 base holes measured across four quadrants and 18 depth stations
- Measured dimensions in close agreement with manufactured dimensions (0.375” diameter).
- This infers no erosion has occurred.
- Small differences between measured and manufactured dimensions are likely to be due measurement inaccuracy.

<table>
<thead>
<tr>
<th>Dimension (mm or mm²)</th>
<th>Diameter (in)</th>
<th>Perimeter (in)</th>
<th>Area (in²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufactured</td>
<td>0.375</td>
<td>1.178</td>
<td>0.110</td>
</tr>
<tr>
<td>vs Average</td>
<td>0.371</td>
<td>1.180</td>
<td>0.103</td>
</tr>
<tr>
<td>Measured</td>
<td>0.371</td>
<td>1.180</td>
<td>0.103</td>
</tr>
</tbody>
</table>
Area of flow restricted by debris was measured for four base holes at each depth, and compared with original hole size.

Average percentage flow restricted area was then calculated:

1. Measure individual base hole area
2. Measure unrestricted flow area
3. Calculate restricted flow area

\[
\text{Percent Restricted Flow Area} = \left( 1 - \frac{\text{Unrestricted Flow Area}}{\text{Base Hole Area}} \right) \times 100\%
\]

\[
= 55\%
\]
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**Screen Restricted flow area increases with depth**

- 54% of base holes have restricted flow.
- Average Restricted Flow Area increases from ~5% at top of screen to >50% at bottom of screen.
- Average restriction for all measured holes 21%.
- Slight preference for restriction at 90° phase.

**Average Flow Restricted Area (blockage) per 90° phase (0° = high side)**

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Average Restricted Flow Area %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1586.34</td>
<td>5%</td>
</tr>
<tr>
<td>1586.65</td>
<td>3%</td>
</tr>
<tr>
<td>1586.97</td>
<td>8%</td>
</tr>
<tr>
<td>1587.00</td>
<td>22%</td>
</tr>
<tr>
<td>1587.31</td>
<td>38%</td>
</tr>
<tr>
<td>1587.67</td>
<td>4%</td>
</tr>
<tr>
<td>1587.98</td>
<td>17%</td>
</tr>
<tr>
<td>1588.33</td>
<td>25%</td>
</tr>
<tr>
<td>1588.67</td>
<td>25%</td>
</tr>
<tr>
<td>1589.33</td>
<td>36%</td>
</tr>
<tr>
<td>1590.00</td>
<td>40%</td>
</tr>
<tr>
<td>1590.36</td>
<td>17%</td>
</tr>
<tr>
<td>1590.67</td>
<td>13%</td>
</tr>
<tr>
<td>1591.02</td>
<td>32%</td>
</tr>
<tr>
<td>1591.34</td>
<td>44%</td>
</tr>
<tr>
<td>1591.61</td>
<td>55%</td>
</tr>
</tbody>
</table>

Trend of increasing restricted flow area from top to bottom of screen

\[ R^2 = 0.43 \]
SAND CONTROL – THE NEXT ANALYTICS QUANTUM

**PERFORATIONS:**
Typically 4-6 shots per ft
Magnitude ≈ 1,500 per well

**MACHINE LEARNING**
Automated Identification/Quantification
Near-Time to Real-Time

**SAND SCREEN BASE HOLE**
Typically 100 holes per ft
Magnitude ≈ 100,000 per well
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WATER PRODUCTION CHALLENGE

INCREASING HIGH WGR WELLS

INCREASING PROCESSING COSTS

INCREASING LIFT COSTS

SPE-166301-MS: Video Production Logging and Polymer Gel Yields Successful Water Isolation in the Fayetteville Shale
GAS ENTRY IN WATER

Gas bubbles flowing from perforation to high side of hole

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Several water entry points coming from a perf cluster, laminar flow
WATER ENTRY IN GAS

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Water jet spraying from a single perforation

SPE-166301-MS: Video Production Logging and Polymer Gel Yields Successful Water Isolation in the Fayetteville Shale
WATER SHUT-OFF PROGRAM RESULTS

RESULTS:

- Up to 98% water reduction
- Gas rate increases up to 500 Mcf/day
- Reduced costs by ~65%
- Expanded the candidate list for water isolation
- Reduced wellbore clean-up requirements (removed spinner)
- Reduced deferred production by maintaining an undisturbed flow
- Post treatment water production rates decreased by an additional 20%
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Thank you

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