SPE Applied Technology Workshop — ATW

Opportunities in Mature Oil Fields: Technical and Economic Challenges

Lima, Peru — 23-25 August 2006

Technologies for Mature Fields — A Compilation

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Mature Fields — Presentation Outline

- **Mature Fields Themes**
  - Resources
  - Major Issues
  - Concepts and Practices
  - Reservoir Description and Dynamics
  - Production Management
  - Water Management
- **Social-Technical Issues**
  - People
  - Environment
  - Social-Technical Systems

Mature Fields — Resources

- USGS and BP/Amoco (Schollenber-ger, 1998) estimate reserve addi-tions from mature fields worldwide at 400 billion barrels of oil and 600 trillion cubic feet of natural gas.
- SPE 62518 (Blaskovich) "Most of the remaining discovered oil in the world is either in fields that were initially developed before modern technology was available (pre-1970) ...

  Therefore, "old" is much more a function of development and operating practices than time. Roughly half of this oil (500 *billion barrels*) *is in these "old" fields."*

Mature Fields — Major Issues

- At current estimated decline in production of 2-5 percent/year, 10-19 MMBOPD of additional production will be required by 2010 just to keep up with demand.
- Not all mature fields can be rede-veloped profitably — environmental liabilities and redevelopment costs may exceed the value of proved and potential reserves.
- Mature field re-development has attracted attention because of high oil prices and moderate (or low) risk.
- The optimal recovery method for a particular field/reservoir should be established. Small companies target faster recovery whereas large companies generally pursue maxi-mum ultimate recovery.

Mature Fields — Concepts and Practices

- The start of tertiary recovery must coincide with the time/conditions for optimal microscale displacement efficiency.
- Mature fields revitalization consists of a set of activities which are focused on:
  - —The increase of recovery factors.
  - —The reduction of oil production decline.
  - —The anticipation of oil production.
  - —Management of the water cycle.
  - —Optimization of costs.
  - —Environmental assurance.
- Main challenges — Find and access the remaining oil and then lift and process the fluids while optimizing costs.
- The old paradigm — "Higher water injection rates and infill drilling could result in earlier water breakthrough and lower ultimate oil recovery" needs to be broken.

Mature Fields — Reservoir Description/Dynamics

- Reservoir simulation techniques have not changed substantially in ~20 Years. We cannot perform simulation "better" than we could 20 years ago — but we can do it better, faster, and easier.
- Unique challenges with mature fields — massive volume of data of varying quality.
- There is only 1 reservoir model — not a "static" or a "dynamic" model, but the true reservoir model. The entire team must approve the model and must participate in the development of the reservoir model.

Mature Fields — Reservoir Description/Dynamics

- Operational problems affect past history and will affect future performance.
- Today's oil recovery practices leave behind a large quantities of "stranded oil." For example, in only six regions (Onshore California, Onshore Gulf Coast, Offshore Louisiana, Oklahoma, Alaska and Illinois) it is estimated that there are 43 billion barrels oil considered to be recoverable using the latest CO2-EOR technologies.

Mature Fields — Production Management

- Two-phase flow (wellbore).
- Gas Lift (design/optimization).
- Production Optimization:
  - —Barriers (lack of skill/time).
  - —Well/reservoir performance.
  - —Detailed reservoir knowledge.
- Economic Issues:
  - —Cost management.
  - —Utilization of surveillance data.

Mature Fields — Water Management

- **Surveillance Technologies:**
  - —Injection/Production: Tracers (Chemical and Radioactive), Selective Polymers, MEOR, etc.
  - —Operation Practices: Flow logs (PLTs), selective completions, measurement systems, cement-ing corrections.

- **Integrated water management — water quality control, injection maintenance via hydraulic fracturing and infill drilling.**

- **Gel Technologies:**
  - —Interval isolation (high WOR).
  - —Gel placement requires specific practices.
  - —Evaluate water compatibility,

Mature Fields — People

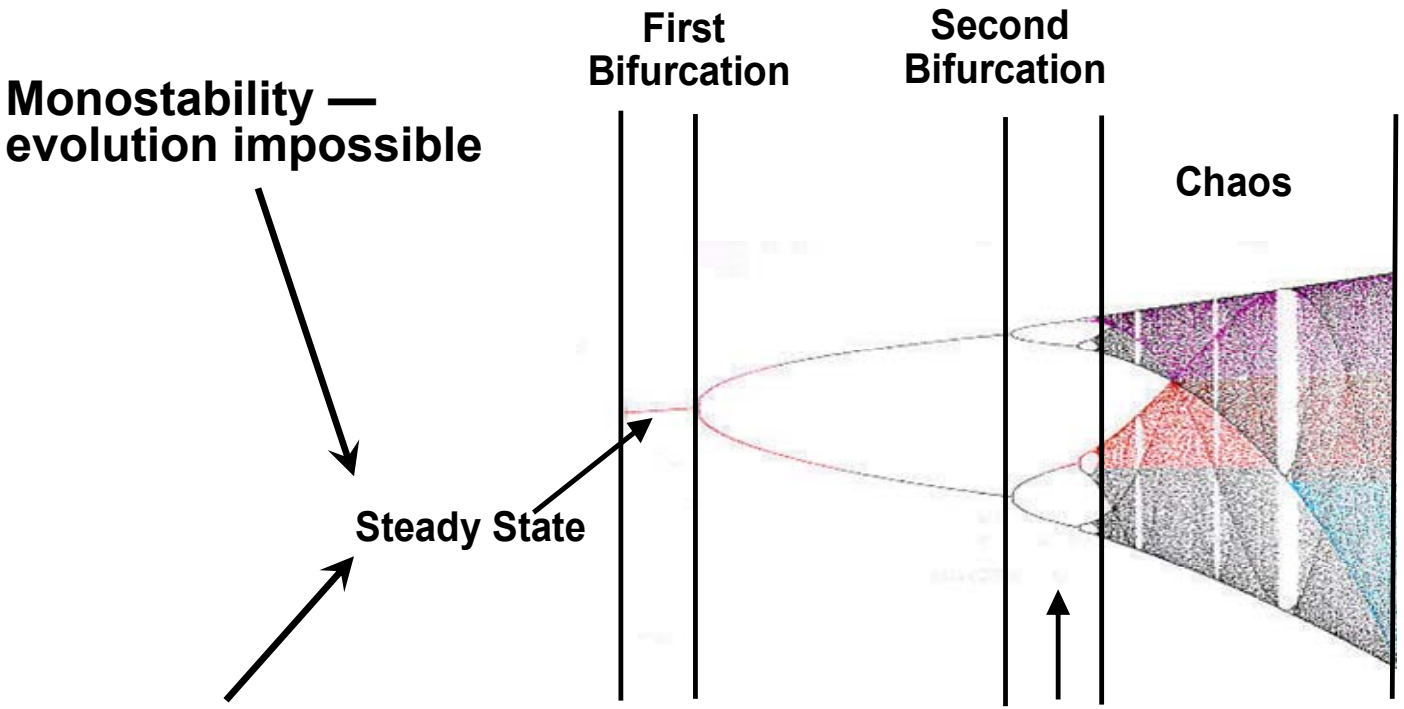
- Greatest threat is lack of skilled personnel — present and future. Input (academia) and knowledge retention (retirees) require attention … now!
- Integrated teams — geology, petro-physics, geophysics, sedimentology, geostatistics, geomechanics, produc-tion engineering, drilling operations, reservoir engineering, surface facilities … and more.
- Well construction requires drilling, geology, petrophysics, geosteering experts — and real time data.
- Integration = communication.
- Time must be provided to develop competence in required job skills.

Mature Fields — Environmental Aspects

- Environmental impacts — CO2, Flares, CH4, H2S, Drill cuttings, HC contaminated soils, HC contaminated water, toxic gasses, solids and chemicals
- Water Management:
  - —Re-injection of produced water.
  - —Discharge of produced water (oil in rivers & seas).
- Regulations: Offshore safety and environmental issues, environmental rules and regulations from government about water/sand deposition

The "Edge of Chaos:" (Interesting Things Happen…)

"GREEN FIELDS" "BROWN FIELDS"



Opportunistic Regime
"Edge of Chaos"
Conducive to Self Organizing Systems
Conducive to Complex Adaptive Systems

Organizations capable of evolving and adapting

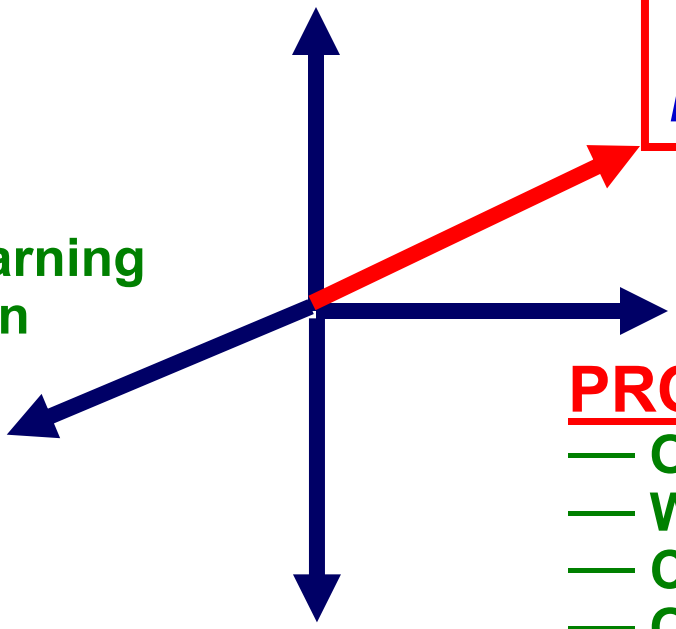
Diagram courtesy of Dr. Linda Beckerman,
Director of Systems Engineering
the ASSET Group, SAIC

Socio-Technical Systems: Dimensions

TECHNOLOGIES
(R&D → APPLICATION)
- Cycle Time
- Methods, Tools & Equipment

PRODUCTIVITY (MORE VALUE LESS TOTAL COST)

PEOPLE
- Demographics
- Competencies
- Networking
- Individual/Team Learning
- Creativity/Innovation



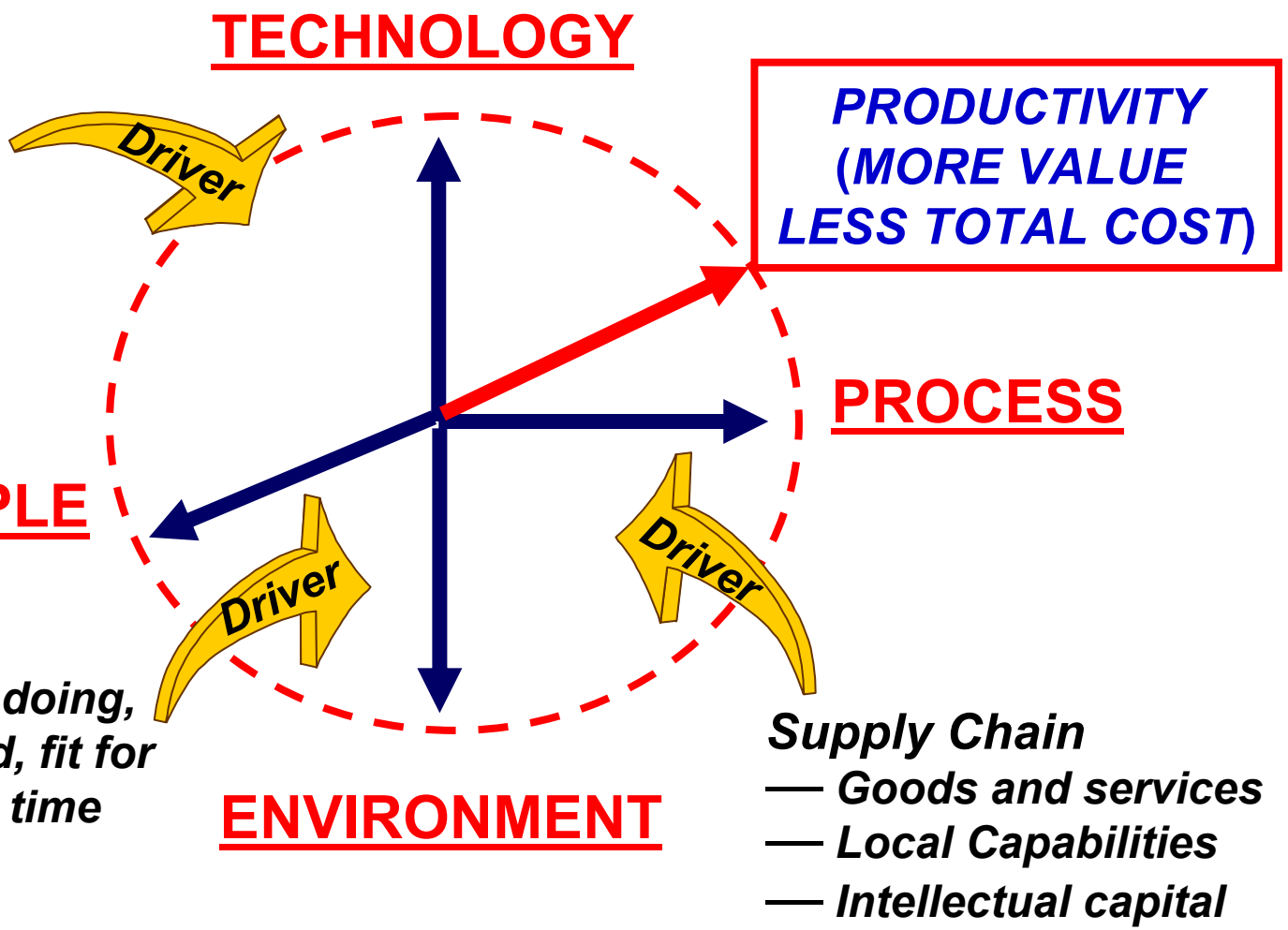
PROCESSES
- Organizational Capacity
- Work flow
- Cycle Time
- Quality

ENVIRONMENT
- Natural resources
- Air, Water, Land
- Biodiversity
- Work

Socio-Technical Systems: Drivers

Integrated Risk Management of Assets

- *Risk/Reliability*
- *Data/Information*
- *Reservoir Life Cycle*
- *Total Cost*



Knowledge Management

- *Learning while doing, results-oriented, fit for purpose just in time methodologies*

Supply Chain

- *Goods and services*
- *Local Capabilities*
- *Intellectual capital*

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(End of Presentation)

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