SPE DISTINGUISHED LECTURER SERIES is funded principally through a grant of the SPE FOUNDATION.

The Society gratefully acknowledges those companies that support the program by allowing their professionals to participate as Lecturers.

And special thanks to The American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME) for their contribution to the program.
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And special thanks to The American Institute of Mining, Metallurgical,
and Petroleum Engineers (AIME) for their contribution to the program.
Use of 21st Century Computer and Communications Technologies to Make Effective Drilling Decisions
The Good Old Days of Drilling
The Good Old Days of Drilling

The rig Site
(Downtown L.A.)
The Good Old Days of Drilling

Real time data (the martin-decker)
The Good Old Days of Drilling

MWD
(The totco)
The Good Old Days of Drilling

The Data Logger
(The Geolograph)
The Good Old Days of Drilling

Remote Comm
(as far as you could shout)
What Happened?
What Happened?

Close

Not so Close
What Happened?

Straight is good

Straight is Bad
What Happened?

Funny

Not Funny
What Happened?

Exploitation

Stewardship

Exploration

Stewardship
Result:

Complexity
Isolation
Stress
Error
Solutions?

More People
Training
Engineering Advances
Psychology
Social Science
Ergonomics
Environmental Science

→ Computer Technologies
→ Communications Technologies
Two Case Studies

1. Computers manage the complexity of the drilling process

2. Telecommunication brings together people and information in real time
Computers manage the complexity of the drilling process.
Good Old Days WERE Good (ergonomically speaking)

- Comfortable Working Position
- Good Vision of Process
- Simple Display of Critical Information
- Low complexity
  - Low stress
  - Best performance
But now add:

- Intercom
- SCR Controls and Autodriller
- Pit/gas monitoring
- BOP Controls
- Service Company Info
And You Get:
THEN add controls and displays for:

- Top Drive
- Automated Drawworks
- Computer display of sensors and alarms
- Iron Roughneck
- Pipe Racking System
And You Get:
Ergonomic Nightmares

- Uncomfortable Working Position
- Poor Vision of Process
- Information Overload
- High complexity
  High stress
  Demotivation
  Potential for error
Other Examples
Managing Complexity

1. Create Comfortable but Engaging Work environment

2. Manage Presentation of Information and Controls
Step 1: Create Comfortable, Engaging Work Environment

First generation (early/mid-90’s)
Step 1: Create Comfortable, Engaging Work Environment

Second generation (mid/late-90’s)

- Stand up - Sit down
- Rotating pedestal
- Adjustable arm rests
- Workspace

- Front Entry
- Rotating Chair mount
- Clear view front and down

Displays use hi-brite color CRT’s or touch screen LCD’s
Ergonomically Designed Workstation

Up to “Hi-brite” Touch Screen Terminals with optional CCTV Support

Adjustable arm rests with gel packs and fingertip joysticks

Footrest
Ergonomically Designed Workstation

- Space for discrete controls
- Ergonomic Chair with Options
- Sliding Chair for Stand-up/Sit-down workstation operation
- Rotating Pedestal
Step 2: Manage Presentation of Information and Controls

First generation:

Data hardwired to console

Driller sees:
All the data
All the controls
All the time
Block Diagram of Second Generation System

Second generation:
Data routed to console by software, not hardwired
Driller sees:
Software-controlled presentation
Second Generation Operator screens

Custom Screens to fit specific applications
Process Based Screen (drilling)
Process Based Screen (drilling)
Process Based Screen (drilling)
Process Based Screen (auto drilling)

- HookLoad Window
- Elevator Position
- Auto Drill ON/OFF
- StandPipe Pressure
- Parameter Select
- ROP, WCB, TORQUE, DELTA P
- Top of Block Height;
- High Stop Point;
- Position Alert;
- Drill Stop Point;
- Lo Stop Point;
- Lo Travel Limit;
- Brake % Indicators
- Drawworks Direction Indicator
- Rig Status Windows
Process Based Screen (tripping)
Process Based Screen (tripping)

- Hookload Window
- Top of Block; High Stop Point; Position Alert; Drill Stop Point; Lo Stop Point; Lo Travel Limit;
- Brake % Indicators
- Elevator Position
- Auto Drill ON/OFF
- Stand Pipe Pressure
- Elevator Velocity Meter
- Maximum Hoist Speed
- Maximum Lower Speed
- Drawworks Direction Indicator
- Rig Status Windows
- Hookload Capacity Limit
Critical Information only: Kick “Smart Alarm”

Flow In/Out monitored in background
Trend anomaly triggers alarm
Driller pushes button to see:
Verification
Recommendation

<table>
<thead>
<tr>
<th>ALARM PAGE</th>
<th>DRILLING</th>
<th>8595 FEET</th>
<th>MARKS</th>
<th>22-MAR-94 11:49:32</th>
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</thead>
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<tr>
<td>FLOW IN</td>
<td>675</td>
<td>GPM</td>
<td></td>
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<tr>
<td>FLOW OUT</td>
<td>685</td>
<td>GPM</td>
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<td>TOTAL GAS</td>
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<td>UNITS</td>
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<td>GAIN/LOSS</td>
<td>2.7</td>
<td>BBLs</td>
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<tr>
<td>DELTA FLOW</td>
<td>8.4</td>
<td></td>
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</table>

DELTA FLOW INFLUX ALARM AT 11:41:26 8:06
FLOW OUT IS INCREASING BUT FLOW IN IS STEADY
A KICK IS POSSIBLE IF THIS TREND CONTINUES

FLOW IN/OUT monitored in background
Trend anomaly triggers alarm
Driller pushes button to see:
Verification
Recommendation

MASTER HORN ON | M/D TOTCO (C) 1994 | ALARMS ACTIVE
1 ALARM ACK | 2 RESET ALARM | 3 PRINT | 4 EXIT

FLOW IN/OUT
Flow/pressure monitored in background
Trend anomaly triggers alarm
Driller pushes button to see:
Verification Recommendation

Critical Information only: Washout “Smart Alarm”

### ALARM PAGE

<table>
<thead>
<tr>
<th>ALARM PAGE</th>
<th>DRILLING</th>
<th>8595 FEET</th>
<th>MARKS</th>
<th>22-MAR-94 11:49:32</th>
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</thead>
<tbody>
<tr>
<td>PUMP PRESS</td>
<td>3390 PSIG</td>
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<td>TOTAL SPM</td>
<td>205 SPM</td>
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<tr>
<td>FLOW IN</td>
<td>675 GPM</td>
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<td></td>
<td></td>
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<tr>
<td>WASHOUT</td>
<td>8.9</td>
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</table>

### PRESSURE DROP ALARM

- AT 11:41:26
- 8:06

PUMP PRESSURE IS DROPPING BUT FLOW IN IS STEADY

A WASHOUT IS POSSIBLE IF THIS TREND CONTINUES

### Graphs

- **FLOW IN**
- **PUMP PRESSURE**

### Controls

- MASTER HORN ON
- M/D TOTCO (C) 1994
- ALARMS ACTIVE

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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<tbody>
<tr>
<td>ALARM ACK</td>
<td>RESET ALARM</td>
<td>PRINT</td>
<td>EXIT</td>
</tr>
</tbody>
</table>
Result: Improvement of Physical and Mental Work Environment
Real Life Examples
Real Life Examples
Final thoughts on computers:

Potential Pitfalls
Potential Pitfall #1

Hardware and Software Reliability
Potential Pitfall #2

Software Programmers are not:

- Drillers
- Psychologists
- Ergonomics majors
**Potential Pitfall #3**

Computers manage details.
Humans synthesize and adapt.
**DON’T MIX THESE UP!**
Potential Pitfall #4

Don’t underestimate the time it takes to design “simple, reliable systems”
Computers manage the complexity of the drilling process
Telecommunication brings together people and information in real time.
The Good Old Days of Drilling

Remote Comm
(as far as you could shout)
What Happened?

Close

Close

Not so Close
What Happened?

Straight is good

Straight is Bad
Increased Complexity

Number of High-Technology Wells being Drilled

- **Horizontal**
- **Under-Balanced**
- **Coil Tubing**
Increased Complexity requires:

- Specialized expertise
- Specialized software
- “Real Time” decisions
“Specialized Expertise”
Problem: Shrinking Talent Pool

Employee Count of the 25 Largest Oil & Gas Companies

Average Age of SPE Member (2002)
“Specialized Software”
Problem: Too sophisticated for rig-site use

- Much Sophisticated software not local
  - Earth models
  - Geosteering
  - Drilling optimization

- Requires specialized training
  - Operate
  - Interpret
  - Consult with stakeholders
“Real Time Decisions”
Problem: Remote Locations

- Travel to rig-site increasingly impractical
  - Hours (land)
  - Days (offshore)
  - Not possible (political/safety)

- Offsite-onsite issues
  - Miscommunication
  - Lack of shared knowledge
  - Mistrust
Telecommunication can help bring together (electronically):

1. The “right” people
2. With the “right” information
3. At the “right” time
Telecommunication can help

Centralized Operations Center

Subject Matter Experts

Rig A

Rig B

Rig C

INTERNET

Subject Matter Expert
Earliest Example of Telecommunication in Drilling?

DAT (Digital Acquisition Technique). Teletype transmits data to time-sharing computer facility.

From 1972 “History of the Martin Decker Corporation”
First Generation Systems (80’s-mid 90’s)

- Amoco Critical Drilling Facility
- Tenneco Real Time Data Center
- Mobil Real Time Data Center (still in operation)
- Superior
- Pemex
- Later: Chevron, PDVSA, AGIP
Lessons learned

• Projects that failed:
  - Underestimated psychological impact (“Big Brother”)
  - Used “bleeding edge” communications technologies
  - Were operationally effective, but doomed by time and cost

• Projects that succeeded:
  + Kept control in hands of rig personnel
  + Used simple, conventional technologies
  + Had simple, compelling benefits shared by all
  + Emphasized consultancy over command-and-control

From SPE ATW on “Off Well Site Decision Making” (Austin, April 2002)
Second Generation Systems

Operations Centers (operators)

“Limited Duration Events” e.g. Remote Geosteering (Service Companies)

Integrated Services Centers (Service Companies)

Remote Rig Equipment Monitoring (Rig Equipment Suppliers)
Example 1: Operations Centers

Anadarko’s Operations Intelligence Center

- Based at Headquarters: The Woodlands (near Houston)
- Open since April 2002
- Collaborate around any activity (both on-line and off-line to rigs)
- Use in lower 48 and Alaska
- Soon to expand internationally
Anadarko’s Operations Intelligence Center

- Data Pilot Stations
  - Displays for weather/news
- Observation/Training Gallery
- Conference Area seating 12
- Display Wall with DLP Projection
Anadarko’s Operations Intelligence Center

With Real Time Data Feed
- Critical drilling operations
- Cementing operations
- Casing Point Selection
- Well testing/MDT logging
- Emergency response incidents
- Completions and stimulation treatments
- Logging operations
- Pressure transient analysis
- Non-critical drilling surveillance

With No Real Time Data Feed
- Training
- Development planning
- Post appraisals of engineering activities
- Learning curve analysis
- Acquisition and divestiture evaluations
Anadarko’s Operations Intelligence Center: Critical Problem Solving

- E-mail alert hits drilling engineer’s computer or Blackberry
- Rig needs decision critical information within next hour
- Team gathers in OIC and using all available data, software and communications capabilities
- Problem reviewed, data analyzed and decision made in minutes
- Decision relayed to field
Example 2: Integrated Services Centers

- Based in Stavanger, Norway
- Commercialized in 2001-2002 with BP and Norsk Hydro
- New center opened April 2002
  - capacity 15 rigs
  - 24 hours operation with real time data
- Second center opened in Houston

Information Courtesy of Baker Hughes, Inc. BEACON Service
Integrated Services Centers

RIG

- X-trained Dir. Driller
- Mud logger
- Operator personnel
- Drilling Contractor

Online:
- MWD
- Data Engineer
- Directional Driller

Increased TEAM IQ

Support Specialists:
- Directional Drilling
- Drilling Dynamics
- Pressure Management
- Formation and Log Evaluation
- Reservoir Navigation
- Software Support
- Product Expertise
Integrated Services Centers: Support Software Applications

- QC log “real time”
- Update of geological and reservoir models
- Geo steering
- Improved personnel utilization
- Real Time Data Transfer
- Drilling Optimization
Example 3: “Limited Duration” Events (Remote Geosteering)

- Real time wellbore placement
- Specialist runs operation from operator’s visualization room
- Monitor/analyze/control operation of geosteering tool
- Correlate LWD to modeled logs
- Wellplan adjusted dynamically
- Remote re-orientation possible
- Used on all North Sea, Middle East, South America and North America jobs since 2003

Information Courtesy of Halliburton StratSteer® 3D Service
Remote Geosteering
Remote Geosteering: Results

- Optimal wellbore positioning decisions
- Involves entire asset team
- Access to global experts
- Avoid NPT associated with waiting on orders
Example 4: Remote Rig Equipment Monitoring

“Smart People” offsite are connected on-line to “Smart Equipment” onsite

Service Center in Houston, TX USA
Since January, 2002
Four major offshore contractors, 14 rigs
One major land contractor, 19 rigs
Equipment monitored:
  Control and Information Systems
  Top Drives
  Pipe Handling Equipment
  Drawworks

Information Courtesy of Varco e-Drill Service
Remote Rig Equipment Monitoring

Goals:

1. Reduce Down Time (re-active)

2. Improve Performance (pro-active)
   - Insure Proper Operation
   - Insure Optimum Usage
   - Insure Proper Maintenance and Tuning
Rig Equipment Problem Resolution

- Rig Site Data Logging Computer
- Control and Information Systems / Top Drives / Pipe Handling Equipment / Drawworks
- Subject Matter Expert
- The Internet
- Service Center
- Network
- Voice

The Internet Service Center
Final thoughts on Telecommunication: Potential Pitfalls
Potential Pitfall #1

Big Brother
Potential Pitfall #2

Lack of Process and Policy

HSE Recommends:

- Process: Enhance, not restructure
- Policy: Develop formal decision policies that describe proper use of the technology

From SPE ATW on “Off Well Site Decision Making” (Austin, April 2002)
Views from the Health and Safety Executive (UK), Norwegian Petroleum Directorate (NPD) and Minerals Management Service (MMS)
Potential Pitfall #3

Making a “Bad” Situation Worse

• Operator-Contractor-Service relationship today:
  - conflicting goals
  - “bad” communication

• “Computer mediated” decision inadequacies
  - Less psychologically satisfying
  - Less efficient
  - Decision Quality degrades over time

From SPE ATW on “Off Well Site Decision Making” (Austin, April 2002)
From Presentation by Dr. Charles Samuelson, Industrial/Organization Psychology, Texas A&M
Potential Pitfall #4

Data Security

• In an IT sense, we have it
  – Virtual Private Networking (VPN) technology
  – Point-to-point data security

• In an operational sense, we don’t have it
  – Multiple creators and consumers of data
  – Who owns what data?
  – Who has the need-to-know?

• May be an irresolvable problem
Potential Pitfall #5

“Everybody Wants to Get into The Act”

- Multiple centers
  - Operators
  - Service Companies
  - Equipment Suppliers

- “Über-center” inefficient

- Must learn to “play together”
Further Study: Analogs from Outside our Industry

• International Space Station
  “Human Interactions in Space”
  – Remote, dangerous environment
  – Multi-cultural
  – More info at: http://www.kanas1.net

• Space Shuttle: Mission control
  and shuttle crew interaction
  – Command Structure
  – Roles and responsibilities
  – Use of situation simulations
Lessons Learned

- Technology readily available
- Focus on people and process
- Enhance, not change, decision structure
- Can be effective, but troubles ahead
Telecommunication brings together people and information in real time.
Questions?