Redpaper

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Case Study: Production Optimization Scenario for Chemical and Petroleum

This IBM® Redpaper™ publication is one in a series of service-oriented architecture (SOA) papers that feature a case study that involves a fictitious company called JKHL Enterprises (JKHLE). In this paper, we focus on the chemical and petroleum division of JKHLE, JKHL Oil and Gas.

This paper shows that by automating workflows for well testing and well performance monitoring processes, and optimizing the use of existing upstream assets associated with oil production, JKHL Oil and Gas can reduce lost production and increase the effective amount of barrels of oil produced each year.

IBM Chemical and Petroleum Integrated Information Framework

IBM provides industry solution offerings based on industry assets and best practices that enable agile and efficient real-time operations. Many leading chemical and petroleum companies are approaching transformation progressively, implementing solutions one project at a time. But how do you do this and ensure that your solutions fit together? The answer to this is the IBM Chemical and Petroleum Integrated Information Framework. It provides a framework for transformation that creates flexibility and accelerates the deployment and integration of multiple chemicals or petroleum solutions (Figure 1).

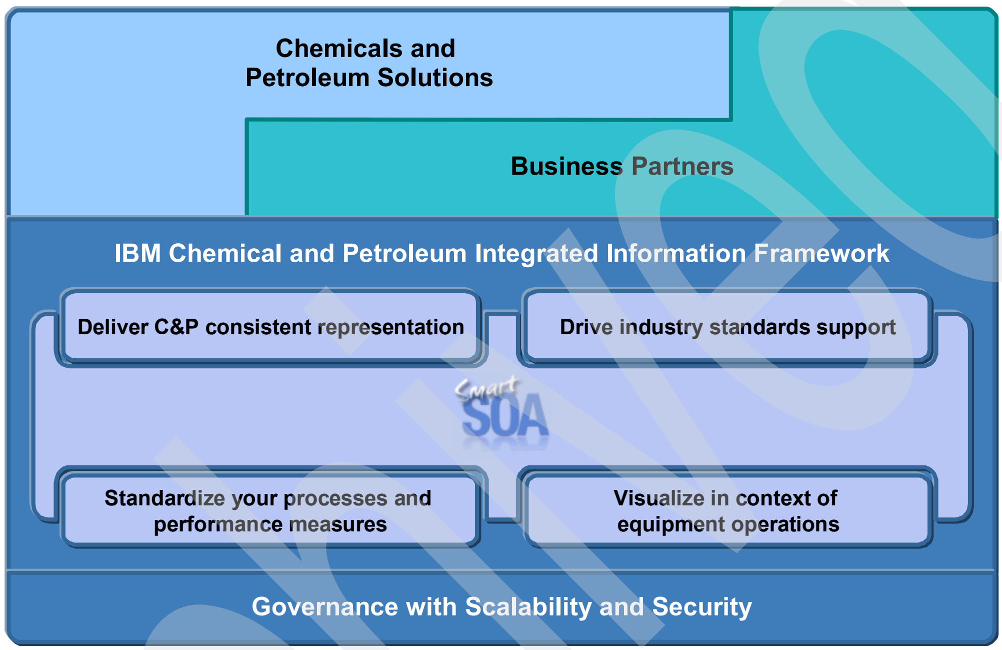

Figure 1 IBM Chemical and Petroleum Integrated Information Framework

The IBM Chemical and Petroleum Integrated Information Framework provides the following capabilities:

- A chemical and petroleum standards-based model built by linking multiple industry standards to form an enterprise-wide ontology.
- Enterprise name space management that provides a consistent data and object naming service that effectively maintains equipment relationships, as well as tracks events and conditions across multiple unit operations, well fields, plants, and refineries.
- Industry standards-based information access that allows reuse.
- Visualization, KPI's, and complex event management with configurable events and alerts that integrate with business processes and Web services.
- Performance monitoring, production monitoring and reporting that helps speed standardization of work processes.
- A single visual access method to your operations through an interactive, thin-client workbench that provides a foundation for collaboration and business execution.

The IBM Chemical and Petroleum Integrated Information Framework addresses problems across multiple domains (Figure 2):

- The integrated operations for upstream petroleum domain helps deliver optimized integrated operations at a lower cost.
- The integrated operations for downstream petroleum domain drives better refining decisions and processes at lower cost with optimization.
- The integrated operations for chemicals production domain helps optimize batch and continuous production performance at lower cost.
- The asset management domain integrates operations with enterprise asset management to reduce down time to raise production and reduce unplanned outages.
- The location awareness and safety domain uses instrumented devices to speed processes, reduce errors, and increase safety.
- The performance management domain helps you use business analytics to monitor and increase business performance.
- The supply chain management optimization domain helps you transform your supply chain to be more efficient and competitive.

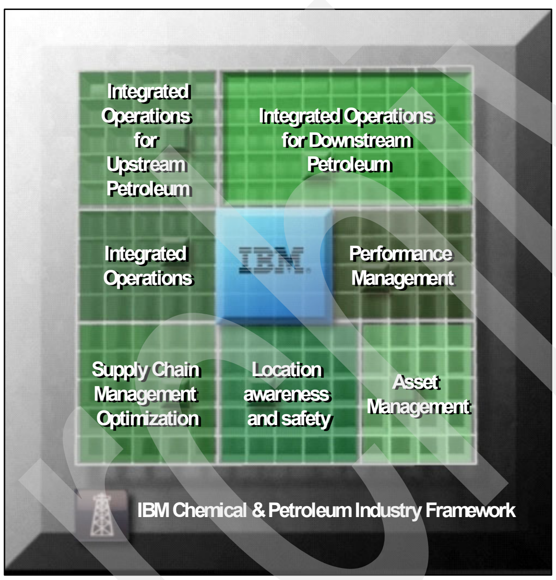

Figure 2 IBM Chemical and Petroleum Integrated Information Framework domains

Chemical and Petroleum market forces

This section explores some of the emerging market forces in the chemical and petroleum industry.

Chemical and petroleum market forces

The following market forces are driving the chemical and petroleum industry to transform its operations:

- Economic pressure

  A growth in energy demand coupled with a constrained supply strains reserves and production.

- Environmental

  Climate change, rising energy costs, and Health Safety Security Environment (HSSE) are factors.

- Risk management

  The industry faces regulatory and compliance pressures, and enterprise-wide risk management beyond HSSE.

- Technology

  Technology forces include advances in connectivity, overwhelming amounts of complex data from instrumented equipment, high performance and services computing, and the need for real time collaborative decision making. These technology changes, coupled with the difficulties of oil exploration, continue to test the limits of IT.

- Operations

  Areas of focus include production costs associated with existing assets, a skills shortage heightened by remote asset-intensive operations, hard standardizing processes across diverse environments, and siloed systems challenge operators and operations analysis.

The chemical and petroleum industry must focus on enabling more efficient and flexible operations to address the challenges of their changing environment.

How companies are responding to industry forces

Today, smart oil and gas organizations are working to make better use of data. This means smarter oil and gas fields, smarter refining operations, and smarter supply chain processes to achieve the following benefits:

- Enhanced exploration and production
  - Integrating and processing geophysical and other relevant data to develop 3D models of reservoirs to find previously inaccessible oil and gas, and to capture information about its volume and quality before a new well is drilled.
  - Using sensors embedded across pipes, pumps, and an entire field to generate data that can be compared against historical trends and applied to optimize well performance and increase recovery rates.
- Improved asset management

  Using sensors and predictive analytics to enhance production flexibility and responsiveness to supply and demand fluctuations in the market that improve asset availability and reliability.

- Optimized global operations

  Increase visibility, mitigate risk and lower costs across the asset chain.

Specific challenges facing upstream oil production

As the exploration production environment grows more diverse and remote, the terrains are more unforgiving and the business challenges are more complex. Some of the challenges facing upstream oil production are:

- Difficultly maintaining oil and gas field production targets due to maintenance of existing upstream assets and a depletion of accessible reserves.
- Difficulty increasing the yield on existing physical assets employed.
- A globally disbursed and aging workforce dependent on manual human-centric processes who are unable to collaborate effectively.
- Increased lifting costs brought about by difficulties analyzing and collecting real-time data.
- Numerous technological issues including outdated existing systems and processes, and difficulty obtaining, storing, and validating vast amounts of real-time data across upstream assets.
- Manual processes are not standardized and data calculations are highly error prone.
- Governmental and regulatory (per geography) pressures make it difficult to discover and exploit new oil and gas reserves.

Effective companies will respond to these challenges by:

- Reducing costs by standardizing and automating agile processes across upstream assets.
- Increasing return on assets by integrating and visualizing information across the life cycle of currently employed assets.
- Innovating and increasing agility by increasing real-time operations monitoring, data processing and validation, and workforce collaboration.

JKHL Oil and Gas in the chemical and petroleum industry

JKHL Oil and Gas is a fictitious chemical and petroleum company that, for the sake of this paper, is one of the largest oil and gas companies in the world today. Let us assume the company currently operates on a global scale, conducting exploration and production activities on four continents.

The core mission of JKHL Oil and Gas is to explore for, and produce petroleum and natural gas products to enhance the quality of life for individuals and improve economies worldwide. With the recent discovery of three new oil and gas fields, JKHL Oil and Gas has shown its ability to compete effectively against the competition in an industry where oil supplies are increasingly harder to find. However, the current economic climate has resulted in major setbacks and has forced JKHL Oil and Gas to look for leaner operating models and processes.

JKHL Oil and Gas are considered innovators in the industry and are committed to adopting technology to integrate disparate systems, increase production capacity, and lower production costs so that they may better meet the growing demand for energy. Ultimately, JKHL Oil and Gas plans to become the worldwide leader in oil and gas exploration and production.

The case study described in this paper includes the following key actors and roles:

- Thomas Arnold, Chief Operating Officer, JKHL Oil and Gas
- Sandy Osbourne-Archer, Chief Technical Architect, JKHL Oil and Gas
- Matthew Chu, Chemical and Petroleum Industry Architect, IBM

In a meeting with Sandy Osbourne-Archer, Chief Operating Officer Thomas Arnold says that he wants to:

- Reduce lost production.
- Decrease maintenance costs.
- Eliminate HSSE incidents.

Thomas challenges Sandy to deploy new technology to lower production costs and help make safer and faster operational decisions.

How JKHL Oil and Gas plans to respond to upstream challenges

Thomas Arnold and Sandy Osbourne-Archer have agreed that JKHL Oil and Gas will focus on production optimization to address upstream challenges. These challenges and their solutions include:

- Difficulty maintaining oil and gas field production targets

  JKHL Oil and Gas will monitor the production and contribution of each well continuously to ensure demand is properly met.

- Difficulty increasing the yield on existing physical assets employed

  JKHL Oil and Gas will reduce planned and unplanned shutdowns, increase production effectiveness, and improve decision-making on existing assets from centralized sites and process centers of excellence.

- Manual processes are not standardized and data calculations highly error prone

  JKHL Oil and Gas will work to standardize and automate human-centric processes to reduce costly errors, increase collaboration and response times, and eliminate HSSE incidents.

- Validity of real time well data

  JKHL Oil and Gas will ensure accuracy of decisions by increasing the correctness of data gathered by upstream assets.

- Geography specific regulatory compliance

  With operations in multiple countries worldwide, an effort will be made to ensure accurate oil and gas production data per geography so that compliance with industry and government regulations is met.

Why JKHL Oil and Gas will optimize production operations

Oil production for JKHL Oil and Gas includes:

- Continuously monitoring reservoir performance to gather well data, identify problems, and ensure maximum hydrocarbon recovery.
- Performing periodic well tests to identify issues and recommend corrective actions.
- Reconciling and validating data throughout the production process.
- Estimating, mitigating, and managing declines in production and injection rates.
- Maintaining reservoir pressure.

Carefully monitoring performance is an operational necessity, because a reservoir shift in productivity for one or more wells endangers projected production schedules and fulfillment targets for the well platform of field. Additionally, a key building block and significant business value contribution for performance monitoring is the care and discipline taken to do periodic well tests (a typically human-driven manual operation).

To reduce lost production and increase the effective amount of barrels of oil produced each year, Thomas and Sandy agree to recruit IBM to analyze their existing business processes and provide recommendations for a business transformation. This IBM team is led by Chemical and Petroleum Industry Architect Matthew Chu.

Capability model for optimized production processes

Matthew Chu draws up a capability model. A capability model ties business capabilities to initiatives. In this case, Matthew verifies that the core capabilities that JKHL Oil and Gas identified as being vital to the company are mapped to its new offerings that will, in turn, be addressed by the company's new initiatives. The capability model is shown in Figure 3.

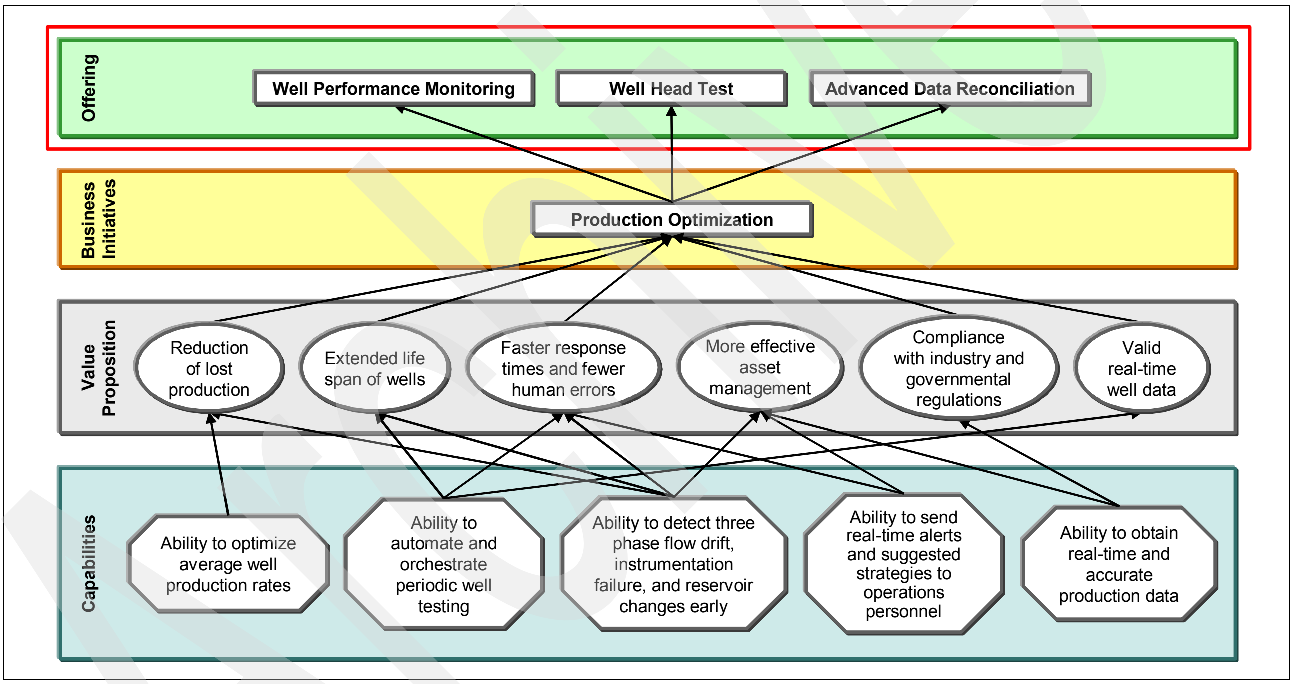

Figure 3 Capability model for optimized production processes

Based on the capability model, the production optimization initiative will consist of three offerings (Figure 4 on page 8):

- Well Performance Monitoring
  - Continuously monitoring the three phase flow of sediments (water, oil, and gas) retrieved from reservoirs.
  - Calculation of the gas to oil ratio (GOR) at the piping manifolds and separator units, and comparing well potential with actual output.
  - Detection of wells that are not performing properly.

- Well Head Test
  - Production and optimization technique driven by unacceptable drift identified during well performance monitoring.
  - Tests the input and output flow rates at multiple choke valve settings while connected to a test separator.
  - Output is used during well performance monitoring.
- Advanced Data Reconciliation
  - Continuous detection of incorrect real-time data stored in the data historian.
  - Enables the substitution of invalid or missing data with corrected measurement values.

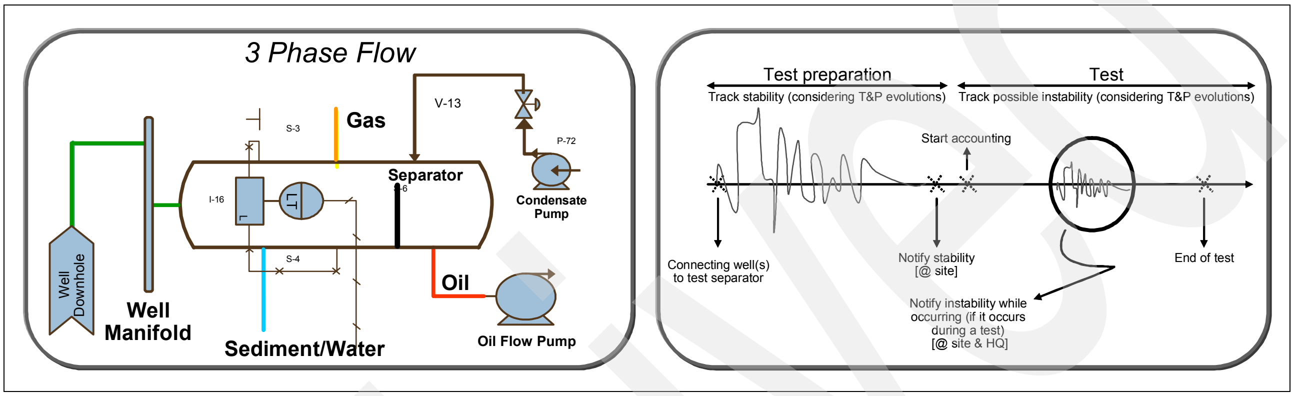

Figure 4 Production optimization processes

Modeling the Well Performance Monitoring, Well Head Test and Advanced Data Reconciliation processes

In this section, IBM Chemical and Petroleum Industry Architect Matthew Chu and his team works with Sandy Osbourne-Archer to define an improved business process model for production optimization at JKHL Oil and Gas.

Refined Well Performance Monitoring process

The first production optimization process that Matthew Chu focuses on is the Well Performance Monitoring process. Sandy Osbourne-Archer explains the challenges that JKHL Oil and Gas are currently experiencing with this process:

- Difficulty in monitoring and maintaining production level targets in large and mature gas-lifted fields.
- An inability to measure and monitor effectively the drift of estimated GORs to the cumulative data captured from the separator.
- Process events and alerts are not defined, distributed, and subscribed to across the enterprise to initiate business processes or personnel collaboration or prompt attention.
- Production engineers are unable to identify quickly suspect wells that are in need of a well head test.

Matthew Chu shows Sandy the refined Well Performance Monitoring process (Figure 5).

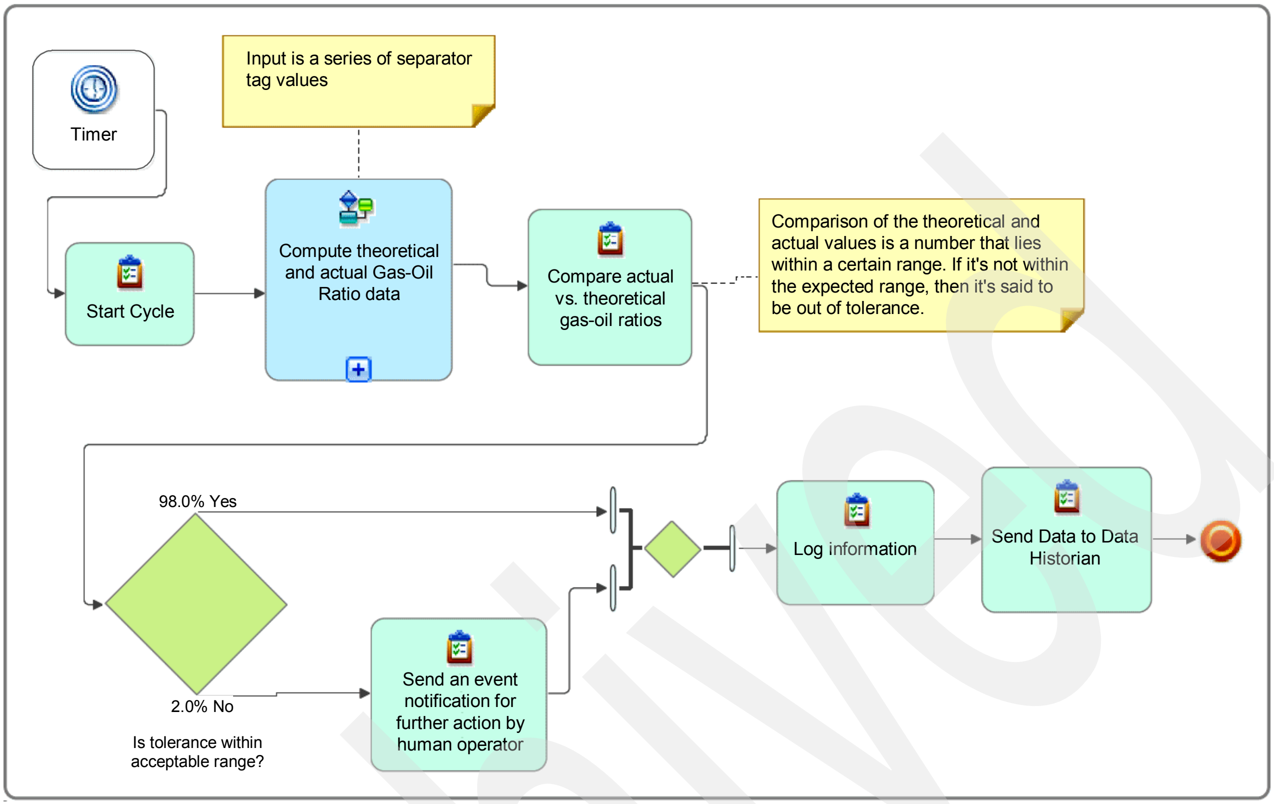

Figure 5 Well Performance Monitoring: tier 1

The Well Performance Monitoring process performs the following actions:

1. Computes the theoretical and actual gas oil (GOR) ratio with data loaded from the data historian.
2. Compares theoretical and actual GOR data.
3. If GOR values for each well are not within the acceptable tolerance range, a notification is sent to a production engineer to perform the necessary next steps.
4. All resultant data is logged to the data historian.

Matthew Chu explains the benefits of this refined process:

- Comprehensive well performance monitoring enables production engineers to optimize average well production rates by quickly pinpointing individual well or separator train issues.
- Corrective actions can be initiated in less time, minimizing deferred production while also gaining valuable insight into oil and gas field issues.
- Allows the reservoir and production engineers to identify under-performing wells easily, promptly intervene, and recommend corrective actions.

Compute Theoretical and Actual Gas-Oil Ratio Data subprocess

The Well Performance Monitoring process shown in Figure 5 on page 9 contains a sub-process to obtain theoretical and actual gas oil ratios. This sub-process is shown in Figure 6.

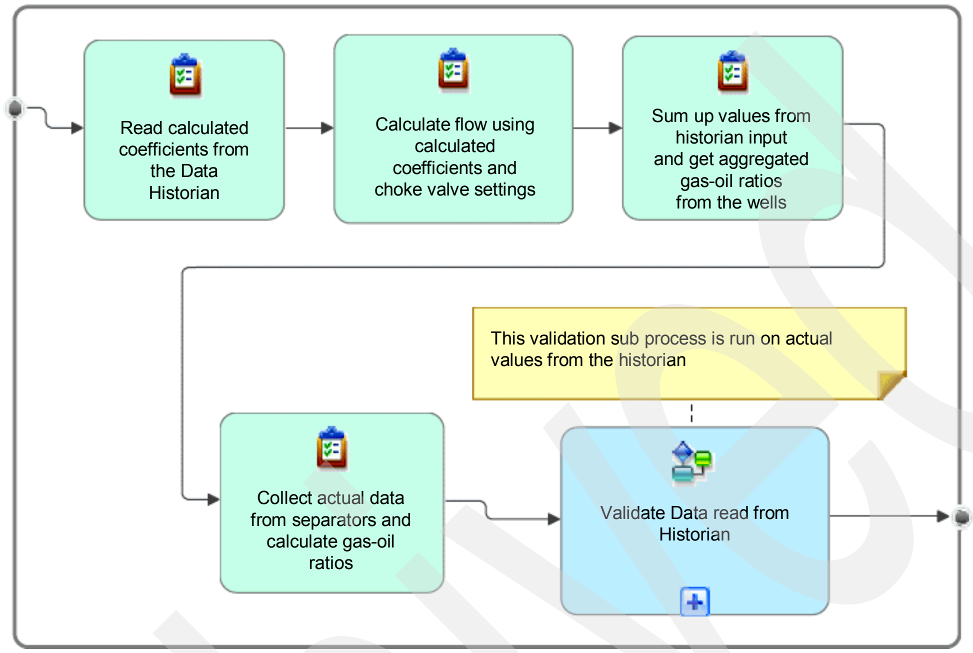

Figure 6 Well Performance Monitoring: tier 2

This process involves the following steps:

1. Calculated coefficients computed by the periodic well test are read from the data historian for all wells connected to the separator.
2. Calculated gas, oil, and water flow values are computed for each well using the calculated coefficients and choke value settings stored in the data historian.
3. Resultant gas, oil, and water values are summated to determine the theoretical gas oil ratio (GOR) for each well.
4. Actual gas, oil, and water data is read from the historian and calculated to determine the actual GOR for each well.
5. Actual GOR data is validated to ensure it is within expected operational limits.

Matthew Chu explains the benefits of this refined process:

- Gas oil ratios are now calculated in near real-time, allowing for faster response times and streamlined repeatable well performance monitoring.
- The refined process adds the ability to measure and monitor effectively the drift of estimated gas oil ratios to the cumulative data captured from the separator.
- The Well Performance Monitoring process now includes a reusable sub-process called Validate Data Read From Historian and is a candidate for reuse across Well Performance Monitoring and Well Head Testing.

Validate Data Read From Historian subprocess

The Compute Theoretical and Actual Gas-Oil Ratio Data subprocess shown in Figure 6 on page 10 contains a validation sub-process that is used to validate actual data read from the data historian. This sub-process is shown in Figure 7.

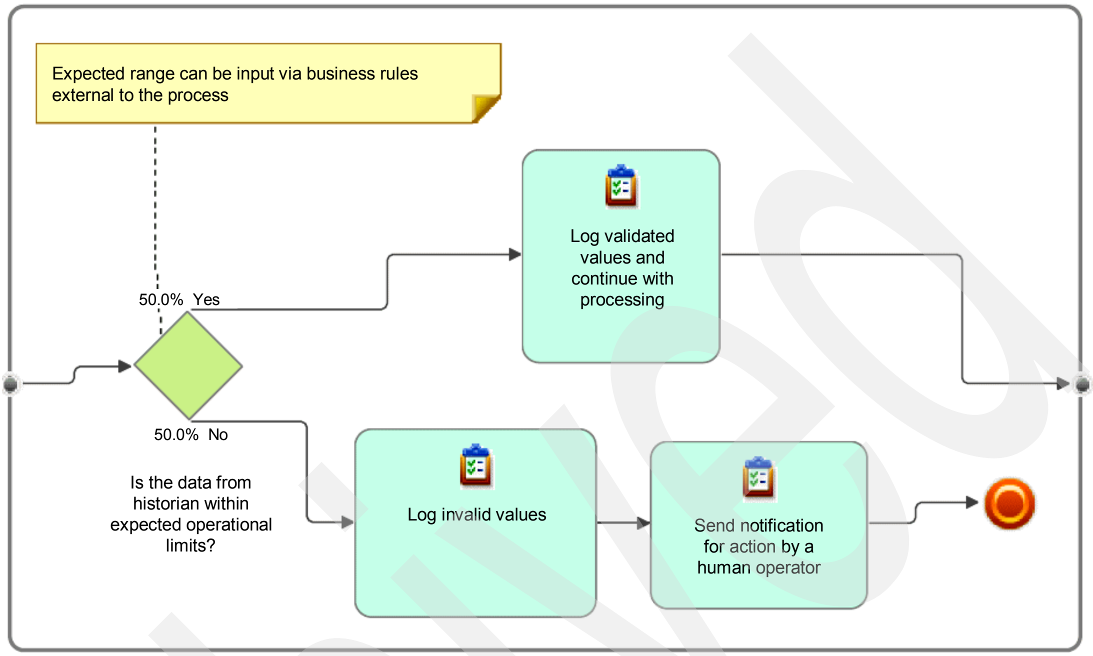

Figure 7 Well Performance Monitoring: tier 3

This process involves the following steps:

1. Actual gas, oil, and water data is validated to ensure it is within an acceptable operational range.
2. If the data is valid, the valid values are logged and processing continues.
3. If the data is invalid, the invalid values are logged, and notification is sent to an operator, and the process terminates.

Matthew Chu explains the benefits of this refined process:

- Events and rules are tied to assets in the performance monitoring process.
- Rules can be set to trigger a business process based on some criteria set in the business rules.
- Production action flows can alert and send notifications for immediate action by production personnel.
- There is lower maintenance time and cost by exposing a single system and method for data validation.

Refined Well Head Test process

The next production optimization process for refinement is the Well Head Test process. Sandy Osbourne-Archer explains the challenges that JKHL Oil and Gas are currently experiencing with this process:

- Current well head test procedures are labor-intensive human-driven operations.
- Unplanned shutdowns caused by equipment faults lead to production losses and increased costs from constant surveillance by production engineers.
- Production analysis calculations are often done off-line, requiring data replication, and are not accessible for reuse.

Matthew Chu shows Sandy the Well Head Test process, shown in Figure 8.

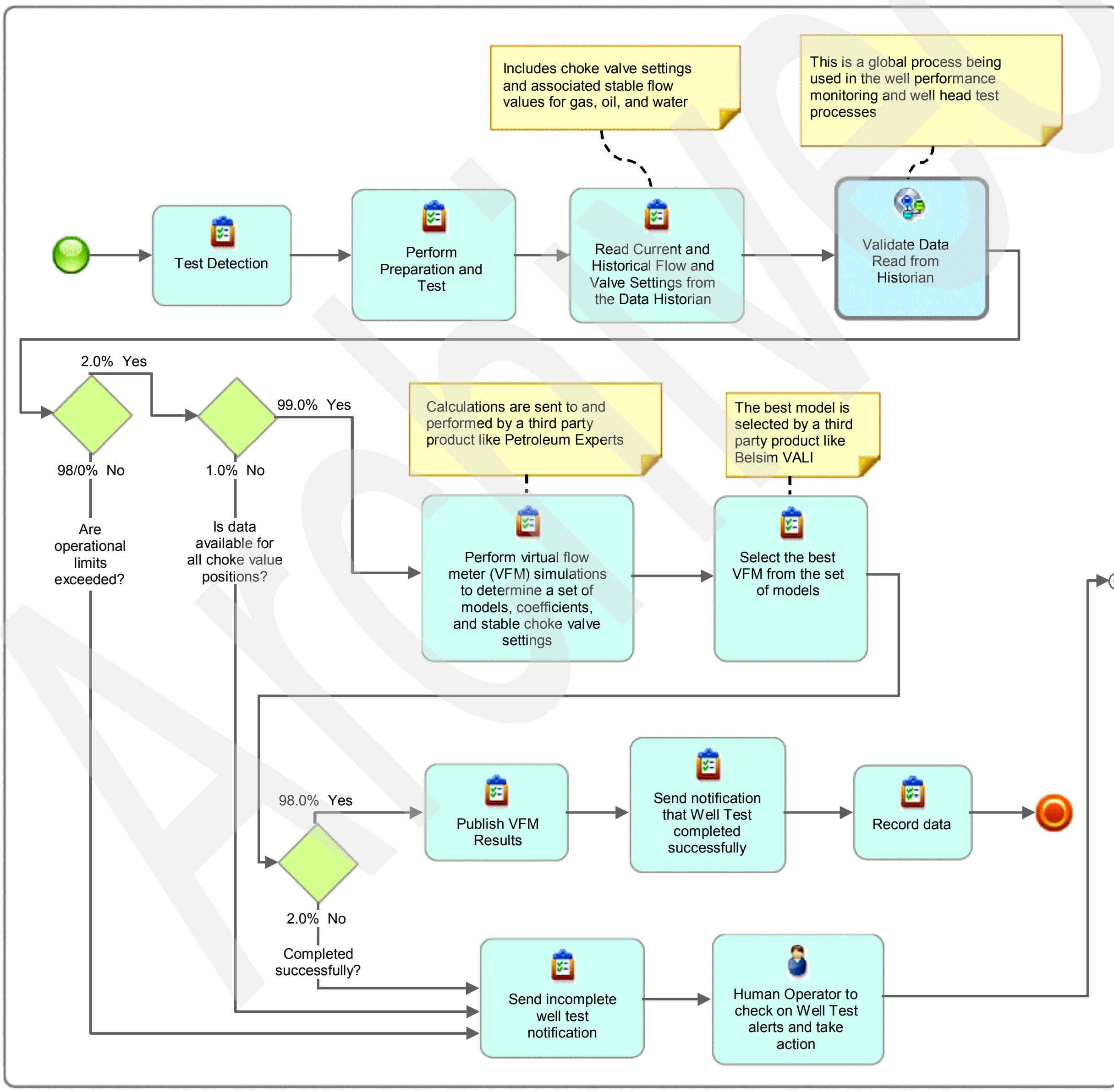

Figure 8 Well Head Test

The Well Head Test process performs the following actions:

1. Well test status is detected based on interactions with data stored in the historian.
2. Stability is checked during the test preparation. Once stability is achieved the test execution is completed.
3. Well test data (choke valve settings and stable flow values) is loaded from the data historian and validated to ensure its accuracy and stability in the test.
4. If the tolerance of the data is within an acceptable range and available for all choke valves, the data is collected and formatted for the Virtual Flow Meter (VFM®) simulator. Otherwise the process is terminated.
5. VFM calculations are performed for each mathematical model producing a set of coefficients for each VFM.
6. If the test completes successfully, the VFM results are published, a notification of success is sent, and the results are published to the data historian.
7. If the test does not complete successfully, an notification is sent to a production engineer alerting them to take action.

Matthew Chu explains the benefits of this refined process:

- Automation of well test procedures leads to a reduction in the amount of time that production engineers monitor, gather, and calculate well data.
- There is a reduction in the number of errors caused by human interaction in the well test procedure.
- Cost avoidance results from quick analysis of faulty equipment and resolution of problem wells.
- The Validate Data Read From Historian sub process is reused from the Well Performance Monitoring process.

Matthew Chu explains that this refined process enables intelligent well testing completion alerts. The process also enables predictive performance monitoring alerts that can detect acceptable and unacceptable production tolerances that drive information and actions to both human and system participants.

Refined Advanced Data Reconciliation process

The final production optimization process for refinement is the Advanced Data Reconciliation process. Sandy Osbourne-Archer explains the challenges that JKHL Oil and Gas are currently experiencing with this process:

- Difficultly in obtaining valid real-time data used during upstream production.
- Increased drift in GOR drift from sub-surface meters leads to inaccurate GOR measurements from the platform separator.

Matthew Chu shows Sandy the refined Advanced Data Reconciliation process (Figure 9).

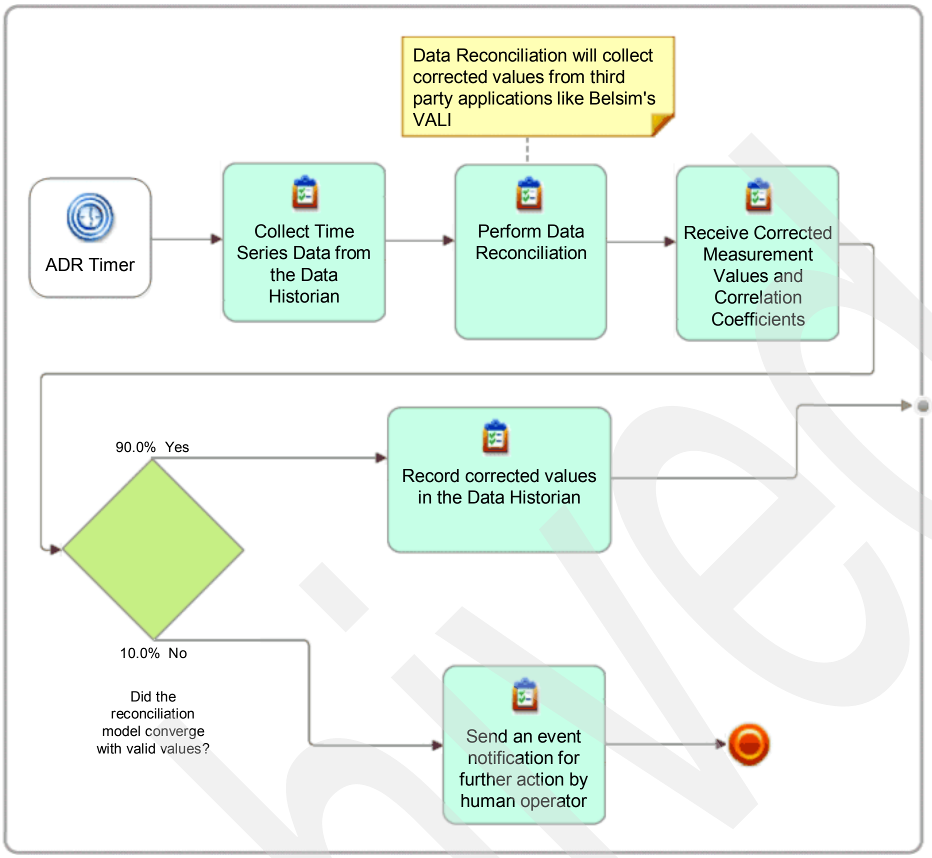

Figure 9 Advanced Data Reconciliation

The Advanced Data Reconciliation process performs the following actions:

1. Collects time series data to be processed from the data historian.
2. Reconciles data against values corrected to account for drift in production meters.
3. Receives corrected measurement values and correlation coefficients.
4. Validates if the reconciliation model converged with valid values.
   a. If yes, record corrected values in the data historian.
   b. If no, send a notification for further action by a human operator.

Matthew Chu explains the benefits of this refined process:

- Corrected values of measured drift recorded from sub-surface flow meters enhances the accuracy of GOR measurements.
- Accurate oil and gas production data ensures regulatory compliance with the industry, governments and joint ventures.

Service modeling

After performing business process modeling, the next task is to delineate the services that comprise the business processes. JKHL Oil and Gas wants to identify the services that need to be enabled in the solution architecture that is being proposed. Matthew Chu advises JKHL Oil and Gas to use the service-oriented modeling and architecture (SOMA) approach from IBM, illustrated in Figure 10, to identify these services.

SOMA is the IBM solution development method that is engineered to deliver and define hybrid solutions applicable to both SOA or non-SOA projects. The technique and process followed as a part of the SOMA development method is fundamentally based on four essential steps of business aligned services:

- Identification
- Specification
- Realization
- Implementation

Although beyond the scope of this Redpaper, the SOMA method, through its four essential steps, supports the Business Modeling and Transformation, Solution Management and Deployment Monitoring and Management phases in a typical software development life cycle.

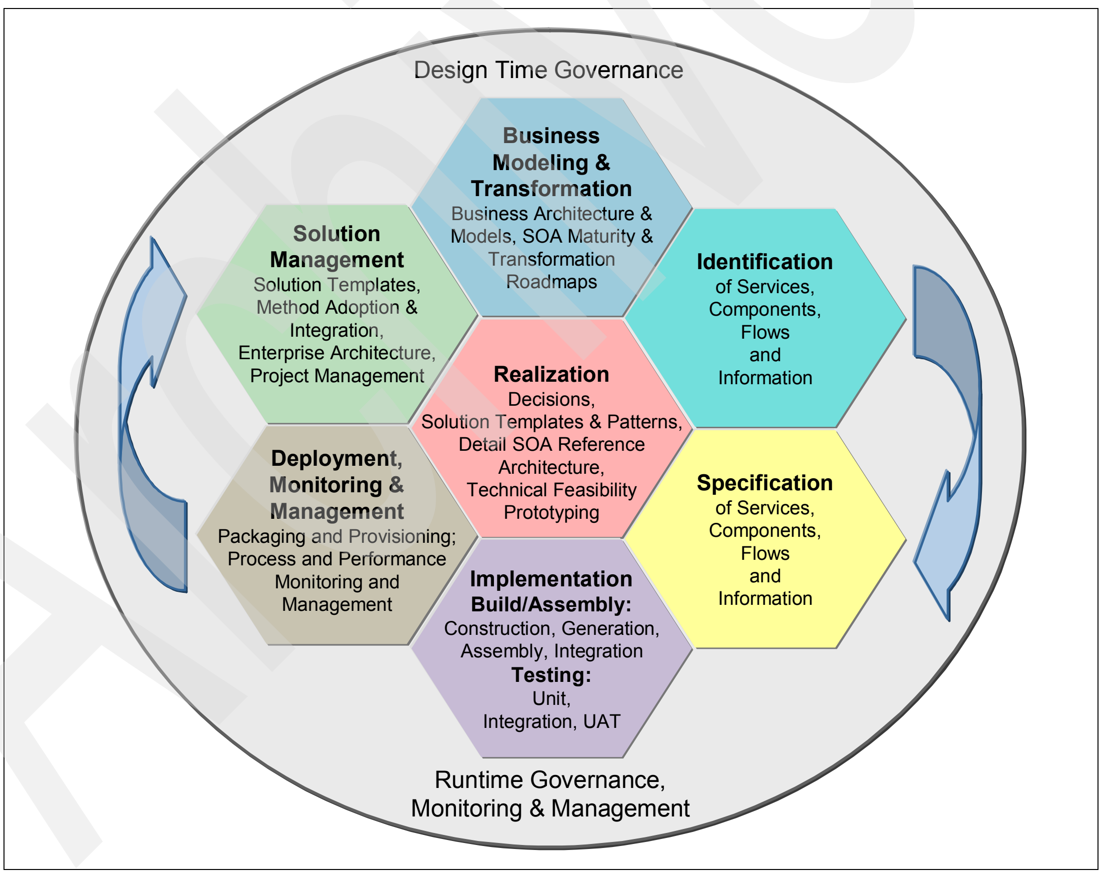

Figure 10 Service-oriented modeling and architecture

The service identification step of SOMA consists of three techniques that can help identify services for the Production Optimization business processes of Well Performance Monitoring and Well Testing:

- Domain decomposition
- Goal-service modeling
- Existing asset analysis

Domain decomposition

This is a top-down technique that consists of the decomposition of the business domain into its functional areas and subsystems, including its flow or process decomposition into processes, sub-processes, and high-level business use cases. These use cases often are good candidates for business services exposed at the edge of the enterprise, or for those used within the boundaries of the enterprise across lines of business. Apart from identifying candidate services, it helps identify functional areas that identify boundaries for subsystems, business process (flows) and commonality, and variation of functionality.

Process decomposition is one of the three techniques within domain decomposition. In process decomposition we decompose business processes into their constituent sub-processes and further into more atomic activities or tasks. The resultant process model depicts both the business level and IT level flow of events that realize a business process. It also forms the basis of candidate service identification. A process is a group of logically related activities that use the resources of the organization to provide defined results in support of the organization's objectives. Process models describe the work that an organization is involved in and the behavior of systems the organization uses. Each of the business processes that are in the scope of the business or IT transformation is decomposed into sub-processes and further into leaf-level sub-processes. Each of the activities in the resultant process model or process breakdown tree is considered as candidates for service exposure. Hence, each of them is added to a list, which is called the *service portfolio*.

For example, the Production Optimization initiative can be decomposed into the following processes or business use cases:

- Well Performance Monitoring
- Periodic Well Testing

Each sub-process can be decomposed further, ultimately leading to a list of candidate business services.

The Well Performance Monitoring sub-process is decomposed into services as follows:

- Well Performance Monitoring Service

  This service encapsulates the functionality of detecting an anomaly between the GOR production rates from the separator and the collective/cumulative GOR production rates from each of the constituent wells that feed into the manifold.

- GOR Calculator Service

  This service encapsulates the functionality of calculating the GOR for various equipment or assets in an oil or gas production setup. Assets are typically in the form of sub-sea wells and surface separator trains.

The Well Testing sub-process can be decomposed into services as follows:

- VFM Configuration Service

  This service encapsulates the functionality of calculating the Virtual Flow Meter (VFM) configuration details for a specific well given a set of choke valve settings and its related gas, oil and water production volumes.

- Historian Accessor Service

  This service encapsulates the connectivity to the data historian through a set of well defined operations.

- Steady State Data Detector Service

  This service encapsulates the important functionality of identifying when the tag values for the gas, oil and water production steadies after the initial swing of data values has settled down.

Goal-service modeling

Goal Service Modeling (GSM) is the third of the three techniques used to validate and unearth other services not captured by either top-down or bottom-up service identification approaches. It ensures that key services have not been missed. GSM provides the key link between the business goals and IT through the traceability of services directly to a business goal. The attainment of the goal, through the supporting service, is measured through the KPIs and its metrics that were documented as a part of the inputs from the business. GSM also ensures that stakeholder involvement and accountability are maintained through their consent on the business goals that need to be achieved. Services that are directly linked to the business goals then have a higher probability of being prioritized and funded for their subsequent design and implementation.

For example, goals can be defined as follows:

- Reduce Frequency of Well Tests
- Increase Well Performance

These goals might consist of sub-goals, such as Increase Oil Production by 15% (the percentage value will, of course, vary dependant on the project). Business services can be identified and grouped under these goals.

Existing asset analysis

The asset analysis is a bottom-up approach in which you examine assets, such as existing custom-packaged applications and industry models, to determine what can be used to realize service functionality. It is also designed to uncover any services that may have been missed through process decomposition. While analyzing existing and custom applications, we recommend performing a coarse-grained mapping in which we map business functionality in the portfolio of existing applications to the business processes and determine which step in the process can be potentially realized by some application functionality.

Existing systems are analyzed according to their suitability for inclusion in business processes. For example, the Well Performance Monitoring and Well Testing processes can be analyzed to determine if any of the services used in this existing process meet the needs of the new business processes. Typically, reuse of existing systems and assets provides a lower cost solution to implementing service functionality than creating new assets.

IBM provides service offerings for working with SOMA, as shown in Figure 11.

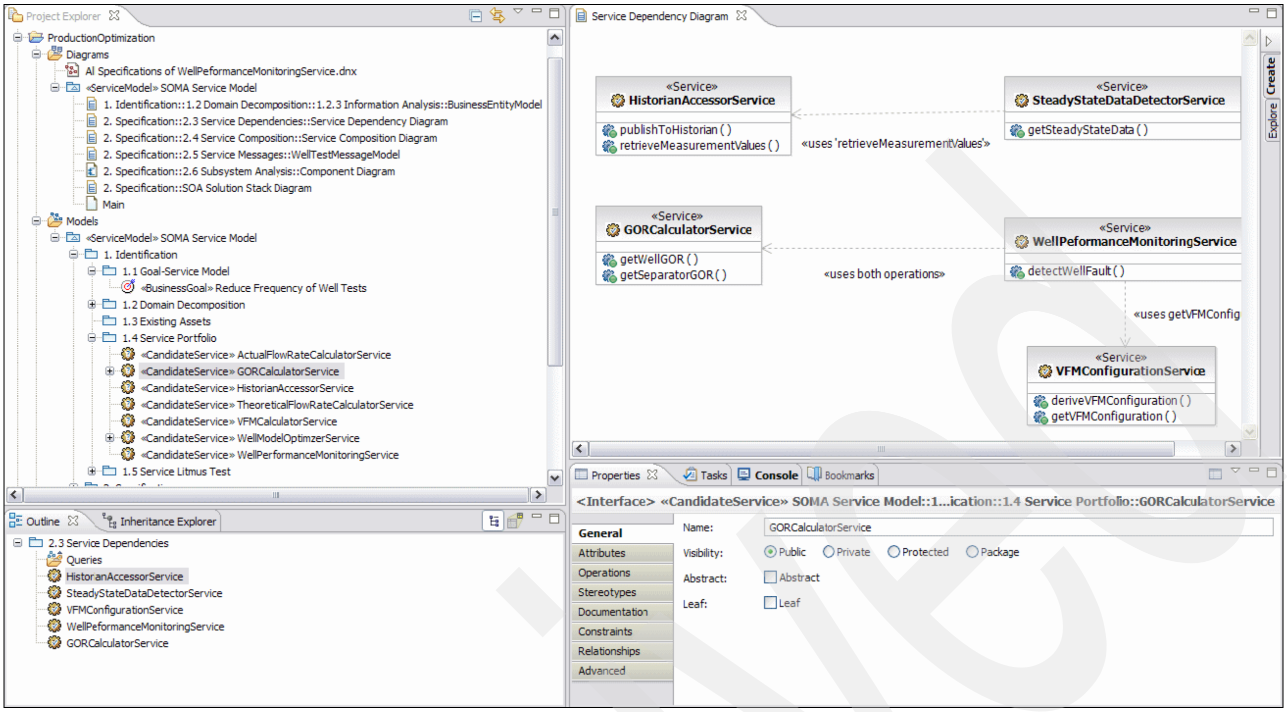

Figure 11 Using Rational® Software Architect to perform SOMA decomposition

> **Note:** The SOMA Services described in this section are not part of the core Chemical and Petroleum Integrated Information Framework. See your IBM representative for more information about available IBM Service Offerings and the SOMA services described in this section.

JKHL Oil and Gas technical environment

This section discusses the current technical environment at JKHL Oil and Gas, describes the architectural principles used in designing an improved technical environment, and provides more information about the IBM Chemical and Petroleum Integrated Information Framework.

Challenges in the technical environment

Matthew Chu states that the JKHL Oil and Gas technical environment faces significant technical challenges in the way that business is conducted today. He notes the following:

- There are multiple unique and inconsistent well testing processes per production facility with different engineers using separate methods to perform data manipulations and calculations. There is no single method to gather real-time data, apply data smoothing/correction, and perform mass-to-volume conversion calculations.
- Production analysis calculations are performed off-line. This leads to data replication and a lack of reuse by existing business processes. In many cases, data is exported to applications such as Microsoft® Excel, leading to data duplication that is outdated and out of sync across the enterprise.

- Difficulty seamlessly integrating well production processes with third party applications and external vendor systems that handle complex analytics and data access.
- Asset tag information and its context to equipment is not conveyed in real-time system integration, leading to manual and error prone engineering interpretation.
- An inability to process complex data quickly and accurately in real time to anticipate equipment deviations and failures during oil production.
- Each application has its own private reference and data store, and there can be millions of process tag information entities that are not conveyed in the context they represent.
- There is no single system of record (enterprise view of data), such as asset tag information and gas oil ratio production data, and enterprise documents.
- Existing upstream processes are supported by large monolithic software systems duplicated across many disparate platforms and applications.
- Upstream IT projects are implemented on a per project basis and are not planned at an enterprise level, leading to governance, service management, and service/data security to be only partially implemented.

Architectural principles

Matthew Chu and Sandy Osbourne-Archer agree on the architectural principles that JKHL Oil and Gas will use in designing an improved system:

- Use existing equipment by taking a SOA approach.
- The architecture should be able easily to adapt to changes in underlying technologies, support newer versions of products, and enable new business requirements.
- Connection to the server is essential for the visualization functionality to be accessible by plant supervisors, operators, and production engineers.
- Workflows should be constructed as an orchestrated set of business services, with state held at the workflow level.
- A reference model will provide the information abstraction to support informational services.
- External data and messaging, outside the IBM Chemical and Petroleum Integrated Information Framework boundaries, will follow published industry standards.
- Application functionality should be provided as a set of reusable services.
- There should be a single service to support a given business function.
- Services will be discoverable and governed and access to those services will be defined and managed through policies.
- Interaction logic will be separated from the processing logic.
- Business rules should be externalized from programs.

IBM Chemical and Petroleum Integrated Information Framework

Finally, Matthew explains that the IBM Chemical and Petroleum Integrated Information Framework will be used in the solution. The IBM Chemical and Petroleum Integrated Information Framework product is comprised of three parts: build, run, and manage.

- Build

  The Build component consists of a Solution Studio, used by a non-programmer to create production configurations. These configurations consist of an enterprise/asset model, piping and instrumentation diagrams, KPI definitions, event definitions, process definitions, data mappings, and event-to-process associations. The studio allows users to import and categorize available services. It is these services that are used to construct a business process. The studio also manages configuration deployments and undeployments.

- Run

  The Run component consists of a complex rules engine to filter events, and a highly available and scalable event processing engine that mediates, routes, processes, and logs the events. The Run portion supports use cases to manage up- and down-stream operations using events and event-triggered action flows and is responsible for logging those events in a standard way.

- Manage

  The Manage component consists of a standards-based client that is easily used by any service or application in the framework, a server-side component that receives and processes logged events, and a set of filterable views of the log information. Additionally, the Manage component includes selected products from IBM Tivoli® that are used to monitor and manage the elements of the chemical and petroleum IBM Chemical and Petroleum Integrated Information Framework solution. The Manage component is based on the IBM Common Event Infrastructure and IBM Tivoli System Management software.

The software components that make up the IBM Chemical and Petroleum Integrated Information Framework V1.3 are:

- IBM Chemical and Petroleum Integrated Information Framework Build Server Edition
  - IBM WebSphere® Service Registry and Repository
  - IBM WebSphere Application Server Network Deployment
  - IBM Chemical and Petroleum Integrated Information Framework Build Toolkit
- IBM Chemical and Petroleum Integrated Information Framework Build Client Edition
  - IBM WebSphere Integration Developer
  - IBM Rational Software Architect for WebSphere Software
  - IBM Rational Asset Manager
- IBM Chemical and Petroleum Integrated Information Framework Run Edition
  - IBM WebSphere Process Server
  - IBM WebSphere Business Events
  - IBM WebSphere Application Server Network Deployment
  - IBM Chemical and Petroleum Integrated Information Framework Run Extensions
  - IBM Chemical and Petroleum Integrated Information Framework Manage Extensions
- IBM Chemical and Petroleum Integrated Information Framework Manage Server Edition
  - IBM Tivoli Composite Application Manager for Applications
  - IBM Tivoli Business Service Manager
- IBM Chemical and Petroleum Integrated Information Framework Manage Client Edition
  - IBM Tivoli Business Service Manager Tier 1
  - IBM Tivoli Composite Application Manager for SOA
  - IBM Tivoli Composite Application Manager for Applications

SOA patterns

Matthew Chu explains that a good way to define an architecture that meets the needs of JKHL Oil and Gas is to break the solution into simple SOA patterns. These SOA patterns simplify the understanding of the overall solution from an SOA perspective. Applying SOA patterns and leading practices makes it easier for JKHL Oil and Gas to understand the impact of each piece of the solution and helps JKHL Oil and Gas adopt the solution in phases.

There are two distinct types of SOA patterns:

- Core business patterns

  Patterns required to solve the business problem at hand. The business patterns used in this scenario, along with the business needs they address are shown in Table 1.

Table 1 Business patterns used by JKHL Oil and Gas

Business need	Business patterns
► Need to provide a single source of access for field supervisors, process engineers, maintenance supervisors, and asset owners to manage all aspects of well performance monitoring and well testing procedures visually across the enterprise.	Interaction and Collaboration patterns: ► Rich Web Based Applications ► Process Portal
► Adopt end-to-end process automation to enhance performance, lower costs, reduce cycle times, and address regulatory compliance requirements associated with upstream oil production. ► Need the ability to sense business events / patterns and initiate appropriate production action flows.	Business Process Management patterns: ► Process Automation ► Process Modeling ► Business Activity Monitoring ► Events ► Business Rules Integration
► Need the ability to consistently represent equipment, relationships, unit operations, measurements, equipment state, as well as measurement data, reports, and vendor specifications involved in the oil production process. ► Need accurate, real-time, and remote access to all data and information related to wells, reservoirs, and associated equipment.	Information Integration patterns: ► Semantic Model Management ► Enterprise Asset and Content Management

- Core infrastructure patterns

  Patterns required to implement a comprehensive SOA-based solution and build upon a strong SOA foundation (for example security, management, and governance of services). The infrastructure patterns used in this scenario, along with the business needs they address are shown in Table 2.

Table 2 Infrastructure patterns used by JKHL Oil and Gas

Business need	Infrastructure patterns
► Need for integration of existing products and services during upstream production such as data analytic and modeling tools ► Need to secure, manage and govern services across the enterprise for an optimal operational environment and success with future SOA based projects	► SOA Connectivity pattern ► SOA Governance pattern ► SOA Security pattern ► SOA Management pattern

Core business patterns

This section describes the core business patterns adopted by JKHL Oil and Gas in more detail.

Applying the Interaction and Collaboration business patterns

Two Interaction and Collaboration patterns are used by JKHL Oil and Gas: Rich Web Based Applications and Process Portal.

The following sections address the Rich Web Based Applications pattern.

Technical problems addressed by the Rich Web Based Applications pattern

- Engineers lack a single visual access method to manage production services, and their physical infrastructure.
- Existing methods for modeling, simulating and optimizing operations are inefficient and antiquated.
- Productivity is affected as a result of the labor intensive manual operation of well head test procedures.

How JKHL Oil and Gas applied the Rich Web Based Applications pattern

- JKHL Oil and Gas decides to adopt a standards-based platform with integrated information about processes and assets across multiple enterprises, with a browser-friendly front-end.
- An interactive, thin-client, graphical workbench provides a more pleasing and easy to use GUI experience for users.
  - The GUI is used to define KPIs.
  - Visualization and animation of oil field assets indicate an alert on the GUI, when an under performing well is detected or equipment is faulty.
  - A view of upstream assets such as manifolds and separator trains are provided, where data from gas oil ratio sensors is presented in clickable, hierarchical levels of detail, ready for analysis and decision making.

The thin-client graphical workbench used by JKHL Oil and Gas is shown in Figure 12 on page 23.

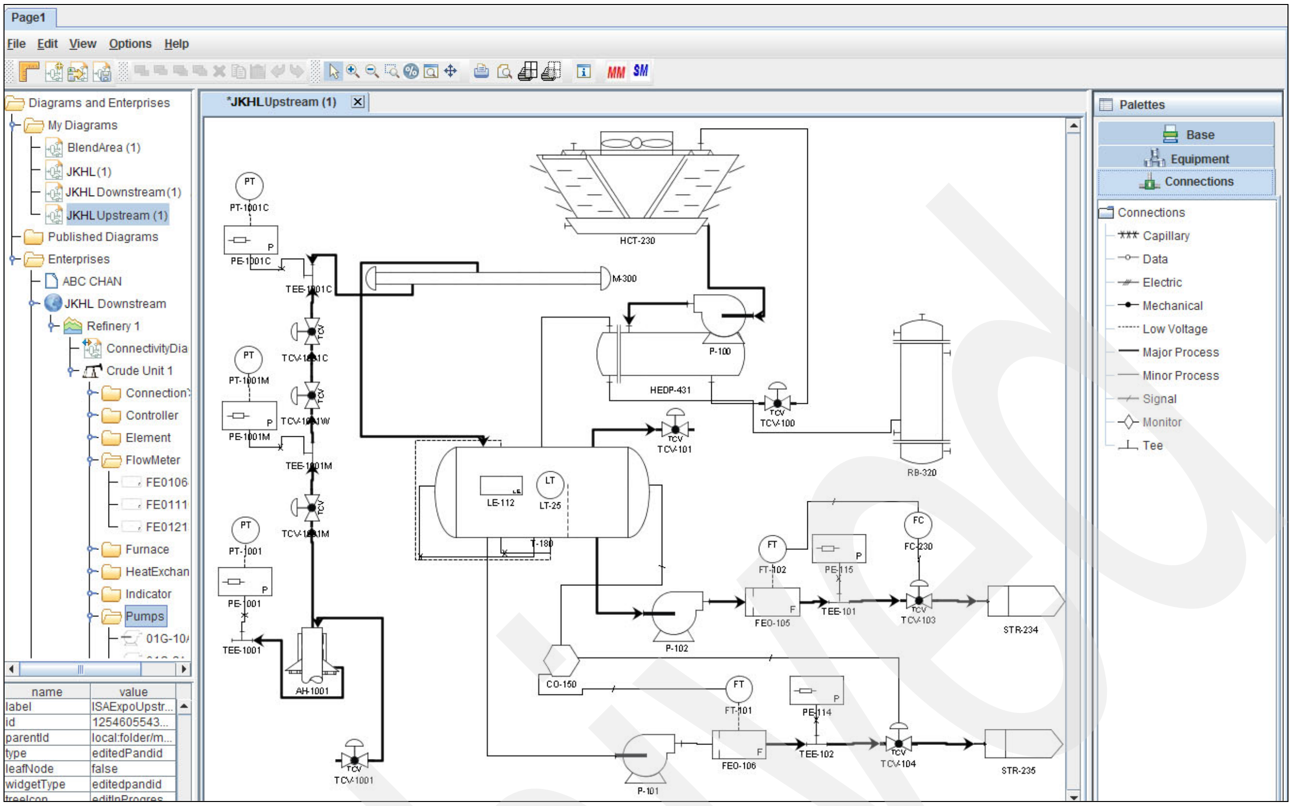

Figure 12 Applying the Rich Web Based Applications pattern

Business value of adopting the Rich Web Based Applications pattern

- Provides a single visual access method for performance monitoring and well testing processes across the enterprise through a workbench.
- New technology increases productivity for modeling and configuring tasks and reduces the number of errors caused by human interaction in the well test procedures.
- Reservoir and production engineers can observe the under-performing wells and promptly recommend corrective actions.

The following sections address the Process Portal pattern.

Technical problems addressed by the Process Portal pattern

- Various departments within the enterprise have their own home-grown applications for supporting and maintaining production activities.
- A constant surveillance of measured streams to determine operational performance and production level targets are not readily available.
- It is difficult for field supervisors, process engineers, maintenance supervisors, and asset owners to collaborate effectively during upstream production operations

How JKHL Oil and Gas applied the Process Portal pattern

- Integrated Desktop

  JKHL Oil and Gas provides an integrated desktop to accommodate the online needs in the enterprise, enabling plant supervisors, operators, and production engineers to compose events and event subscription, generate KPIs, and view real-time analysis results in the form of graphs.

- Instantaneous Collaboration

  Experts exchange information regarding well testing and performance monitoring applications, enabling faster research, response and turn-around times for problem resolution.

- A Web user interface is provided with the full functionality to view the wells, piping manifolds and separators diagrams along with their properties, measurements, and associated KPIs.
- Company-specific applications also appear within the portal and each engineer's panel is personalized for their role.

An implementation of the Process Portal pattern for JKHL Oil and Gas is shown in Figure 13.

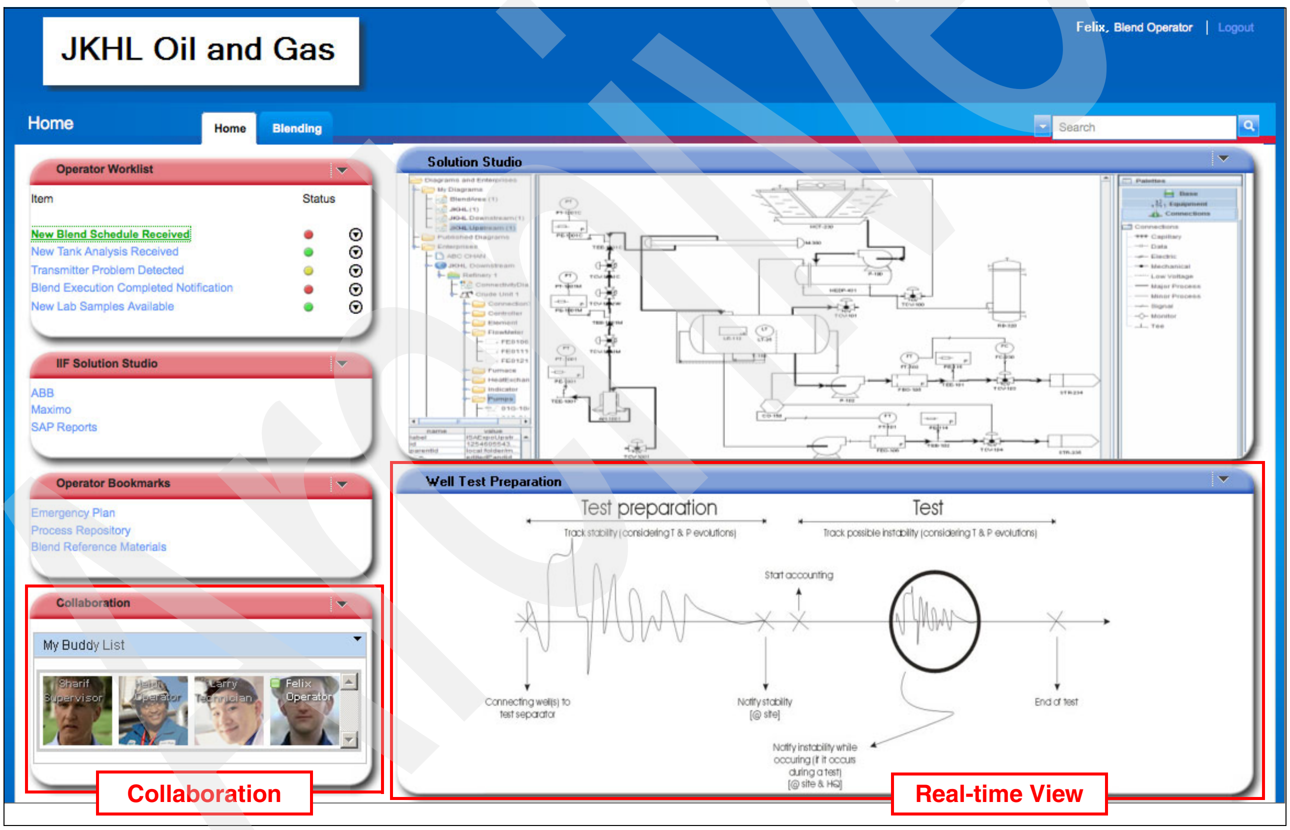

Figure 13 Process portal for JKHL Oil and Gas

Business value of adopting the Process Portal pattern

- Improve overall productivity and customer satisfaction by presenting a unified user experience.
- Minimize deferred production as communication improves among functional groups, enabling faster decision-making on any corrective actions required for individual well or separator train issues
- Expedite tasks based on specific roles of the individual user or group for their expertise in handling.
- Reduce costs and increase collaboration and access to multiple applications and information sources.
- Ability to facilitate heterogeneous mashups by integrating new function with existing departmental applications without requiring any changes to those applications.

Recommended components used to implement the Interaction and Collaboration patterns

The following IBM components are recommended to implement the Interaction and Collaboration business pattern:

- Core components
  - IBM Chemical and Petroleum Integrated Information Framework Build Server and Client Editions
  - IBM Chemical and Petroleum Integrated Information Framework Run Edition
- Pre-requisites

  IBM WebSphere ILOG JRules and JViews Diagrammer
- Advanced components
  - IBM WebSphere Portal
  - IBM Lotus® Sametime®
  - IBM Lotus Expeditor
  - IBM Cognos®

Applying the Business Process Management business pattern

JKHL Oil and Gas uses the following Business Process Management patterns:

- Process Automation
- Process Modeling
- Business Activity Monitoring
- Events
- Business Rules Integration

Technical problems addressed by the Business Process Management pattern

- The current business processes for JKHL Oil and Gas require several manual steps for performing calculations and validating data during well performance monitoring and testing.
- There is a lack of a good auditing and tracking mechanism due to manual intervention.
- Current business processes have embedded business rules and policies for exception handling and routing. Changes to that logic creates delays because it requires a direct change to the business process as well as IT involvement.
- Simple-to-critical decisions require manual invention, resulting in tasks taking longer to complete.

How JKHL Oil and Gas applied this pattern

- JKHL Oil and Gas has used business processes analysis, modeling, and simulation techniques to increase productivity by automating certain key manual processes such as gas oil ratio calculations, well data reconciliation, and performing virtual flow meter simulations.
- Manual intervention and decisions have been replaced with business rules for help in determining non-functional wells, identifying unacceptable drift, calculating gas-oil ratio tolerance values and validating real-time data.
- An anomaly in the system caused by under performing wells or unacceptable drift or invalid data readings can trigger an alert and launch specific processes for exception handling.
- The business process is being closely monitored to gather statistics on the speed and efficiency of how the Well Performance Monitoring, Well Head Test, and Advanced Data Reconciliation processes are performing.
- These statistics are iteratively fed back into the business process modeling and simulation steps where they are analyzed to further make business process improvements.
- JKHL Oil and Gas also implements the capability to fashion complex events from aggregated measurements obtained from well performance monitoring and uses them to drive production action flows.
- JKHL Oil and Gas enables intelligent well testing completion alerts and predictive performance monitoring alerts that can detect acceptable and unacceptable production tolerances that drives information and actions to both human and system participants.
- Events allow for early warning of a shift during production leading to a reduction in the frequency of well tests.

An implementation of a JKHL Oil and Gas business process is shown in Figure 14.

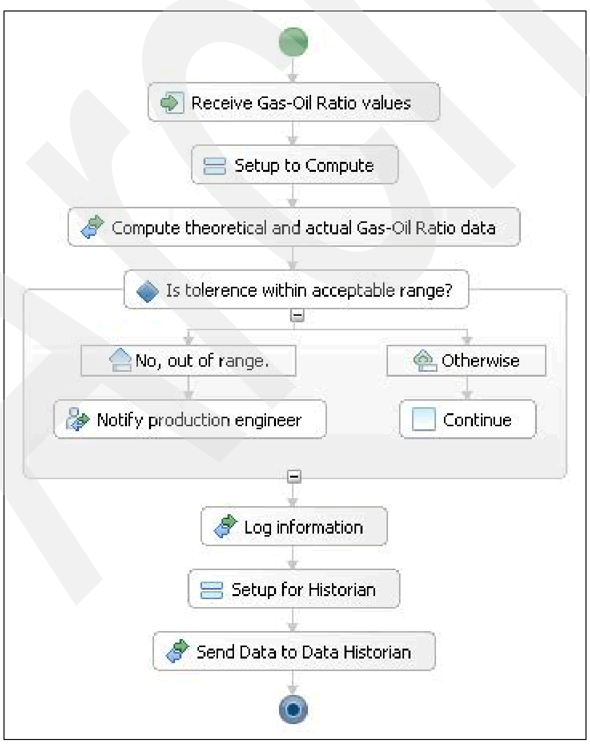

Figure 14 A JKHL Oil and Gas business process implementation

Business value of adopting this pattern

- Increases productivity of staff by successfully automating manual processes.
- Improves employee satisfaction by reducing the time it takes for employees to interface with internal and external business applications.
- Integrated business rules increases flexibility to changing business requirements.
- There is a separation of concerns. The business process policy is separated from the business process logic.
- Fast, simple, and nondisruptive additions to existing business processes that decreases the time and cost of adoption.
- Business Activity Monitoring provides real-time dissemination of key business metrics, allowing JKHL Oil and Gas to respond quickly to changing business dynamics.
- JKHL Oil and Gas benefits from a better understanding of their business model and obtains better insight as to how the process is performing during well performance monitoring, as well as identifying where bottlenecks are occurring. By implementing these solutions, JKHL Oil and Gas will move to a more agile business model.
- Events from multiple sources related to alarms generated from well production optimization are correlated into actionable event patterns.
- Events and rules are tied to assets. Rules can be set to trigger a business process based on some criteria set in the business rules. Event deviation can invoke a business process with integration to an Asset Management existing application for incidence management.

Recommended components used to implement this pattern

The following IBM components are recommended to implement the Business Process Management business pattern:

- Core components:
  - IBM Chemical and Petroleum Integrated Information Framework Build Server and Client Editions
  - IBM Chemical and Petroleum Integrated Information Framework Run Edition
- Advanced components:

  IBM WebSphere Dynamic Process Edition

  - IBM WebSphere Business Modeler
  - IBM WebSphere Business Monitor

Applying the Information Integration business patterns

Two Information Integration patterns are used by JKHL Oil and Gas: Semantic Model Management and Enterprise Asset and Content Management.

The following sections address the Semantic Model Management pattern.

Technical problems addressed by the Semantic Model Management pattern

- Operational managers and production engineers do not have timely data measurements nor visibility of the wells and associated equipment during the oil production process.
- Data is tracked in different formats and systems.
- Difficulty in associating hundreds and thousands of tag names to the context of the equipment and its connectivity.

How JKHL Oil and Gas applied the Semantic Model Management pattern

- Using a unique reference semantic model, JKHL Oil and Gas implements the capability to create and maintain a consistent representation of equipment, relationships, unit operations, measurements, and equipment state during oil production.
- JKHL Oil and Gas extends the model with additional properties, relationships, and connection information for the wells and all associated equipment that will be required for the production optimization processes.
- Additionally, the referenced model is applied to preserve existing application and system investments and associated measurement data, reports, and vendor specifications are accessible through defined information service definitions.
- The final semantic model repository stores the necessary classes, associations, and definitions relevant to the production process.

The reference semantic model used by JKHL Oil and Gas is shown in Figure 15.

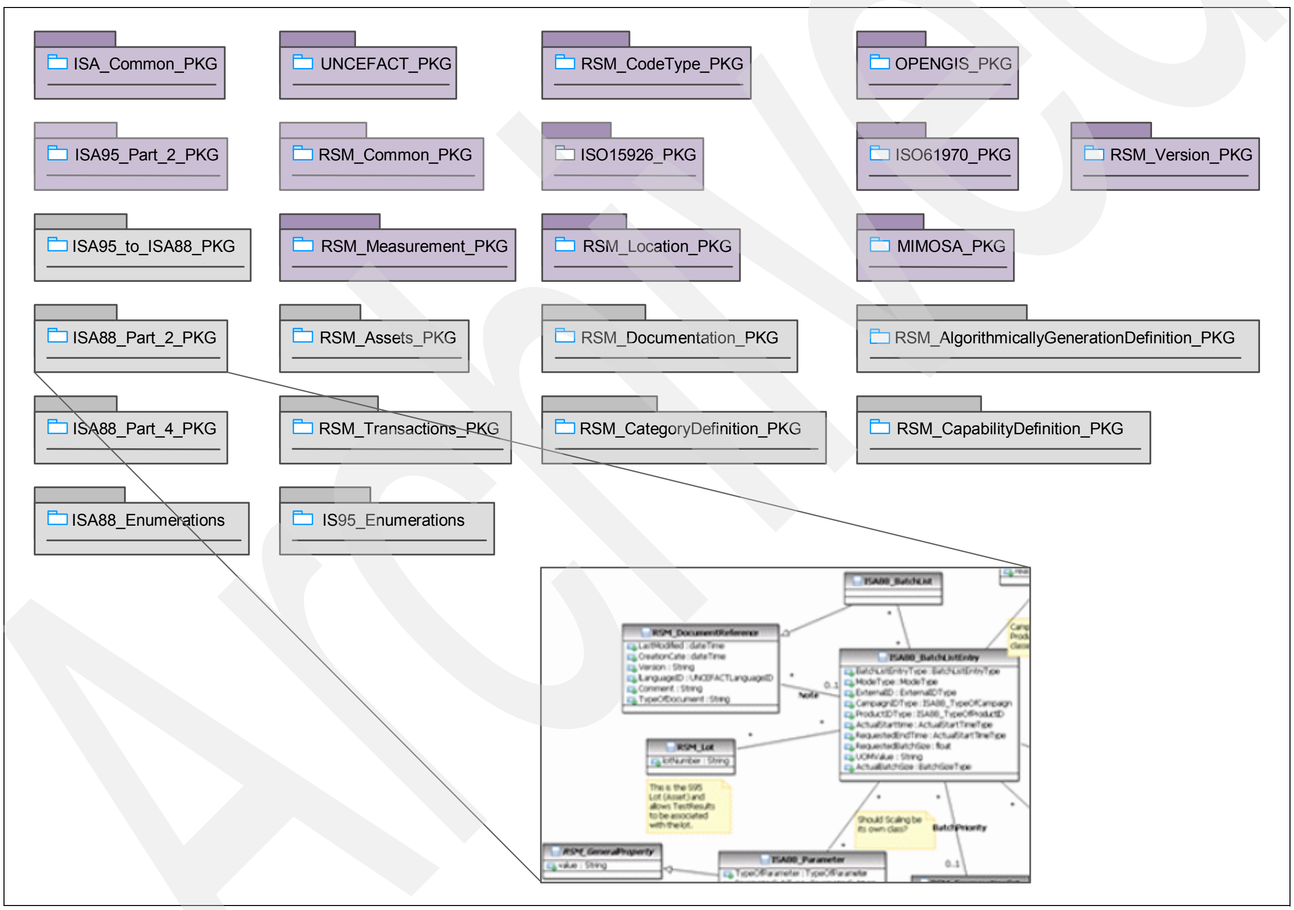

Figure 15 Reference semantic model used by JKHL Oil and Gas

Business value of adopting the Semantic Model Management pattern

- An information model governed by chemical and petroleum industry standards representing the properties and relationships of entities involved in the production process and the operations that can be performed on them.
- Real-time production data is federated rather than replicated and the real-time source data stays untouched.
- A simplified view of the production facilities presented in a single homogenous semantic namespace with real-time visibility of measurements.

The following sections address the Enterprise Asset and Content Management patterns.

Technical problems addressed by the Enterprise Asset and Content Management patterns

- Technical problems relating to assets
  - JKHL Oil and Gas lacks an integrated approach to manage all critical assets associated with upstream productions (for example, manifolds and separators associated with Well Performance Monitoring and Testing).
  - Additionally, there is no real-time visibility to asset performance and maintenance.
- Technical problems relating to content
  - JKHL Oil and Gas finds it challenging to manage efficiently unstructured content in the form of asset problem reports resulting from performance monitoring and well testing processes.
  - Additionally, technical documents and specifications related to manifolds, meters, and separators exist in multiple locations (paper and digitally) as well as various formats and versions.
  - Each department or line of business maintains their documents using different procedures, and delays in obtaining documents results in increased costs for the organization.
  - There is unknown exposure due to potential litigation or internal policy noncompliance.

How JKHL Oil and Gas applied the Enterprise Asset and Content Management patterns

JKHL Oil and Gas adopts enterprise-wide standards for asset and content management:

- A single, central content and asset repository is implemented to maintain documents and content associated with wells and related equipment.
- Electronic forms for filling reports on troubled assets are made available for use within multiple business processes within the company.
- Analysis reports to coordinate changes, which provide visibility to critical data flows, are accessed from one common content repository.

An example of an electronic form is shown in Figure 16 on page 30.

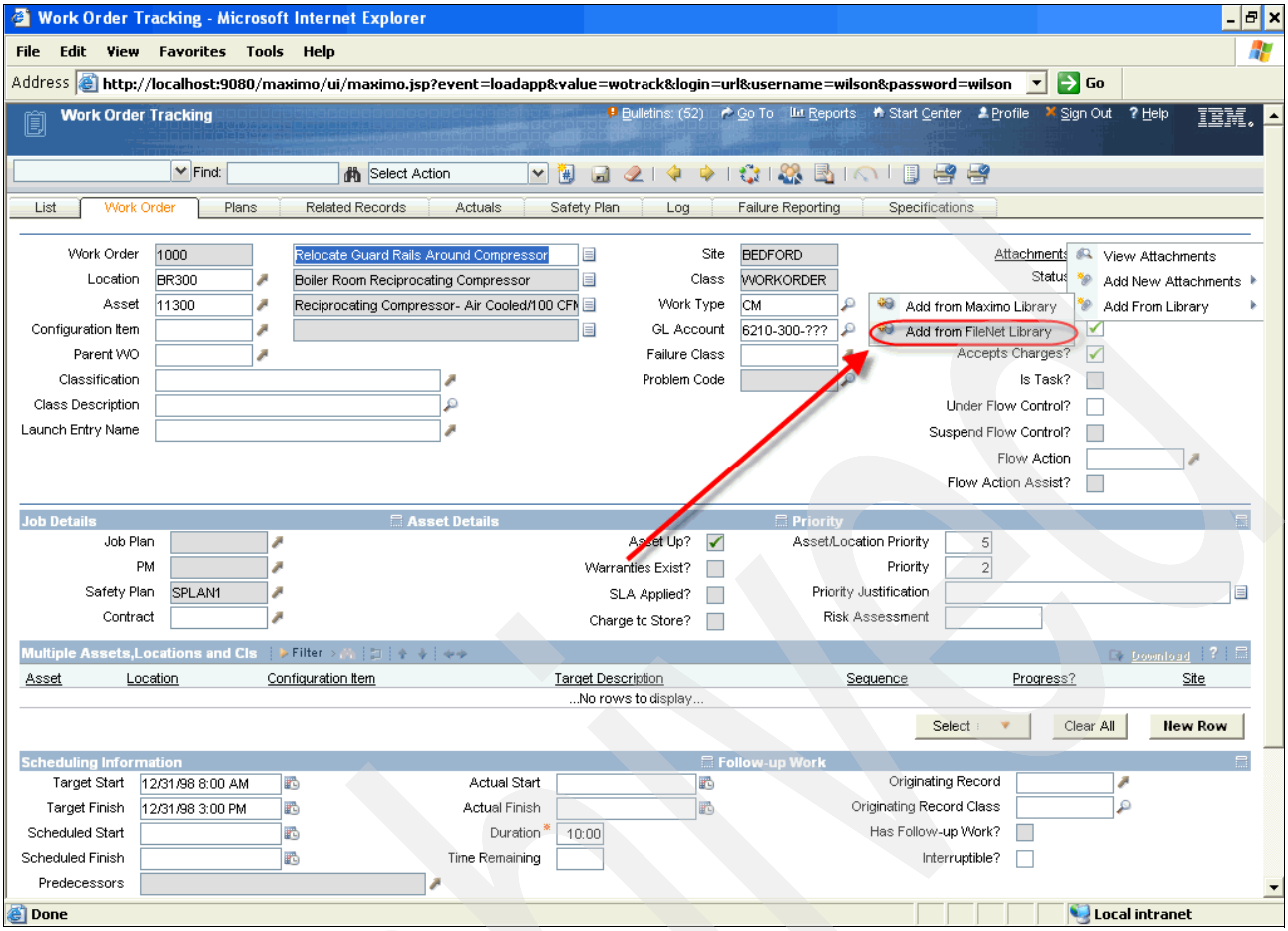

Figure 16 Electronic form for filing reports

Business value of adopting the Enterprise Asset and Content Management patterns

- Ability to deliver integrated content to employees, customers, and partners from a single, accurate repository.
- Ability to access the right content at the right time quickly and easily.
- Improved risk management for assets and lowered discovery costs for documents (pulling backups to find information needed).
- Having the right information available due to captured, single version, single location for all unstructured content.
- Reduced cost and complexity associated with redundant asset management structures.

Recommended components used to implement the Information Integration patterns

The following IBM components are recommended to implement the Information Integration business pattern:

- Core components
  - IBM Chemical and Petroleum Integrated Information Framework Build Server and Client Editions
  - IBM Chemical and Petroleum Integrated Information Framework Run Edition
- Advanced components
  - IBM Maximo® Asset Management
  - IBM Maximo for Oil and Gas
  - IBM FileNet® Content Manager

Core infrastructure patterns

This section describes the core infrastructure patterns adopted by JKHL Oil and Gas in more detail.

Applying the SOA Connectivity infrastructure pattern

This section addresses how JKHL Oil and Gas can build a strong SOA platform with the SOA Connectivity infrastructure pattern

Technical problems addressed by this pattern

- JKHL Oil and Gas has many existing applications with which they need to connect, such as SAP for ERP, Maximo for asset management, Petroleum Experts for analytical and interpretation functions, and BELSIM for data validation.
- In many cases, interaction with these applications is unique and performed through inflexible point-to-point connections or not at all.
- Current integration techniques struggle to support multiple event and message formats and exchange patterns.
- Isolated low level events have little meaning to the process engineers that may need to act on them.

How JKHL Oil and Gas applied this pattern

- JKHL Oil and Gas deploys an ESB infrastructure with adapters to connect to their existing applications such as their ERP system and other third-party applications.
- The ESB exposes the applications as services by using the appropriate adapter to transform incoming messages to and from the existing system, and to route the messages between the presentation services and the ESB. The ESB supports different message protocols implemented at JKHL Oil and Gas.
- Lower level events are normalized and correlated for further processing using an Event Processing Engine.

Business value of adopting this pattern

- The ability to share critical operational information with key enterprise applications, therefore enabling personnel to better plan, forecast, and respond to business challenges.
- Increased speed in availability of enterprise applications by using existing messaging deployments.
- The ESB exposes services in a channel agnostic fashion to support user interface flexibility, allowing processes to focus on value added business logic and not connectivity concerns.
- Decoupling of service providers and consumers without the need to change services and applications, results in decreased time to market for application deployments.

Recommended components used to implement this pattern

The following IBM components are recommended to implement the SOA Connectivity infrastructure pattern:

- Core components

  IBM Chemical and Petroleum Integrated Information Framework Run Edition

- Advanced components

  IBM WebSphere Adapters

Applying the SOA Governance, Security, and Management infrastructure patterns

JKHL Oil and Gas has the following governance, security, and management goals:

- Governance goals
  - JKHL Oil and Gas strives to align fully their business strategy with their IT strategy through adherence to standards and governance of services.
  - Upstream services require versioning and change management capabilities for existing events and action flows.
- Security goals

  In an effort to adhere to corporate security guidelines concerning data confidentiality and system access, JKHL Oil and Gas works to provide a secure environment by addressing the authentication of users, system and service access control, and data integrity and privacy.

- Management goals
  - The production optimization effort at JKHL Oil and Gas is key to ensuring oil production is maximized and asset downtime is minimized.
  - JKHL Oil and Gas must ensure that all deployed IT services and physical assets critical to the operational aspects of oil production are continuously monitored, highly available, and performing to expectations.

How JKHL Oil and Gas applied these patterns

JKHL Oil and Gas applied the SOA Governance pattern as follows:

- JKHL Oil and Gas enforces governance by providing guidelines such as patterns and leading practices, and by adopting SOMA for design, development and operations of IT systems.
- JKHL Oil and Gas forms a cross-organizational decision-making body with lead representatives from business strategy and IT, and an architecture board to oversee the implementation of business agility initiatives over time.
- The framework helps to keeps accurate records on oil production for government regulation, auditing, and joint ventures as well as to distribute costs across the different organizations.
- JKHL Oil and Gas uses the IBM Chemical and Petroleum Integrated Information Framework for versioning and change management capabilities.
- Additionally, the IBM Chemical and Petroleum Integrated Information Framework is used to adhere to real-time industry standards
  - Uses OPC and WITSML/PRODML information mapped to the Reference Semantic Model ontology measurement values and classes.
  - Uses ISA S88/S95, ISO 15926, and IEEE 61970/68 for asset and physical hierarchy representation.
  - Uses ISO 15926 and Mimosa for asset life cycle management.

JKHL Oil and Gas applied the SOA Security pattern as follows:

- At the presentation level, JKHL Oil and Gas uses the IBM Chemical and Petroleum Integrated Information Framework's integrated dashboard to ensure that users must be authenticated and authorized to use the system.
- IBM Tivoli Identity Manager is deployed to handle role management and access control at the user level to determine which applications and integration services are available to the operators and production engineers.

JKHL Oil and Gas applied the SOA Management pattern as follows:

- JKHL Oil and Gas uses the IBM Chemical and Petroleum Integrated Information Framework to:
  - Monitor the UI interaction with the framework, ESB, and the Well Performance Monitoring and Test business process execution.
  - Monitor reference semantic model services and services requests that flow from the process engine to the Web service providers.
  - Provide better visibility of the operational systems, to get instant visibility into incidents and move towards rapid resolution.
  - Monitor data and service components within the JKHL Oil and Gas architecture against SLAs (applicable to production optimization services such as performance monitoring, data reconciliation, and so forth).
- IBM Tivoli Performance Analyzer is used to keep historical data on system use, determine trends and thresholds on active IT systems, forecast the time capacity will be reached, and provide up-to-date reports.

Business value of adopting these patterns

- Production operations
  - Provides an overarching structure to support the JKHL Oil and Gas business objectives on strategic, functional, and operational levels.
  - Enables controlled access to subsets of operational data, controls over changes to event thresholds, action flows, and alert definitions.
  - Constant monitoring ensures that contextual information is available at critical points in the process flow allowing JKHL Oil and Gas to identify bottlenecks successfully, such as data values that are stuck for extended periods of time.
  - JKHL Oil and Gas is able to allow off-shore operations a consistent view of the systems making it possible for personnel to manage and access data effectively in their natural production working environment.
- IT
  - Enables greater innovation and business value from IT by aligning business goals and IT investments while reducing the risks and costs of operating a secure, resilient business.
  - By integrating, automating and optimizing data, workflows and policies, it helps JKHL Oil and Gas align the ongoing management of its infrastructure with its business.
  - Strengthens data integrity and ensures only authorized individuals can access project assets, sensitive information, and business functions.
  - Increases accountability and audit posture as well as compliance to security, governance and other corporate policies.

Recommended components used to implement these patterns

The following IBM components are recommended to implement the SOA Governance, Security, and Management infrastructure patterns:

- Core components:
  - IBM Chemical and Petroleum Integrated Information Framework Manage Server and Client Editions
  - IBM Chemical and Petroleum Integrated Information Framework Build Server and Client Editions
  - IBM Chemical and Petroleum Integrated Information Framework Run Edition
- Advanced components:
  - IBM Rational Team Concert™
  - IBM Tivoli Access Manager
  - IBM Tivoli Directory Server
  - IBM Tivoli Identity Manager
  - IBM Tivoli Performance Analyzer

Solution architecture

By applying the SOA patterns, Matthew Chu, with his team of IBM consultants, and Sandy Osbourne-Archer can define a proposed solution architecture for JKHL Oil and Gas. This is shown in Figure 17.

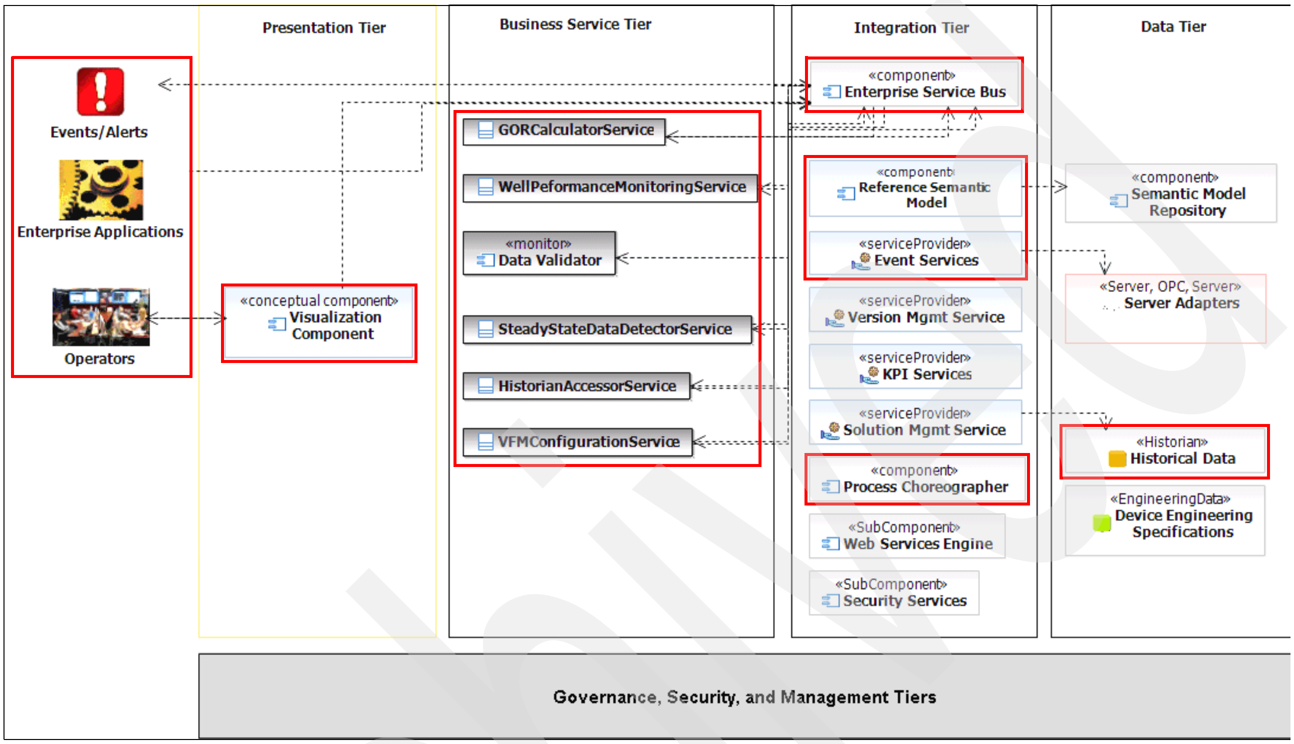

Figure 17 Solution architecture for JKHL Oil and Gas

Matthew explains that this solution architecture brings significant benefits to JKHL Oil and Gas. Oil production is enhanced in the following ways:

- Increased accuracy of GOR inference and improved adherence to production targets through using sophisticated measurement and predictive analysis.
  - Performs complex analysis of calculated GOR's and KPIs to determine overall field production performance.
- Early detection of reservoir changes and water break-through by using intelligent alerts and event management.
  - Enables intelligent well testing completion alerts and predictive performance monitoring alerts that can detect acceptable and unacceptable production tolerances which drive information and actions to both human and system participants.
- A reduction in the uncertainty of measurements due to increase automation and decreased human interaction.
  - Provides an open enterprise data and process integration framework that automates existing manual well testing procedures and enhances well data reconciliation techniques.
- Increased collaboration amongst platform supervisors, engineers, and operators
  - Enables or extends the ability to collaborate with experts on challenges and solutions instantly through collaboration technologies and shared information, across well testing and performance monitoring applications.

Oil production downtime and maintenance costs are decreased by:

- The ability to manage the separator train as single unit through visualization of contextual oil field information.
  - View upstream assets such as manifolds and separator trains through an intuitive graphical interface, running on a thin client, where data from gas oil ratio sensors is presentable in clickable, hierarchical levels of detail, ready for analysis and decision making.
- A reduction in well testing frequency brought about by the standardization and optimization of procedures enhanced by enterprise connectivity.
  - Integrates well production information with other enterprise applications, such as data modeling, simulation, and validation systems, enabling more automated, accurate, and complete business processes.

Summary

Thomas Arnold and Sandy Osbourne-Archer have seen that by adopting the SOA-implementation roadmap using SOA patterns and disciplines described by Matthew Chu in this paper, JKHL Oil and Gas can construct a solution for production optimization.

By automating workflows for well testing and well performance monitoring processes, and optimizing the use of existing upstream assets associated with oil production, JKHL Oil and Gas can reduce lost production and increase the effective amount of barrels of oil produced each year.

References

- For more information about the IBM Chemical and Petroleum Integrated Information Framework refer to *Discovering the Business Value Patterns of Chemical and Petroleum Integrated Information Framework*, SG24-7735.
- For more information about applying SOMA, refer to the developerWorks® article, *Service-oriented modeling and architecture*, available at the following Web page:

  http://www.ibm.com/developerworks/library/ws-soa-design1/
- For more information about domain decomposition, goal service modeling, and existing asset analysis see *Executing SOA: A Practical Guide for the Service-Oriented Architect*, ISBN 978-0132353748.

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- **Kay Freund**, IBM Software Industry Marketing for Industry Frameworks
- **Vishwanath Narayan**, Distinguished Engineer, IBM CTO Industry Solutions Architecture

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