Leveraging the Microsoft Upstream Reference Architecture to Fully Integrate E&P Decision-Making Processes in the Digital Oilfield

The Oil and Gas industry is working to break down the traditional exploration and production (E&P) data and application silos and moving towards integration of the entire E&P value chain through digital oilfield solutions. However, a crucial part of that value chain—decision making—has not been automated and integrated, which means businesses are losing out on capturing and fully leveraging the value of that information.

This joint paper from PointCross and Microsoft explains how a solution framework from PointCross can be simply and elegantly deployed with the Microsoft Upstream Reference Architecture (MURA) to integrate decision-making processes and results to create and retain information relationships, history, and context—a complete institutional memory for your digital oilfield—that can further inform, optimize, and potentially transform operations and business.

Contents

Challenge: Decision Processes and Results are not Automated and Retained in Digital Oilfield Solutions

Exploration and production (E&P), the upstream oil and gas industry, is a knowledge-intensive, decision-centric, and high-risk/high-reward business where the resource owner/operators depend on an ecosystem of oil field service companies, joint-venture partners, and a myriad of contractors, including engineering procurement and construction (EPC) and many others, to explore for, produce, and develop resources.

In addition to using the huge volumes of data that they collect for operational monitoring, analysis, and decision making, operators and their multi-company teams use that data to monitor and demonstrate compliance, and satisfy the many regulatory reporting requirements that they are subject to.

Operators collect massive amounts of data as they conduct seismic surveys, drill, build infrastructure and facilities, and operate these facilities for production of oil or gas–*and yet, the data and information about their activities remains in silos, which are managed by specialized applications that make most of is the data undiscoverable by people who need it to make decisions.*

E&P Decision Process Overview

Most E&P companies have common processes for maturation of entities, using toll-gated or phase-gated processes to evaluate, learn about and understand prospects and move them from initial exploration through to development and full production. While a wide range of digital oilfield technologies exist along the entire E&P value chain to gather data and automate processes, the review and decision-making processes are hardly ever automated. The people responsible for tactical and operational activities tend to consider these decision-making processes from a workflow or maturation point of view, and they require choreographed progression through well-established procedures.

The upstream oil and gas business is also a risk- and asset-management game where entities such as projects, prospects, assets, wells, and deals are assessed in both the aggregate or individually in a portfolio view. Interpretations and metadata generated by assessment processes drive strategic decision making at the asset, regional and corporate levels. Decisions made in these strategic layers act as set points or objectives to be achieved by the projects, processes and people who execute them.

Decisions, directions and objectives flow downward from management to assets and projects while data, observations and interpretations from the assets or projects flow upward, creating rich metadata that ideally should be captured as part of an "institutional memory" that serves as a historical record that is incorporated as a component of the big picture.

Decisions, directions and objectives flow downward from management to assets and projects, while data, observations and interpretations from the assets or projects flow upward, creating rich metadata that ideally should be captured as part of an "institutional memory" that serves as a historical record that is incorporated as a component of the big picture. Compliance, peer reviews and HSES (health,

safety, environment and security) also require an institutional memory of the metadata and decisions to enable retrospective look backs and other compliance-driven activities, such as audits.

How an Upstream Reference Architecture can Help

Business factors in E&P are driving the need for an upstream information technology (IT) reference architecture that provides a common, reliable environment for implementation and integration of the many technologies that make up the digital oilfield. Ultimately, the reference architecture will help to dramatically improve efficiency and cost-effectiveness for upstream oil and gas analysis, operations and business.

The right reference architecture will make it possible to implement solutions that integrate decision-making capabilities, capture the results (decisions), and build an "institutional memory" that becomes part of the digital oilfield operations that will continuously inform those systems.

Reference Architecture Overview

The reference architecture must form a framework into which vendors and partners can plug their specialized offerings, either in the form of standard software solutions and applications or as services. Such a framework must address essential needs of the industry today and scale up and across to meet future needs. Oil and gas operators and producers, the entire range of oil field service companies, and EPC companies should find that this reference architecture offers a way to rapidly execute their business with their extended stakeholders, partners and service providers, without compromising their internal processes and practices.

Requirements for a Reference Architecture

To be practical, useful and easily adopted, the reference architecture must be more than just a collection of technologies or slots for technologies with a pre-integrated framework. The reference architecture must become the equivalent of an E&P business operating system that manages all aspects of digital data acquisition, metadata extraction, data provisioning for processes and workflows, aggregation into decision dashboards and portfolio view while managing the presentation of the right information to users wherever they may be, at the right time.

To be practical, useful and easily adopted, the reference architecture must be more than just a collection of technologies or slots for technologies with a pre-integrated framework. The reference architecture must become the equivalent of an E&P business operating system…

The framework should create a single, seamless and consistent pathway of single-truth information from the field to the board room, from the back office to the decision makers and then to the external parties.

Specifically the reference architecture must:

- Make it very easy for oil companies to engage any oil field service company to exchange data and information through adaptable and secure interfaces across either side's firewalls.

- Make it easy for joint-venture partners to share information and collaborate on analysis and decisions under the covenants of their JV contracts. They should be able to work seamlessly from within their firewalls or through optional use of secure cloud services
- Provide a crystal clear relationship of E&P functions expected to be served by functional components and docking points for them in the framework.
- Provide a way for independent software vendors (ISV) and solution providers to effortlessly dock their functional components or applications to readily available adaptors provided in the reference architecture.
- Be capable of provisioning expected data in an expected format at each of the docking points through adaptors in the framework's authorized applications and processes.
- Provide documentation and certification processes that allow ISV, OFS, EPC and other contractors to innovate and improve on the performance, capability and safety of functions provided, with the lowest cost of ownership and minimum time to market, while protecting their IP.
- Provide opportunities for software as a service (SaaS) and cloud service providers to configure and deliver "ready-to-operate" data and information environments for JVs of upstream companies.

Benefits

A reference architectural framework for E&P ensures that the appropriate people are provided the correct information at the right time, and in the right manner. Implementing such a framework will also lower costs by eliminating the friction of data exchange among authorized partners, thereby streamlining processes that support better governance and decision making, provide visibility and automation in reporting and dissemination of information among internal and external stakeholders and regulatory agencies. Above all, it makes it possible to set up ventures and get to deployment faster and more consistently.

Microsoft Upstream Reference Architecture

PointCross has chosen to adopt the Microsoft Upstream Reference Architecture (MURA), which is based on a set of foundational principles that include:

- Performance-oriented IT infrastructure.
- Enhanced user experience.
- Optimized domain-specific infrastructure.
- Rich application platform.
- Comprehensive interoperability.

MURA is descriptive (rather than prescriptive), so that it delivers the consistency needed to support unification and simplification of the upstream IT infrastructure, while still providing the flexibility for companies to innovate and establish competitive differences.

MURA's genesis was in late 2009, and early 2010 marked the start of the MURA consortium, an industry-wide group stewarded by Microsoft and representatives from the consortium's member companies, of which PointCross is a founding member. Membership is open to all organizations who work in upstream oil and gas, including operators, service companies, software companies, and

standards organizations. The consortium has begun forming work groups that will chart the course and develop plans for further development, maturation and refinement of MURA.

(For more information, see the Microsoft white paper, *Vision for an Upstream Reference Architecture*.)

MURA also reduces costs for enterprises that have invested in Microsoft foundation technologies and platforms by leveraging server-side Microsoft Office SharePoint™ Server for collaboration; Microsoft Biztalk® Server middle-tier data buses for provisioning data to authorized applications; client-side Microsoft Outlook® and Microsoft Office including Microsoft Office Business Applications (OBA) for data acquisition and presentation of business data and information; back-end Microsoft SQL Server® for databases and associated services; and optional cloud services and mobility capabilities when needed.

This paper discusses how the MURA framework makes it possible to reliably integrate disparate decision-making process—both within the downward and upward decision/information flow, as well as across lateral processes providing information flow and triggers.

PointCross technology fills some of the MURA space including data services layers, business and technical ontologies, and business process orchestration and decision support services. The paper uses this technology implementation to explain how the MURA framework can be deployed with simplicity and elegance to cover many of the business-decision, support and hydrocarbon-maturation processes. Similar papers by other members of the MURA consortium will cover other technology implementation areas, such as the control room and the digitization of the field, as well as some overlap with the areas discussed here.

How the Reference Architecture Integrates Decision Making

Based on MURA and using proven technology, PointCross has developed solutions under its commercial brand IEPS™ (Integrated E&P Suite) that include:

- A data services layer that can:
  - Be configured to connect to any of the applications and systems that collect data from field systems, oil field service (OFS) contractor systems or sub-surface GG&E (geology, geophysics, and engineering) data stores and applications.
  - Provide services for normalization of data names and harmonization of units of measure using semantically enabled transformation and publishing services.
  - Make it possible to dynamically re-purpose thematically relevant data packages to applications, people and authorized third-party requests.
- A vendor-neutral way to store, analyze, provision or exchange any technical or business data dynamically, with semantic relevance, to conduct business despite how the data was acquired through a data services layer.
- Provisioning of applications to authorized users based on the context of their work, where the authorization is granular, and access is determined by the roles that users occupy in projects, deals, assets and other entities.

- Metadata extraction, contextualizing and re-purposing facilities that creates a traceable thread of data and their metadata to serve business decision and hydrocarbon processes.
- A self-organizing ontology of the organization's technical and business information to serve as institutional memory and as a vendor-neutral representation of the company's knowledge and decisions. This data structure is also used for search of authorized data and information.
- A hydrocarbon maturation process suite with standardized templates that can be used out of the box, and reconfigured rapidly, by customers or partner organizations to suit their needs.

Essential Solution Components tied to MURA

Figure 1 shows a high-level abstraction of the systems and sub-systems within the framework that serve to define its major functions.

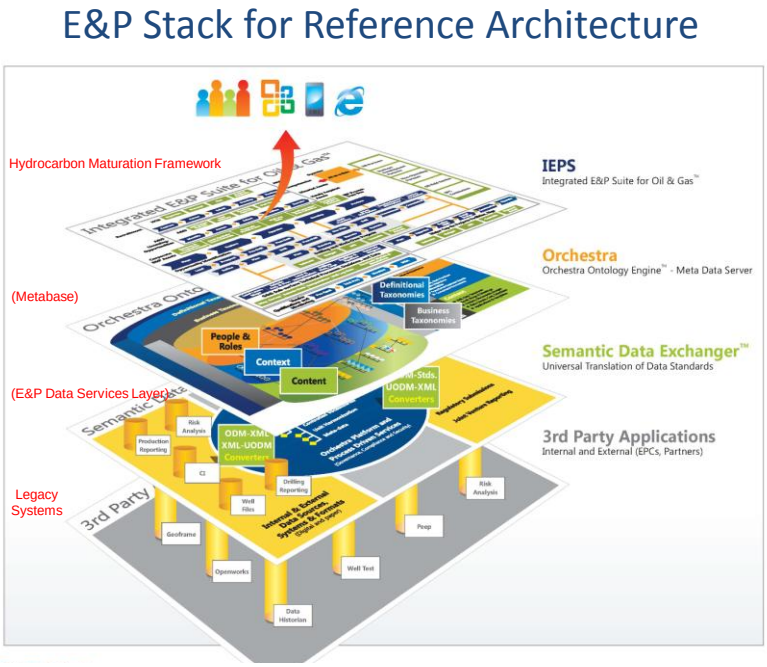

Figure 1 PointCross solution stack makes it possible to automate decision-making processes and results and integrate them into a comprehensive digital oilfield solution.

This framework is built on top of legacy systems with a three-level backbone with these main levels (from bottom to top):

- E&P Data Services (EP-DS) layer that manages the capture, conversion, re-purposing and provisioning of all field and business data needed for any and all E&P activities.
- A Metabase or central ontology layer that holds all the data, metadata and information and their relationships. It maintains the institutional memory of the E&P company or joint venture. This metabase is to the business what the data historian is to the field data.
- A Hydrocarbon Maturation Framework (HMF) layer that can include workflows, analytics and solutions with which E&P technical and business professionals and managers interact.

This stack is essential because it acts as the central nervous system of the E&P decision-making process and control loops.

For example, on the top HMF layer, innovative applications can be plugged in. At the Metabase (ontology) layer, applications that provide key functions such as search, discovery, historical retrospective analytics and others are provided.

Figure 2 shows the architectural framework for this solution, which includes all essential functional components required for providing all the capabilities needed by an E&P company and interactions with all of its partners, service companies and other contractors.

The architecture is sensitive to the crucial components that affect field operations and safety, so the data bus or channels that carry that critical data are kept separate in each layer, from the field to the control rooms to business processes. The control room of the producing field is critical for operations, safety and real-time decision making. These buses are contemplated in Level 1, 2 and 3 (see descriptions of levels and buses below). Here quality of service and uptime is supremely important.

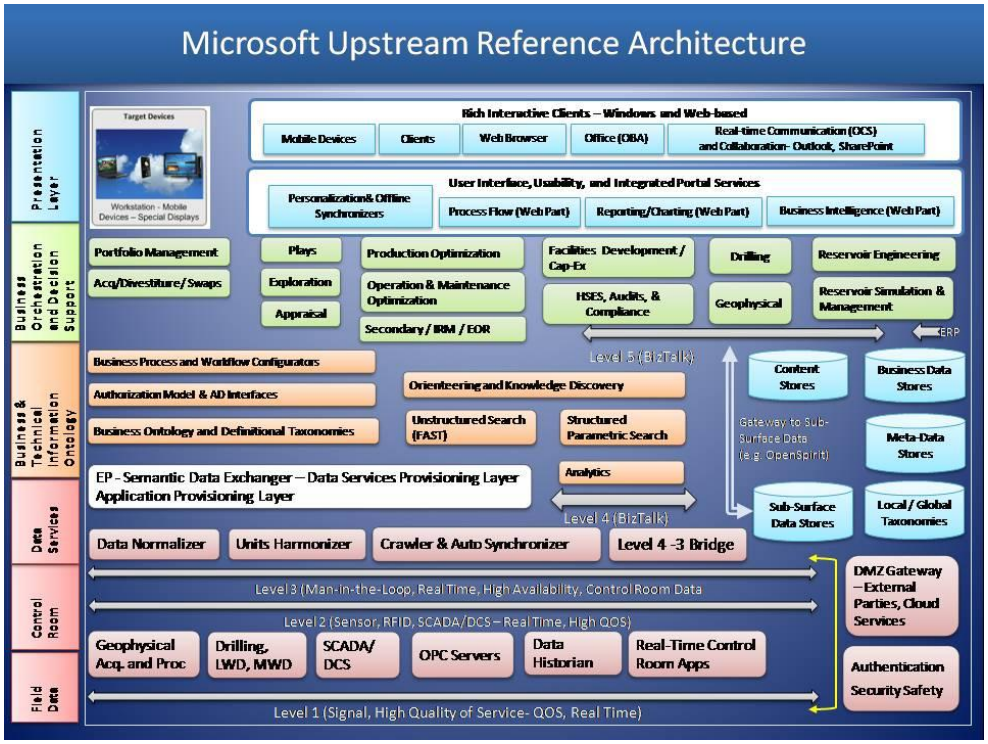

Figure 2 PointCross implementation of the MURA shows how control loop levels leverage the architecture and Microsoft technologies within the architecture.

We have designated the following descriptions for the different data levels, which also correspond to bus or control loop levels (next section) that carry the data:

- **Level 5.** Business transactions and general content related to managing the business. This includes normal emails, documents, HR, ERP and other variable data for critical and sensitive business transactions. It can include both structured and unstructured data.

- **Level 4.** Data and information flow related to E&P workflows; decision-making activities related to the assets, wells, projects, production and drilling and the development of activities related to drilling and production. Set points to which control room activities are executed may be established at this level.
- **Level 3.** Control-room-level decisions and workflows that relate to actual operation of plant or drilling activities. Information and data flows have impact on operation of equipment, safety and other HSE considerations. Information flows and control data are short–cycle, real-time and considered mission critical
- **Level 2.** SCADA, DCS, and MWD wire-logging data from physical equipment that is used directly by the remote or control room systems or transmitted through telemetry systems into data historians.
- **Level 1.** Sensor and control data at the signal level, such as OPC data before it is processed, is unpacked and re-packed into data models.

(Details about Levels 1, 2 and 3 are expected to be the topic of future papers by other MURA members.)

Decision Loops Tied to System Control Loops

Figure 3 shows a virtual representation of oil or gas production operations and maintenance decision cycles that cover the field to the boardroom in three cascading control loops.

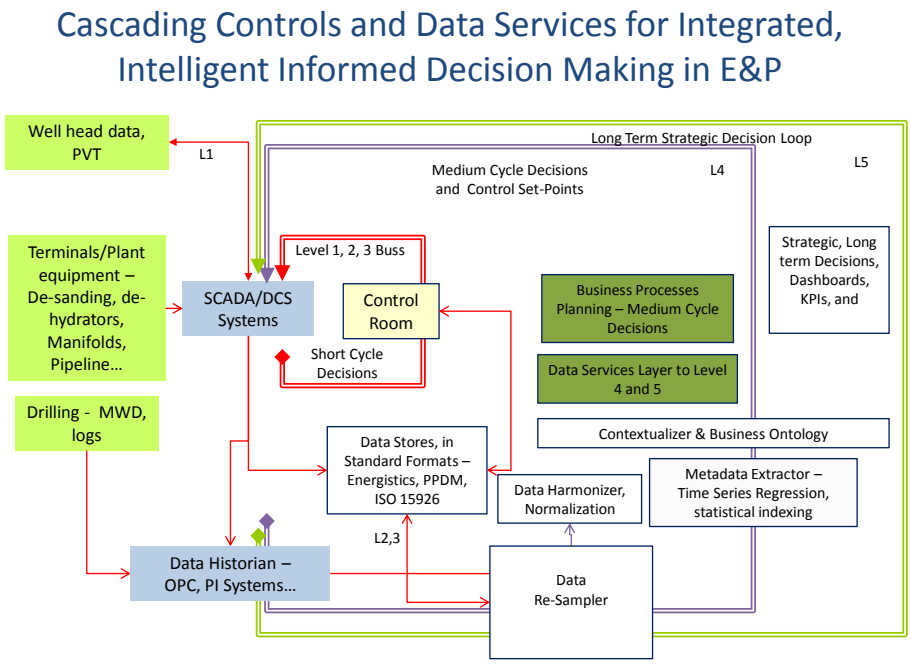

Figure 3 Each of the three control loops provides the data source for the next outer loop where the data is distilled and metadata extracted for use in decision-making or maturation processes.

- **Short-cycle** decision (quick response) control loop uses real-time data from the field (PVT data) and responds with real-time controls through digital control systems. Remoteness, safety and

performance require that these are largely automated and monitored by systems with people acting in supervisory roles in the control rooms.

- **Medium-cycle** decisions and control set point loop applies a higher level of smart feedback controls, usually by inserting a human being into the control loop so that strategically significant, short-to-medium-term decisions, such as production planning, maintenance and operations scheduling can be made.
- **Long-term** strategic decision loop enables strategic decisions to be made with broader understanding of insights and trends. This loop contains sensory data, other internal and external knowledge and decisions that have been made, such as facilities re-development, secondary/tertiary production decisions and portfolio level decisions.

Multiple data buses carry data and control systems. For quality of service (QOS) and safety reasons, the data in these buses (Level 1, 2 and 3) are not connected directly to the higher level 4 and 5 buses. These buses (Level 4 and 5) carry business process and strategic office information because the expectations of QOS are very different and free flow of data from office data busses can affect this QOS.

Each control loop provides the data source for the next outer loop where the data is distilled and metadata extracted for use in decision making or maturation processes. The data is sourced to Level 4 and 5 from Level 1, 2 and 3 and gateway middle-tier applications, such as OpenSpirit, on a read-only basis, either directly from the application or from data historians. In return, the outer loop provides the inner loop with set points or, in the case of people in the loop process, decisions.

For example, the tactical planning and optimization processes set the production levels, which tell the inner control room how much to throttle back or open up the production. This tactical planning control loop is executed in the Level 4 and 5 buses. Individual organizations decide whether these set points are allowed to write into the control room bus, pass it through a semaphore to the real-time bus or pass it manually.

Data in the planning and operational control loops are re-sampled over weeks and months and passed to the outer strategic control loop through the Level 4 and 5 buses, the business processes and portfolio decision-support solutions. This decision loop includes reservoir engineers, portfolio managers and executives who make decisions on long-range set points related to production and facility improvements to achieve strategic goals.

Business processes and Level 3 buses can interoperate with specialized middle tiers, such as OpenSpirit, so that they can easily dip into the sub-surface data stores and extract data and metadata from GG&E data and soon from reservoir simulators.

Semantically Enabled EP-DS Layer with Ontology Engine Delivers "Institutional Memory" for Decisions

Why is a data services layer that has a built-in, semantically enabled smart data exchange so important? Because it is this combination of technologies that allow an E&P company to use and re-purpose all data sourced from processes and decision making in business. It serves internal applications and other external applications and service requests.

The EP-DS layer (Figure 1) connects and transforms disparate types of data sources from Level 1, 2 and 3, which represent drilling, production, and geophysical data. It also connects to Level 4 and 5 data sources from people and their communications, documents and reports, specifications and drawings, and contracts related to construction of major cap-ex facilities, presentations and proposals for deals.

The EP-DSL sounds like a nerve system because it is a data networking and communication routing system. How does the EP-DSL manage all the data from these types of disparate data types and their relationships? That is the role of the Metabase layer or ontology engine, such as Orchestra. This technology serves as virtual institutional memory that relies on the digital equivalent of a neural network. The ontology engine creates relationships between business contexts which contain information, people who work on that information, and definitions that give semantic meaning.

The EP-DSL together with the ontology engine provides:

- Contextualization.
- Technical and semantically enabled search and discovery through data and information.
- Web-services to internal process in PPS layer or external applications that need data or information for their functional needs.

Therefore, this solution that is aligned with the MURA foundation supports these types of data:

- Unstructured Content
  - Articles of communications and collaboration including emails, SMS, documents and calendar events (Level 5).
  - Narrative content within workflows and decision making processes such as exploration team reports, annotations, contextual emails, journals from geophysical interpreters and geologists, drilling engineers, reservoir engineers and simulations, facilities program management, business development and many others (Level 4 and 5).
- Structured Metadata
  - Metadata extracted from structured data within business or technical data stores including sub-surface (GG&E) data stores.
  - Metadata and metatags extracted from unstructured content including Level 5 and Level 4 communications and content. Figure 4 shows metadata types and their use in E&P applications as technical and geo-spatial search.
- Raw data such as those captured from the field including wire logs, PVT data from production facilities and well data from geophysics operations.

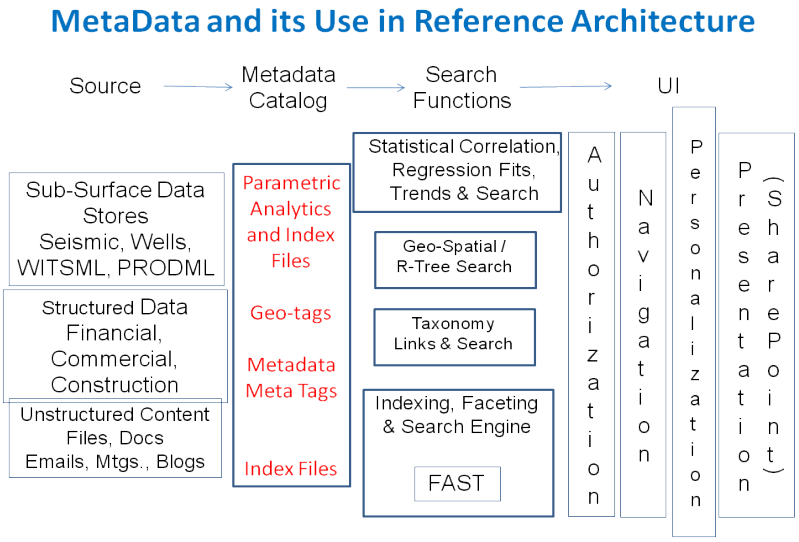

Figure 4 Metadata and metatags are extracted and created from structured and unstructured content that is processed throughout the integrated solution, and then to help people more easily connect to information in the system.

Leveraging Industry Standards

A number of applications and systems from OFS companies are in place today for capturing and transmitting this kind of data to an E&P company's data stores and historians. Some of the raw data and a lot more of the metadata can also be represented within industry standard XML models.

These standards models include WITSML for drilling and well data, PRODML for production data, PPDM, a more general purpose large footprint data model for E&P, ISO15926, a general standard for integrated processes, and other special purpose standards.

These standards provide a clustering point for companies and their applications, a common language by which to exchange data. While the standards do provide a common language, they do not provide the translation service from a data format to the standards or between standards. The reference architecture must provide the capability for other applications to dynamically translate the data in one standard to any other standard that the E&P company chooses. In actuality, it is not necessary that an E&P company adopt a standard, but rather they must be capable of accepting and publishing data in any variety of standards.

The EP-DSL must have an internal universal operational data model (UODM) (Figure 4), a vast but essential collection of thematically organized, semantically enabled sub-models that cover all aspects of an organization's business interests.

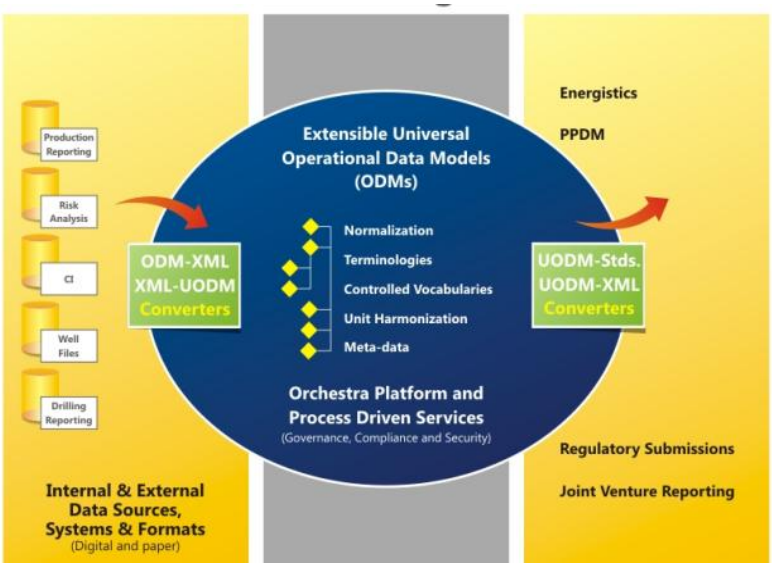

Figure 5 The universal operational data model (UODM) is a crucial part of the technologies on the EP-DS layer that makes it possible to use and re-purpose all data sourced from processes and decision making in the system.

HMF Layer: Where People Interact with the System

The HMF layer is where people interact with the system, working within workflows and making decisions. PointCross offers Integrated E&P Suite for Oil & Gas™ (IEPS) (Figure 6, page13), which provides integrated technology solutions from initial prospect recruitment through development, implementation, operations and monitoring. The technologies described above in the EP-DS layer then integrate with these solutions, driving the right decision-related data and metadata into these processes.

People work in one of two possible environments: 1) processes and tethered workflows that ensure consistency and compliance where data is acquired and matured in a series of stages, each of which are checked by a peer review or toll gate; or 2) they tend to have an executive viewpoint that allows them to look at the metadata of a portfolio of entities.

Each of the processes, shown as swim-lanes, manage separate entities such as assets which have fields that contain other processes that manage the wells within them; or the cap-ex facilities that need to be built or seismic data to be acquired.

Executives and decision makers are more interested in the metadata of the entities, aggregated into portfolio views, with decision options and the ability to track their past (look backs) and consider alternate decision paths.

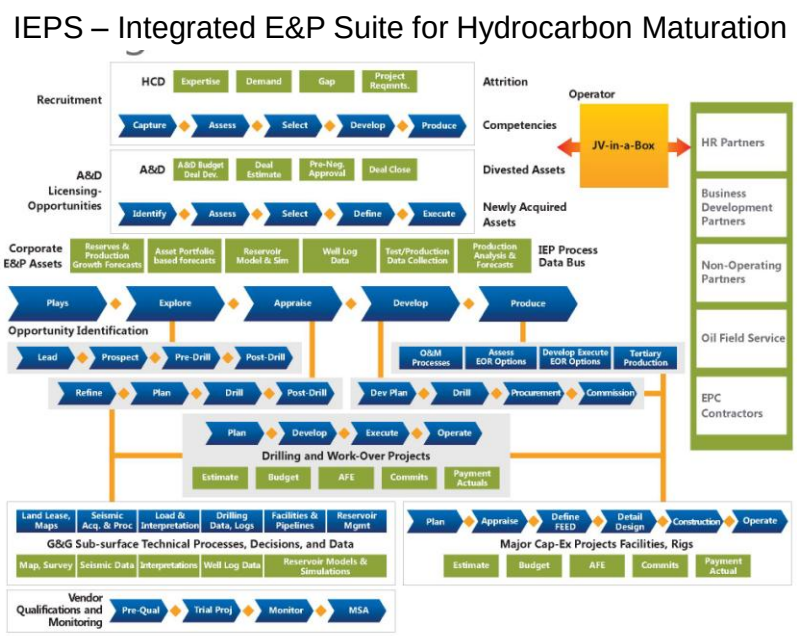

Figure 6 Integrated suite of E&P applications can be integrated with components of decision solutions to capture and process decision-related data across the entire implementation.

Figure 6 also shows how applications seamlessly interact with external parties and their data sources and how the reference architecture supports gateways to cloud applications and externally hosted software as a service (SaaS) applications that allow the operators to work within their firewalls while they seamlessly interact through messaging and cross workflow triggers.

Conclusions

Oil and gas exploration and production is complex, a capital- and risk-intensive business that requires a wide array of technology and systems along the entire E&P value chain to enable the equally wide array of evaluation and decisions required. But these technology and systems remain isolated in silos, requiring expensive integration projects for sufficient interoperability to be useful for decision makers.

The Microsoft Upstream Reference Architecture is a concept with great potential to draw both competing and complementary software technology and services into a common way of working and exchanging information for the benefit of the E&P industry. Because MURA provides the reliable, secure infrastructure for interoperability, operators, software and service companies can focus their efforts on making the best possible domain solutions.

Though MURA is still young, with many aspects yet to be defined, this paper demonstrates what is already possible, what one solution provider is able to do today.

The data services layer, which includes data management and provisioning, allows E&P companies to configure their standard maturation, or stage-gated, processes while also being able to analyze their portfolio of assets, projects and deals. The decision-making processes implemented with solutions aligned with the MURA provides an “institutional memory” to digital oilfield implementations that can

continue to inform and serve E&P processes and deliver important business functions such as enhanced technical searching across the enterprise.

About PointCross

PointCross is a global provider of advanced strategic business solutions to knowledge-rich markets, including the Oil & Gas industry. Our Integrated Exploration and Production Suite (IEPS™) specifically addresses E&P companies' business needs. Orchestra+Solo™, the heart of PointCross solutions, is an adaptive, contextual knowledge environment and personalized client that orchestrates core business processes. This robust solution set provides:

- Single point of access to contextualized tacit and structured knowledge across the enterprise, with search and guided navigation within and across contexts;
- Robust search and orienteering capabilities across studies, emails, documents, meta-data and more across the entire organization, EPCs and partners;
- Flexible, fool-proof IP security based on contexts and roles, determined by business rules;
- Secure multi-party workflows for knowledge sharing and business-social networks within and across companies;
- Semantic Data Exchanger (SDE™) for vendor-neutral data exchange, normalization and unit harmonization;
- Business development, e-discovery, audit, compliance, and more;
- Scalable architecture and development toolkits for additional capabilities.

PointCross represents a new way of doing business. We deliver business ready solutions in 1/10th the time and at a fraction of the cost compared to standard technologies, while offering strategic advice from people who know the Oil & Gas industry.

We are headquartered in the California Bay Area with offices in Houston, Texas and Bangalore. We are a Microsoft Gold Certified partner. We also have a global network of service, consulting and infrastructure partners.

For more information, visit us at www.pointcross.com and call us at (281) 295-1900. Also, check out our blog at http://blog.pointcross.com.

About the Microsoft Upstream Reference Architecture

The Microsoft Upstream Reference Architecture (MURA) is based on a foundation of agreed-upon principles that establish consistent performance for an information technology (IT) environment that supports and easily integrates the full range of technical, operational, safety, regulatory, and business technologies and solutions for the upstream Oil and Gas industry.

MURA is not prescriptive, but rather descriptive, so as to deliver the consistency needed to support unification and simplification of the upstream IT infrastructure, while still providing the flexibility for companies to innovate and establish competitive differences.

The development, maturation, and refinement of the reference architecture is being guided by the MURA consortium, an industry-wide group stewarded by Microsoft and representatives from other member companies, which is part of the broader, ongoing MURA Initiative.

For more information, see the Microsoft white paper, *Vision for an Upstream Reference Architecture*.

About the Microsoft Worldwide Oil and Gas Group

Together with our partners, Microsoft delivers enterprise-class solutions that amplify the impact of people and help companies meet Oil and Gas industry challenges. By putting the right tools in their hands, oil and gas workers can efficiently analyze volumes of data, and communicate and collaborate with colleagues, vendors, and partners around the world to make better decisions faster.

For more information, visit our Web site at http://www.microsoft.com/oilandgas.