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Implementing Chevron's *i-field* at the San Ardo, California, Asset

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Abstract

This is a case study of an integrated "digital oilfield" project. The San Ardo, California, *i-field* Project is one of a number of current Chevron *i-field* implementation projects. It seeks to transform how the San Ardo steamflood is operated, focusing on better decision making for the asset and streamlined work processes for heat, wells, and water management. The San Ardo *i-field* project is nearing the end of the planning and front-end engineering phases, with project execution starting in 2006. The project team created preferred alternatives for transforming 21 work processes. Decision support software would be integrated with improved instrumentation, workflow automation, and data architecture to enable more reliable and efficient field operation and execution of reservoir management targets. The project is integrated in two ways. First, integration occurs across the asset management value chain from reservoir through production optimization to day-to-day steamflood and facilities decisions and work processes. Secondly, it is integrated across technology. For example, reservoir surveillance signposts are created and used with computer models to move day-to-day decisions along correct trajectories for executing reservoir heating and production management. A common collaboration and visualization environment would be used for executing day-to-day field decisions. The knowledge provided in the paper would be helpful for assets where field operators are managing many wells with limited resources and attempting to improve their operability and efficiency.

Introduction and description of San Ardo oil field

The San Ardo field, shown in Figure 1, is located in Monterey County, California. The field includes the Aurignac and Lombardi unconsolidated heavy oil (12.5 gravity) sandstone reservoirs.

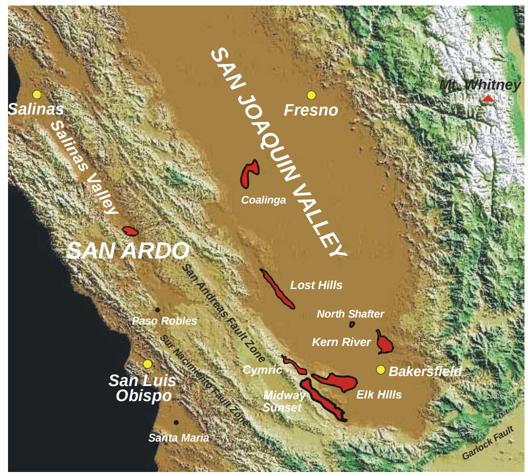

Figure 1. Location of the San Ardo field in California.

The San Ardo Field was discovered in 1947 and to date Chevron has produced 257 MMBO of the field total 453 MMBO through primary, cyclic steam, and steamdrive operations. Chevron currently produces about 3,000 BOPD.

Chevron plans to increase San Ardo production through a major capital project approved in 2005 which would add additional wells and associated infrastructure. The development plan consists of dewatering/depressurizing the reservoir while simultaneously expanding the number of steamflood patterns. A commercial reverse osmosis plant would be constructed to process produced water.

The capital project would also be enhancing the data base infrastructure significantly. This creates a "greenfield" opportunity for *i-field* to take a fresh view when designing workflows. The *i-field* implementation is being phased in as the San Ardo major capital project begins its construction.

Approach used in designing the San Ardo *i-field*

As stated by Unneland and Hauser (Ref. 1), an *i-field* is operating the oil field with:

- Faster and better asset management decision-making
- Taking a multi-discipline, cross-workflow & systems view to asset management – not just "my world"
- Making the right data easily available to whoever needs it
- Balancing automatic & human decision-making

The San Ardo *i-field* project design focuses on automated optimized workflows resulting in better integration, enhanced decision making, and reliable field execution. New technology is critical to success by enabling the integration, decision making, and execution. The approach in designing the San Ardo *i-field* was as follows:

- Identify critical outcomes for success
- Identify key work processes in heat, well, and water management that need to occur with high reliability for success
- Identify input-output "connectors" between these work processes where integration and collaboration is critical to reliable execution in the field.
- Pinpoint and identify behaviors which drive results
- Use a "trajectory and signpost" approach for optimizing short-term decisions with longer term reservoir management tools.
- Identify the preferred alternatives for transforming each of the key work processes. For each work process include necessary hardware, instrumentation, decision support software, collaboration, change management, and new technology requirements.
- Sustain the competitive advantages that flow from *i-field* Project innovations by systematically securing intellectual property rights
- Create a phased execution plan to capture value in time for the major field development project
- Integrate R&D efforts where technology gaps exist
- Share lessons learned in order to accelerate change at other locations

At a high level it was found that *i-field's* integrative role for San Ardo is to provide work processes and technology to accomplish the following:

- Ensuring that the concurrent dewatering and steamflooding of the Lombardi reservoir tracks the Lombardi Expansion Project plan. Creating an optimum plan to implement recommended latent heat requirements. Optimizing the steam system.
- Minimizing the delays in the pattern-by-pattern Lombardi field development. Creating flexibility to respond to reservoir and well changes. Providing a common view, collaboration environment, and tracking of the many facilities and well activities in order to minimize down time.
- Managing the complexity of the water management processes to ensure strict water discharge requirements are met. Providing decision support tools for responding to changing conditions while meeting steam requirements.
- Managing the interfaces between Chevron and the many business partner contractors in the field, particularly during peak field development.

Value Measures for the San Ardo i-field

The most important value measures for this project are:

1. Safety - injury and incident free operations
2. Production – increasing it and minimizing lost or deferred production.
3. Operating expense per barrel reduction - savings related to performing the same task or arriving at the same decisions, but with lower operating expense, improved capital efficiency and well/facility utilization.
4. Workforce capability - Developing capability for San Ardo to enhance business performance for current and next generation work force.

Results to Date

The project team created preferred alternatives for transforming 21 work processes. For each work process the project team included recommended necessary hardware, instrumentation, decision support software, workflow automation, collaboration, change management, and new technology requirements. The work processes are as follows:

<u>Heat Management Work Processes</u>

- Establishing latent heat requirements for patterns
- Generating steam to meet steam demand
- Transporting and delivering steam to injection wells
- Scheduling and executing cyclic steam jobs (see Appendix for more detail)
- Managing casing blow
- Monitoring steam injection
- Heat management lookback
- Reservoir surveillance

<u>Well Management Work Processes</u>

- Oil producer surveillance
- Dewatering and depressuring the Lombardi reservoir
- Lombardi field pattern development
- Identifying well servicing opportunities
- Scheduling and executing well servicing with other field activities
- Responding optimally to changed wastewater discharge capacity
- Scheduling, performing, and documenting idle well integrity tests

<u>Water Management Work Processes</u>

- Receiving produced water and routing to treatment or disposal
- Disposing of waste water by reinjection
- Treating produced water for the softener and reverse osmosis plant
- Delivering softened water to steam generators
- Operating the reverse osmosis plant
- Discharging treated produced water to the wetlands and recharge basins

The Appendix provides an example with more detail for one of the work processes: "Scheduling and executing cyclic steam jobs". It includes a work process description summary, key decisions resulting from this work process, "connectors" (inputs/outputs) with other work processes, alternatives considered, and alternatives recommended.

In the current project phase the team is developing the specifications for the steam system optimizer to help transform most of the heat management work processes. In addition, the team is developing the data architecture, instrumentation and hardware specifications to support the *i-field.* Lastly, the team is developing a prototype field visualizer for a "master scheduler" as described in the Appendix.

Asset Decision Environment

The San Ardo *i-field* Project provides one of the early implementations of the Asset Decision Environment (ADE), as described in Unneland and Hauser (Ref. 1). The San Ardo ADE would support enhanced collaboration and rapid decision making among the various people who are executing key work processes. It includes the physical environment, such as a field Operations Center and a headquarters Decision Support Center. It also includes the underlying information technology, such as data architecture, computer systems, and field telecommunications. Through the Chevron joint venture with SAIC, the project team created the preferred ADE alternatives.

Many of the San Ardo *i-field* work process changes will need a place where people can collaborate by seeing the same up-to-date information. Currently a prototype visualization environment for the San Ardo field is being developed jointly with Epsis. The prototype visualizer will provide an integrated view of the field activities. While this is important for any field operation, it will become even more critical during the Lombardi Steamflood Expansion Project which will increase the San Ardo field activities. The pilot visualizer will use Epsis-proprietary ERA software to deploy these work processes in an Operation Center environment. The next phase of the visualizer development will include displaying information to support important heat management and field development work processes.

In a separate but connected project a headquarters Decision Support Center (DSC) is being developed to standardize and implement maintenance and operational best practices across the San Joaquin Valley Business Unit. The DSC is intended to support field operations by leveraging the knowledge of subject matter experts collectively viewing a standardized data set. The first business unit-wide practice to be supported by the DSC is steam management, which is a significant operating expense.

Engaging the Operating Organization

The project team from its inception had experienced members of the field organization. In addition the Decision Review Board included the San Ardo Asset Operating Supervisor and Manager. The project team found that communication with the people impacted by the *i-field* project was enhanced by creating a large San Ardo *i-field* "Storyboard". People could visualize how *i-field* would work and connect at San Ardo through the Storyboard. It changes as the project changes, and will remain evergreen throughout the project.

Conclusions

1. The San Ardo, California, *i-field* Project is one of a number of current Chevron *i-field* implementation projects. It seeks to transform how the San Ardo steamflood is operated, focusing on better decision making for the asset and streamlined work processes for heat, wells, and water management.
2. The San Ardo, California, *i-field* Project is connected to a large field development capital project. This creates a "greenfield" opportunity for i-field to take a fresh view when designing workflows.
3. The San Ardo *i-field* Project is nearing the end of the planning and front-end engineering phases, with project execution starting in 2006.
4. The project team created preferred alternatives for transforming 21 work processes. Decision support software would be integrated with improved instrumentation, workflow automation, and data architecture to enable more reliable and efficient field operation and execution of reservoir management targets.
5. New and existing technology is a critical enabler for transforming work processes.
6. New collaboration environments in the field and in the headquarters are being constructed.
7. Intellectual property rights shall be systematically secured to sustain the competitive advantages afforded by *i-field* Project innovations.
8. The project team found that communication with the people impacted by the *i-field* project was enhanced by creating a large San Ardo *i-field* "Storyboard".

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References

1. Unneland, T. and Hauser, M., "Real-Time Asset Management: From Vision to Engagement – An Operator's Experience", paper SPE 96390, presentation at the 2005 SPE Annual Technical Conference and Exhibition held in Dallas, Texas, U.S.A., 9 – 12 October 2005.

Appendix

San Ardo *i-field* Work Process: "Schedule and Execute Cyclic Steam Jobs"

Description of work process

The term "cyclic steaming" refers to using producing wells to inject steam on an intermittent basis. In a mature steamflood it is used primarily to improve well productivity. In an immature steamflood it can also be used for reservoir heating. Selecting the best candidates for cyclic steaming and implementing them reliably, efficiently, and safely is an important work process for delivering proper latent heat to the Lombardi patterns and meeting oil production targets. Current processes are mostly manual and sub-optimum.

In addition to work process and technology improvement opportunities, there may also be opportunities for modifying current automated well testing (AWT) manifold limitations (e.g. one well extracting steam per take off to the manifold station) which limit optimization. Figure 2 shows a typical layout.

Lastly, there is an opportunity through *i-field* may to integrate the cyclic steam injection work process into an overall process to automate the controls of steam generation and distribution, driven by heat management design. It may improve reliability, efficiency, and consistent execution of latent heat to the reservoir.

<u>Key Decisions resulting from this work process</u>

- Are latent heat changes necessary, and to which wells (injectors & producers), in order to develop the Lombardi steam chest as planned at lowest cost?
- How does one alter the daily operations schedule (not to conflict with other operations) based on current steam activity?
- How does one prioritize between cyclic and continuous injection demand? How is the steam distribution system operated?
- Given current constraints (e.g. facility and well) where can the steam be put to optimal use, including process heat needs?

<u>This work process uses outputs from the following other work processes:</u>

- Establish latent heat requirements for patterns
- Transport and Deliver Steam to Injection Wells
- Managing casing blow
- Monitoring steam injection
- Responding optimally to changed wastewater discharge capacity

<u>The output from this work process is used in the following other work processes:</u>

- Transport and Deliver Steam to Injection Wells
- Monitoring steam injection
- Delivering softened water to steam generators
- Treating produced water for the softener and RO plant

<u>Alternatives considered:</u>

1. Default – No change from current practice.
2. <u>"No service rig"</u> - Develop a cyclic steam job design (physical setup of well) that successfully delivers the latent heat to the reservoir but does not require the use of a service rig.
3. <u>"No cyclic jobs early on"</u> - Evaluate and compare using some of the producers as temporary continuous injectors.
4. <u>"Change the AWT manifold"</u> - Evaluate alternate AWT manifold geometries to provide more cyclic steam scheduling flexibility. Compare with current design for impact on cost, steam chest buildup rate.
5. <u>"Focus on a better cyclic scheduler"</u> - The schedule could be generated automatically and then modified by key personnel for logistic, other activity, and safety reasons. The schedule would be visible through the "Master Scheduler" and the ADE.
6. <u>"Streamline the entire cyclic steam work process"</u> - Streamline existing manual work process with workflow automation tools and improved decision support software:
   a) *Steam Job Design* (physical setup of well) - Streamline the work process with a template and integrate into the "Master Scheduler"
   b) *Pattern Steam Target* (there may be two different targets depending on goal) – Use latent heat targets from the *"Determining Latent Heat Requirements"* work process
   c) *Candidate Selection* - The schedule would be visible through the "Master Scheduler".
   d) Prepare well for steam – Evaluate work process improvements for rig availability and/or operator setup.
   e) *On steam, monitor cycle* - Continuous measurement of latent heat can dynamically control individual steam jobs and drive the steam schedule.
   f) *Return well to production* - This could either be part of the "Steam Scheduler" or could be integrated into the POC logic.
   g) *Job lookback* – This ensures that proper latent heat was applied.
7. <u>"Integrate cyclic steam process with other Heat Management and well work processes"</u> - Develop Alternative 6 above and integrate with the other heat management work processes. This would automate the controls of steam generation and distribution, driven by heat management design.

<u>Preferred Alternative</u>

The team evaluated the various alternatives and tradeoffs and recommended that particular options be developed in the next project phase. Intellectual property rights are being secured for these options. These options would provide the most cost effective way of creating value through improved production, opex reduction, and increasing the workforce capability.

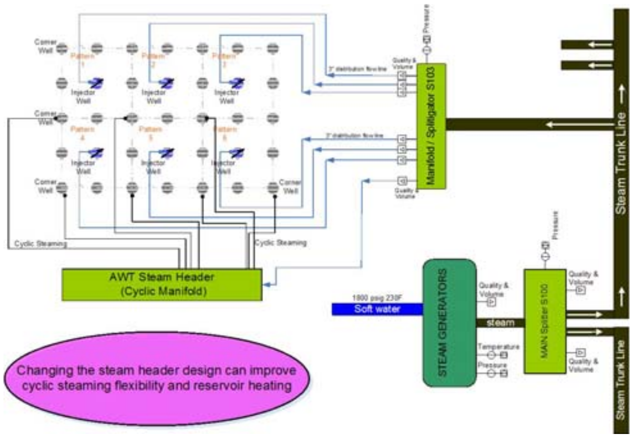

Figure 2. Cyclic steam physical layout