The Microsoft Upstream Reference Architecture

The flow of oilfield data increases exponentially each day. As a result, upstream operators are demanding software solutions that enable them to work smarter and take advantage of new technologies including cloud services, apps, mobility, social computing and platforms that unlock the potential of Big Data. Microsoft is at the forefront of these technology advancements.

Our vision is to shape the future of technology delivery in the energy industry. At Microsoft, we believe that cloud services is the next generation of IT and the next step in the industry's increasing quest for efficiency gains and global collaboration. According to a 2011 Microsoft and Accenture survey of over 200 oil and gas engineers, managers and IT managers, 36 percent have plans to use cloud services in the future and another 32 percent are currently using private or public cloud services.

Respondents expect their computing environment to provide easier access to volumes of data necessary for oilfield operational decision making. Mobile devices such as tablets and smart phones are beginning to offer new ways of accessing this data in simpler, more pervasive ways, from integrated, secure, reliable and instantly-available cloud-hosted Services.

Through the Microsoft Upstream Reference Architecture (MURA) framework, Microsoft is leading the industry to the cloud, and from there, providing the foundation for the next generation of oilfield solutions.

The end result for operators is:

- *Faster time to first oil,*
- *Optimized production,*
- *Improved recovery,*
- *Reduced operating costs,*
- *Improved safety and environmental performance,*
- *Increased return on assets and*
- *Reduced risk.*

This whitepaper will be updated as required – please ensure that you have the latest version.

Microsoft

Created June 2010. Updated May 2013.

This White Paper is One of a Series of Core White Papers:

- Empowering the Upstream Business in a Connected World (May 2013)
- Big Data in Oil & Gas (May 2013)
- Security in Upstream Oil & Gas (April 2012)
- The Microsoft Upstream Reference Architecture (*this document*)

Contents

Upstream Business Demand More from IT Architecture

An upstream reference architecture must support and respond to the functional activities of an upstream organization and provide the capabilities needed to effectively and efficiently run the business.

Oil and gas exploration and production (E&P) is a vast, complex, data-driven business, with data volumes growing exponentially. These upstream organizations work simultaneously with both structured and unstructured data.

Structured data is handled in the domain-specific applications used to manage surveying, processing and imaging, exploration planning, reservoir modeling, production, and other upstream activities. At the same time, large amounts of information pertaining to those same activities are generated in unstructured forms, such as emails and text messages, word processing documents, spreadsheets, voice recordings, and others.

Figure 1 shows the broad spectrum of structured and unstructured data upstream organizations use to orchestrate, automate, integrate, and execute integrated upstream operations and management activities.

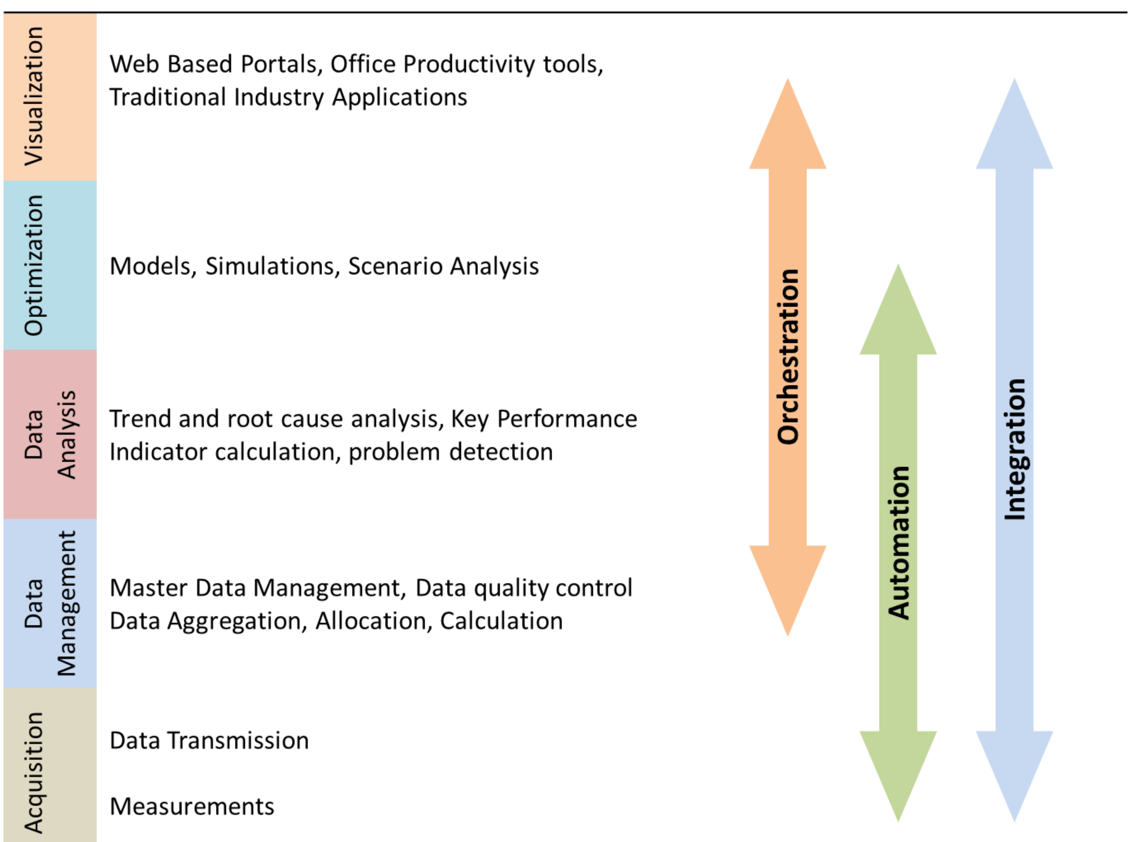


Figure 1. Upstream business activities use a broad range of structured and unstructured data.

Domain-oriented structured data is used for:

- **Collaboration**, including visualization, data fusion, decision tracking, and knowledge management.
- **Optimization**, including simulation, proxy models, decision selection, and implementation.
- **Operational data analysis**, such as trend- and root-cause analysis, solution evaluation, key performance indicators (KPI) and problem detection.
- **Data management**, which includes: quality control, validation, data storage and archiving, loss management, allocation and rate estimation and acquisition, including measurements and data transmission.

A Day in the Life of an Upstream Organization

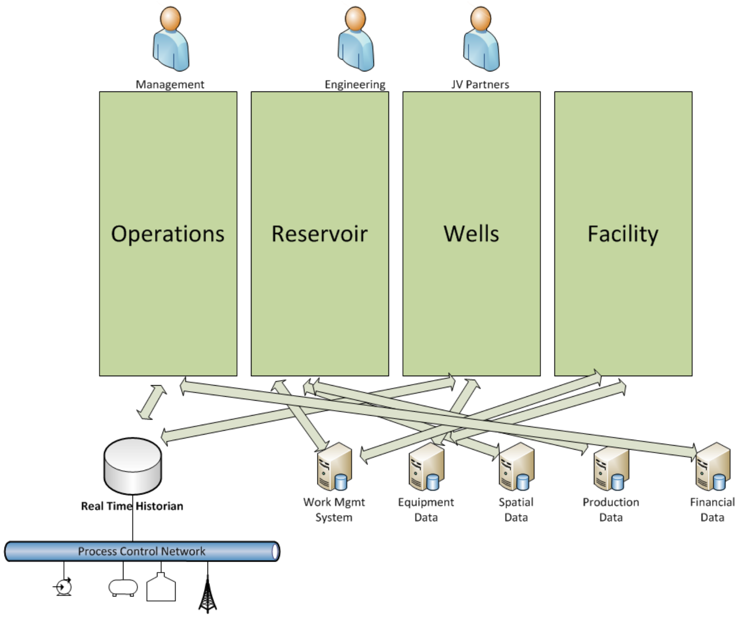
For a clearer understanding of the use of both structured and unstructured data, consider the following scenario.

A global asset team made up of geologists, geophysicists, and reservoir engineers, located in three different countries, works together to develop a field development plan to assess the economic potential for various tertiary recovery options on a key field with declining production. The team tunes the reservoir model in Petrel with all available G&G and production data, and plans several well options modeling fluid flow along streamlines and using reservoir simulation to assess the potential and impact of the placement and timing of those wells. The team works together on the shared models within the application software. However, the number of scenarios and the complexity of the analysis require that the work be an iterative, collaborative effort. So the team also discusses options and exchanges ideas using email and text messaging, and shares necessary documents through their secure team portal, which makes it possible for them to prepare multiple options in parallel for management and partner review.

Current State: Overview and Challenges

The current state of IT infrastructure in most upstream businesses is unable to adequately support and respond to analysis, operations, and business needs.

In most organizations, the volume of information is increasing exponentially because digital sensors are deployed in more exploration and production plays, more data sources are connected to IT systems, and growing volumes of information are captured and stored in enterprise databases. Large volumes of domain-specific information are also embedded in various upstream applications. This data situation means it’s difficult or impossible to use that data to quickly and efficiently get the information and answers needed.



Current Architectures

Existing IT architectures in the upstream oil and gas sector are often limited by applications in silos, poor integration, and barriers to collaboration. Paradoxically, the most common activities across all of these domains are word processing, spreadsheet, email, and other basic business applications.

Figure 2. The current state of IT architectures for the upstream oil and gas sector.

A few basic issues define the requirements of an upstream IT architecture.

Data Management. That growing volume of data now typically resides in disparate source systems, such as Landmark's SeisWorks seismic interpretation software or Schlumberger's Petrel—or maybe even a combination of both. The Web-based tools used for viewing and collaborating on this information are not fully integrated. That means when a geologist is reviewing seismic data for a prospect and he or she needs to cross check core samples, that information can typically be accessed only through an inconvenient and time-consuming search of the different systems, rather than from one common interface.

When integration does exist, it is usually through point-to-point connections or intermediary database tables. These one-off connections add time and cost, and cannot easily be shared or reused by other applications. Various industry solutions provide data- or application-integration frameworks, which create a common access layer to help address this integration problem.

Integration. Each discipline—petrophysics, geology, reservoir engineering, and others—tends to have and use its own analytic modeling systems, but currently little connectivity or interaction exists between those models. Therefore, changes in conclusions for one discipline are not always carried through to others, which can cause increased inaccuracy, errors and uncertainty.

Collaboration. With current IT infrastructure, collaboration is also difficult because there is no convenient, shared location where multiple internal and external partners can access information stored on the corporate network. For example, a seismic service company employee who works on prospects for multiple energy companies needs separate log-in locations and passwords for each of those collaborative partnerships. These same collaboration challenges also typically exist within individual oil and gas companies.

Performance Management. In the current state, KPIs, which are needed to understand and assess the current status and overall health of an organization, are often not readily available. The manual, time- and labor-intensive processes needed to gather and analyze KPIs means that managers and engineers waste valuable time waiting for answers, while data is collected, analyzed, and translated into the insights needed to understand and run the business.

In this siloed environment, it is often difficult to locate information and ensure the timeliness and quality of that data. For example, three or four different systems may compile lists of available field data, but the organization may lack a single, comprehensive, and up-to-date list of those crucial subsurface assets.

Drivers for the Evolution of a More Efficient Architecture

Powerful reasons are compelling oil and gas companies to seek a new and more efficient upstream IT architecture that takes advantage of the cloud. Companies must have:

Reduced implementation and support costs. Oil and gas companies can do this by maximizing their use of existing technology investments when purchasing new solutions from vendors. However, until now, they have had little guidance on how investments in such solutions could fully use existing technology investments that the organizations' IT departments have already made. For example, it would be advantageous for a company to know that a vendor's solution would use already-purchased management solutions like Microsoft System Center to ease deployment or use single-sign on technologies from already-deployed identity management solutions, like Active Directory. Further, by making extensive use of cloud solutions, capital investment on data centers can be reduced as can the support costs of running them, maximizing business agility and lowering IT costs.

Ability to deliver more with less. In today's business and operational environment, companies must deliver more throughput with fewer resources and severely time-constrained work teams. To deliver better results faster, G&G and engineering workers must be able to spend more time doing domain-focused work—and less time searching for and preparing the data needed for that work. Workflows, data-driven events, and automated analysis should help drive their efforts to identify risks and help manage the exploration portfolio or production operations.

Integrated views. Workers also need integrated views that reveal all relevant data, both structured and unstructured, for a particular situation. For example, in an exploration scenario, that comprehensive perspective should include tornado charts that measure risk, analog well production histories, rock properties, log files, rig schedules, and other variables relating to the prospect in question.

Easily accessible KPIs. Management needs up-to-date key performance indicators (KPIs) to fully understand the current status and overall health of an organization. For example, ideally managers should be able to see a single screen showing the portfolio of current opportunities, which ones are drill ready, the available rigs, and the prospect peer reviews that are scheduled for the next two weeks. With appropriate drill-down details, managers can focus their time on the under-performing evaluation teams to quickly take remedial action to bring them back to the expected level of productivity.

Plug-and-play technology. The industry needs an architectural approach that allows upstream organizations to use more flexible and cost-efficient cloud-based plug-and-play business logic. If a technology supplier comes up with a better web-based seismic viewer, the architecture should allow that solution to be deployed quickly and economically to other cloud-based solutions that could make use of it. This approach reduces the constraints on IT, gives companies access to best-of-breed solutions, and can reduce the time needed to deploy new solutions from years or several months to just a month or even days.

Integration of structured and unstructured data. Lastly, upstream organizations also need the ability to connect and integrate the large volumes of unstructured data generated and used by non-domain-specific sources, such as word processing and email programs, unified communications, and collaborative applications. This requirement recognizes that much of the information needed to manage upstream projects is in fact hosted in non-domain applications and environments, both on-premises and increasingly, in the cloud.

Enabling the Evolution

As noted, several emerging industry standards and technologies are now enabling the more flexible, integrated on-premise and cloud-based IT architecture needed in the upstream oil and gas industry.

Standards

XML standards-based technologies such as WITSML, PRODML or RESQML, curated and supported by Energistics, provide common data interfaces. This provides the foundation needed to ensure plug-and-play access to best-in-class hardware and software solutions that run both in the private data center and in the cloud. For example, if a company currently has a wellbore viewer that is WITSML compliant, the company can deploy any WITSML-based wellbore viewer solution with such an interface in place. Further, standard industry database schemas like the Professional Petroleum Data Model (PPDM) further support this, particularly when deployed to cloud-based-based databases like SQL Azure.

Technology

Cloud computing refers to remote centers for storing and accessing data and applications using the Internet, which are designed to save businesses money, in part by reducing the need to build major on-premise computing infrastructure.

The cloud approach is ideal for complex upstream operations, given its multi-vendor, multi-partner environment and huge volumes of data that require a combination of strict security and easy sharing with appropriate partners. Solutions delivered via a cloud infrastructure allow businesses to rent only the functionality they need, when they need it, and on a per-user basis. Cloud-enabled standards, such as the OData standard and industry data standards such Energistics in combination with technology such as secured web services, permit easy, secure integration between different instances of cloud-hosted services, even those provided by different vendors.

Mobility. With the proliferation of devices now available to consumers as well as businesses, especially tablets and smart phones, there is increasing pressure on IT departments to support the flexibility that such mobile devices can enable for end users. This is particularly true when running apps that connect to services and solutions that run in the public cloud as described above. Further, some hardware manufacturers are further enabling these capabilities in the field of oil and gas by providing touch-tablet solutions in “ruggedized” form factors to support long-term survival in the harsh operating environments on the pad or rig and the explosive-gas safety requirements of the plant, for example.

Big Data. Today, organizations need to unlock insights from data of any size and any type. To gain the full value of Big Data, the industry needs a modern data platform to manage data of any type, whether structured such as sensor data from rigs, or unstructured such as raw seismic data - and of any size: from gigabytes to petabytes. This ‘Big Data’ solution should also manage data at rest or in motion, and support modern tooling like Hadoop. Finally, when only a portion of a given set of data needs to be accessed by analytical tools upon this platform, there should be ways of temporarily storing the rest of the data in low-cost, secure cloud storage to lower on-premise data center costs for these huge data sets.

Social. The industry also is now embracing social media capabilities such as status updates and notifications from social networks, messages, instant messaging, blogs, and wikis. As upstream professionals use these technologies to manage their personal connections more and more, the industry is adapting network-based capabilities to foster cross-discipline collaboration and to better understand and manage the upstream operations environment.

Future State

Using a combination of the technologies described above in the manner outlined in this paper and those subsequent to it, upstream businesses will be able to realize an IT infrastructure that supports and rapidly responds to all analysis, operation and business needs.

Data Management. When source data such as seismic interpretation data is hosted in a cloud-based infrastructure then the Web-based tools used for viewing and collaborating on this information are much easier to fully integrate. For example, when a geologist is reviewing seismic data for a prospect, he or she can cross check core samples using one common interface hosted in a web-browser.

Integration. When the analytic modeling systems used by disciplines such as petrophysics, geology and reservoir engineering are all hosted in the cloud as Software-as-a-Service solutions then full connectivity and interaction is possible, leading to much more accurate decision making in a much shorter time.

Collaboration. Using modern cloud-based collaboration solutions, it is much faster and simpler to permit multiple employees within an organization as well as authorized external partners to securely access shared information, and only for the time required, including years, months or just days.

Performance Management. KPIs, used to understand and assess the current status and overall health of an organization, are always readily available when hosted in modern cloud-based applications. The data used to support these KPIs can be processed by the massive compute power available in cloud infrastructures so that answers are available quickly as well.

Guiding Principles

The Microsoft Upstream Reference Architecture (MURA) is not prescriptive—that is, it does not lay out specifics of the architecture's structure and function in order to achieve the future state described above. Rather, the MURA describes a set of guiding "pillars," or principles, that govern it. This descriptive approach provides an agreed-upon set of principles for establishing consistent performance, but also provides the flexibility for companies to innovate and establish competitive differences.

Shown in **Figure 3** are the twenty-seven "guiding principles" used to define qualities that solutions built upon the MURA should encompass (usually in part, not in whole).

The top four "pillars" relate to **business-focused** principles, and the "platform" across the bottom is primarily focused around infrastructure and IT, and underpins those on top.

Each guiding principle is described in the following sections.

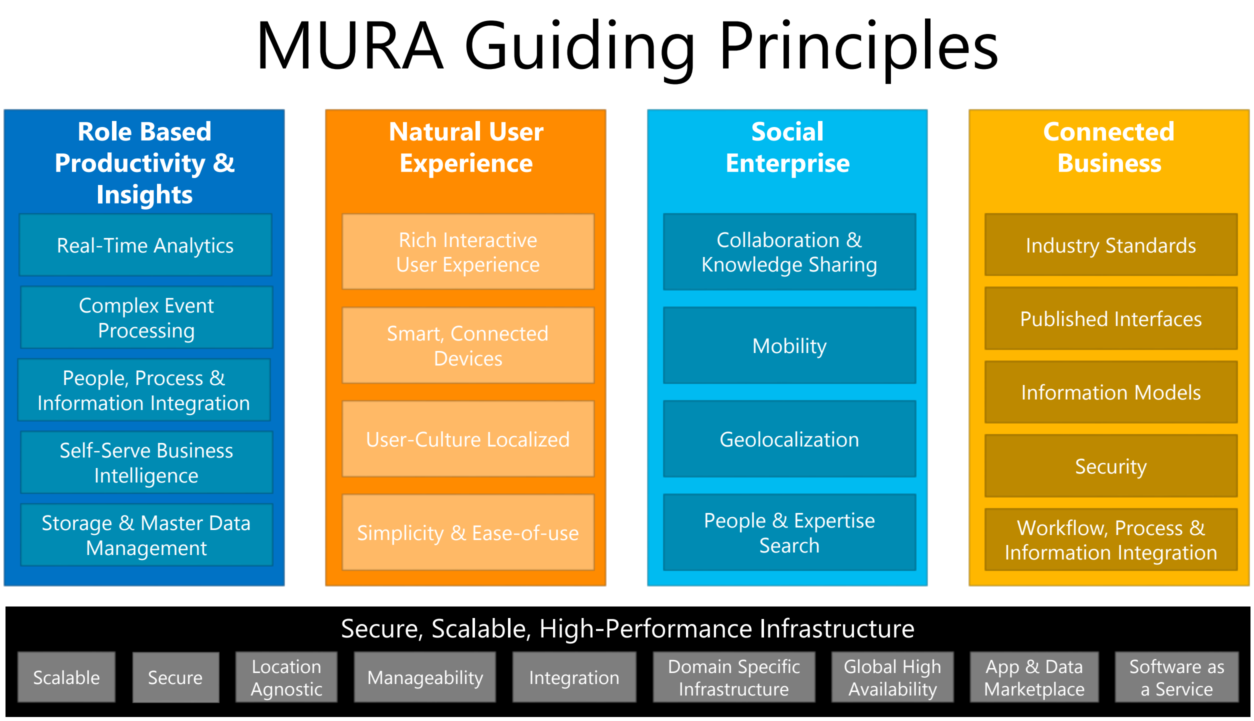


Figure 3. Guiding Principles of the Microsoft Upstream Reference Architecture (MURA).

Role Based Productivity and Insights

This group of guiding principles supports the business need to get the maximum insight from the vast amount of business-related data and to maximize the productivity of workers.

- **Real-Time Analytics.** Rich statistical and analysis packages for data mining, discovery, and reporting for diverse information consumers.
- **Complex Event Processing.** Stream-processing engines that can detect and filter real-time events, either on-premise or in the cloud.
- **People, Process & Information Integration.** Business workers use a variety of differing software tools and systems to do their jobs – often with related or even the same information or data. These tools or systems should be seamlessly integrated in order to allow business workers to avoid continuously importing and exporting data from one system to another in order to complete their workflows. This extends to workflows that include multiple users in their execution.
- **Self-Serve Business Intelligence.** To help them gain deeper insights into the increasing quantities of relevant data that is collected, workers should be able to use tools to find, select, and explore their data in different and flexible ways that make sense to them. They should be able to perform this process on their own and without, for example, having to define a report and request their IT to provide it for them.

- **Storage & Master Data Management.** Repositories to capture and enable analysis of operational and business data; located on-premise, in the cloud, or a hybrid mixture of both.

Natural User Experience

This group of guiding principles includes those features that enable participants to best experience the world and how technology fits into that experience, such as:

- **Rich Interactive User Experience.** This is a key quality of the user experience of applications for field workers, operations staff, control center personnel, and for use at home and on the road using lightweight tablet and smart-phone devices.
- **Smart, Connected Devices.** Devices with integrated capabilities that are also connected to the network. Examples include embedded devices running retail fuel pumps on gas station forecourts, ruggedized slate or tablet devices used to record production data by pumpers at the pad, or line-of-business apps running on smart phones that visualize data or enable collaboration with employees in corporate headquarters using Lync.
- **User-Culture Localized.** Oil and gas is a very global industry and therefore users around the world should be able to interact with their software tools and systems using their local culture's language and their culture's date and number formats.
- **Simplicity & Ease-of-use.** As software tooling gets more feature-rich and runs on ever more powerful devices, it should at the same time continue to be simple and easy to use, as well as support input methods that make the most sense (like mouse and keyboard, touch, both, and/or Kinect).

Social Enterprise

This group of guiding principles supports the needs of business workers to maximize their productivity via the assistance of their colleagues and others in the industry, including those people they do not yet know.

- **Collaboration & Knowledge Sharing.** Collaboration using both thick and thin clients, across a variety of devices, and leveraging today's most advanced collaborative tools through corporate portals and public cloud services.
- **Mobility.** Workers in the field and even in corporate headquarters are increasingly demanding the ability to work from a mobile location using the device appropriate to their needs. Therefore, solutions should support this capability and work across multiple devices.
- **Geolocalization.** There is also a need to know the location of the source of any given set of data, as well as the location of workers in relation to other workers and/or assets that produce this data, on an ongoing and searchable basis.
- **People & Expertise Search.** Due to the massive size and geographic spread of enterprises and project teams, workers needing to collaborate do not always know the expertise of their fellow workers. This tooling allows workers to quickly and easily find colleagues or

business partners with specific skillsets for a workflow they are trying to execute upon and for which they have a need for particular skills in order to successfully complete it.

Connected Business

For the MURA to successfully deliver cost-effective, integrative benefits, it must enable comprehensive interoperability both on-premise and in the cloud. As a result, these features are of critical importance:

- **Industry Standards.** These define a consistent, industry-wide interface to allow new component deployment, such as Energistics or PPDM.
- **Published Interfaces.** These are transparently publicized for open-industry use, even if a standard is not available, and satisfy important interoperability needs. All the elements of an interface are well defined so that applications can be independently developed to leverage the interface.
- **Information Models.** Consistent ontology (naming system) for referring to equipment and assets to enable exchange of information throughout the enterprise and the value chain.
- **Secure.** The definition of the security implementation including authentication, authorization, identity lifecycle management, certificates, claims and threat models to enable secure interoperable design and deployment.
- **Workflow, Process & Information Integration.** Connected, agile businesses require solutions that integrate the workflows of the business workers and the systems they use, their process and procedures, and the information those workers create and manage as part of their work-day across all the upstream systems they interact with.

Secure, Scalable, High-Performance Infrastructure

This group of guiding principles captures the needs of the underlying technical infrastructure and includes:

- **Scalable.** Support for more users, larger models, increased transaction volumes, etc. can be accommodated through increasing hardware performance (scale-up) or the linear addition of hardware and network resources (scale-out), either on-premise, in the cloud, or a combination of both.
- **Secure.** Deployed components, functionality, and associated information are protected from unauthorized access or malicious attacks.
- **Location Agnostic.** Services are designed so that they can be deployed on-premise in a private data center, in the public cloud, on a smart phone, on a tablet or on a workstation. Users and software components have secure access to platforms and services wherever they are located.
- **Manageability.** Infrastructure components can be efficiently deployed, managed and monitored.
- **Integration.** Messaging and database technology for linking together workflow, processes, and data optimization. This includes services and components for communication of device

and equipment data, between solutions deployed in the private data center and/or public cloud, typically via a Service Bus architecture.

- **Domain Specific Infrastructure.** This incorporates trade-specific infrastructure connections leveraging unified communications to manage compliant devices, from down-hole sensors and well heads, to pumps, intelligent bits, compressors, and other plant equipment. The connections then flow that data into appropriate operational systems.
- **Global High Availability.** Solutions should be available around the world, all the time to meet the needs of the global industry.
- **App & Data Marketplace.** Marketplaces are now becoming a common method of deploying applications to both desktops and mobile devices, and a place from which to purchase data from vendors. These may be public or a corporate-managed store.
- **Software as a Service.** Oil and gas companies want to buy their software from their software suppliers as modern cloud-based solutions in order to reduce costs and increase flexibility.

A Note on Enterprise Architecture Frameworks

Although the term "enterprise architecture" is used extensively, no universally accepted definition exists. However, the discipline is crucial in managing complexity and reducing time-to-value as software becomes increasingly interwoven with both business and the daily work lives and home lives of people everywhere.

Enterprise architecture frameworks serve as important vehicles to classify, organize, and structure knowledge repositories and their associated knowledge-maintenance processes. They serve to divide a complex system into interrelated, manageable, and comprehensible perspectives. The information captured in various viewpoints then can be analyzed for specific purposes, providing insights into the operation of the system as a whole. Good enterprise architectures, and their associated frameworks, derive their value from the agility and continuous operational value they provide the enterprise over time.

Several well-known frameworks exist. The white paper titled "*Comparison of the Top Four Enterprise Architecture Methodologies*" by ObjectWatch CTO Roger Sessions offers a good overview and comparison of the Zachman Framework for Enterprise Architecture, The Open Group Architecture Framework (TO GAF), the Federal Enterprise Architecture (FEA), and the Gartner/Meta Methodology. For more information, go to: http://tinyurl.com/3evkw46

Role of the RA Framework within the Partner Network

Microsoft understands that no single company can meet the breadth of any given enterprise customer's needs; it has always relied on an extensive partner network to bring innovative solutions to market. As such, the reference architecture framework must provide a consistent value proposition for both customers and partners, so they can leverage and add their own distinctive know-how and capabilities.

The MURA framework aims to better meet customer needs by sharing Microsoft's strategies and broad technology solutions with its partner network that delivers specialized Oil & Gas industry know-how and line-of-business Solutions. The framework offers guidance on the value proposition of Microsoft's technologies and how they align with industry trends and challenges without constraining the ways in which these technologies can be integrated into innovative partner products and solutions.

Several examples of innovative partner solutions are available on the MURA website in the form of brief, two-sided "Solution Sheets", demonstrating the valuable industry solutions that have already been created, or which *could* be created, using the MURA framework.

The framework also is intended to serve as an "idea beacon" to broadly facilitate innovation within the network, thereby continually reinforcing mutual learning about the needs of tomorrow's markets, and to respond rapidly and flexibly to market and customer pull.

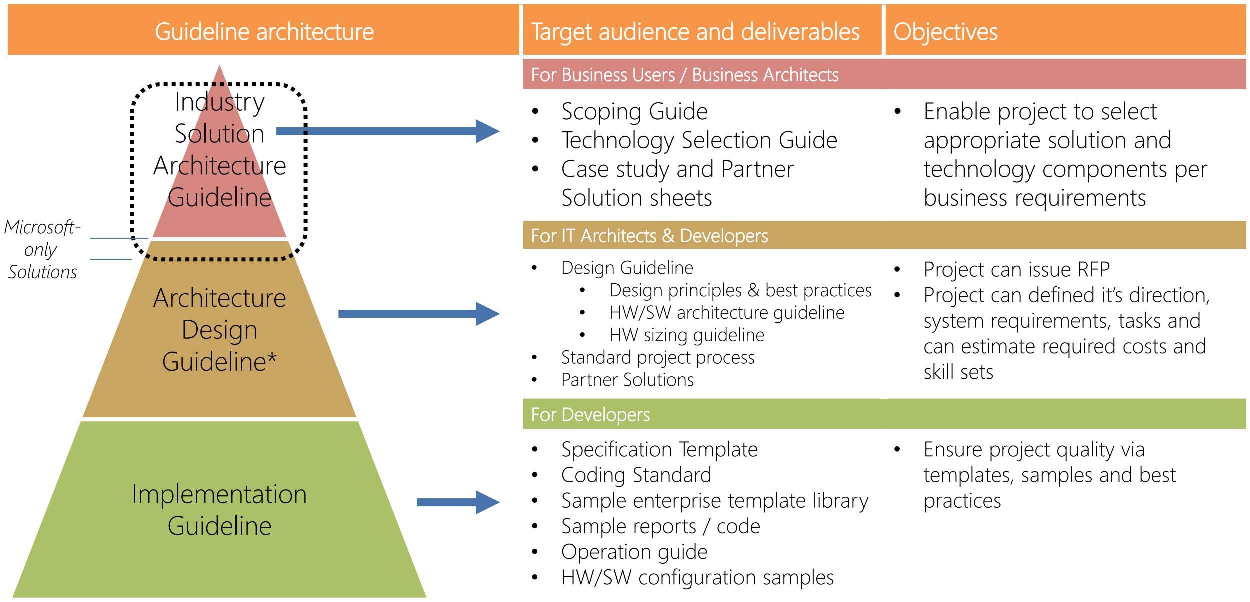
Scope of the Reference Architecture Framework

We have used the word "architecture" knowing that there is no accepted universal definition of that term as it applies to software (see "A Note on Enterprise Architecture Frameworks").

Nevertheless, there is a striking convergence around the objectives of Enterprise Architectures—helping organizations manage complexity, find better ways to use technology to support business goals, and reduce the time and costs of building complex systems.

Figure 4 shows a practical and commonly used architectural layering scheme that is analogous to the architectural segments of the Federal Enterprise Architecture.[1] The MURA framework's aim is to provide the industry and its enterprise and business architects with scoping guidance, solution component selection, and solution best practices. Once these selections are made, the components can be mapped and incorporated into the lower architectural layers for deeper technical and design specification.

[1] http://tinyurl.com/3og3njm



** If a Partner creates an Architecture Design Guideline with Microsoft, this area would fall within the remit of the MURA.*

Figure 4 - Scope of the Reference Architecture Framework

This white paper is intended to offer pragmatic guidance at a business level that influences organizational structure, internal business processes, cross-enterprise business processes, and user roles, among others. At a technical level, the guidance involves object models, data models, interaction diagrams, and so on, but these are beyond the scope of this document. The framework offers input and guidance on the construction of an enterprise architecture but is, of itself, a level removed from specific business scenarios such as those described in MURA Solution Sheets on the MURA website when associated with a particular company's enterprise landscape.

A Note on Terminology

The Open Group Architecture Framework (TOGAF) defines a building block as a (potentially reusable) component of business, IT, or architectural capability that can be combined with other building blocks to deliver architectures and solutions.

Architecture building blocks (ABBs) typically describe the required capability and shape the specification of solution building blocks (SBBs). An enterprise's customer service capability, for example, may be supported by many SBBs, such as processes, data, and application software.

SBBs are the components used to implement a required capability. For example, a network is a building block described through complementary artifacts and then put to use to realize solutions for the enterprise.

For more information, go to: http://www.togaf.org/

As an industry framework, the MURA is informed by the macroeconomic trends and business issues of primary concern to enterprises in the upstream oil & gas industry. Microsoft has taken this approach as a balance between industry-specific needs for greater relevance and generic business solution and technology guidance for broader applicability across the business-process spectrum.

Like any enterprise architecture framework, the MURA framework is a guide. Any framework will need to be adapted to the needs of an organization based on its business objectives, current business structure and IT landscape, and a definition of the desired business state. CIO s and enterprise architects need to accommodate the broader enterprise context and business environment when applying a framework and developing an implementation blueprint.

Among the considerations are:

- Understanding the external and internal business drivers that induce change
- Understanding the goals and objectives of the business that represent an initiative’s outcomes
- Evaluating the existing frameworks, applications, platforms, and technologies that are best suited to deliver capabilities for meeting business goals and objectives
- Developing a business and architecture blueprint that incorporates the appropriate capabilities and solution building blocks, integrates with existing systems and processes, and specifies the business transformation (changed business models, business processes, etc.)
- Implementing and validating the approach through proofs of concept, pilots, and incremental rollouts

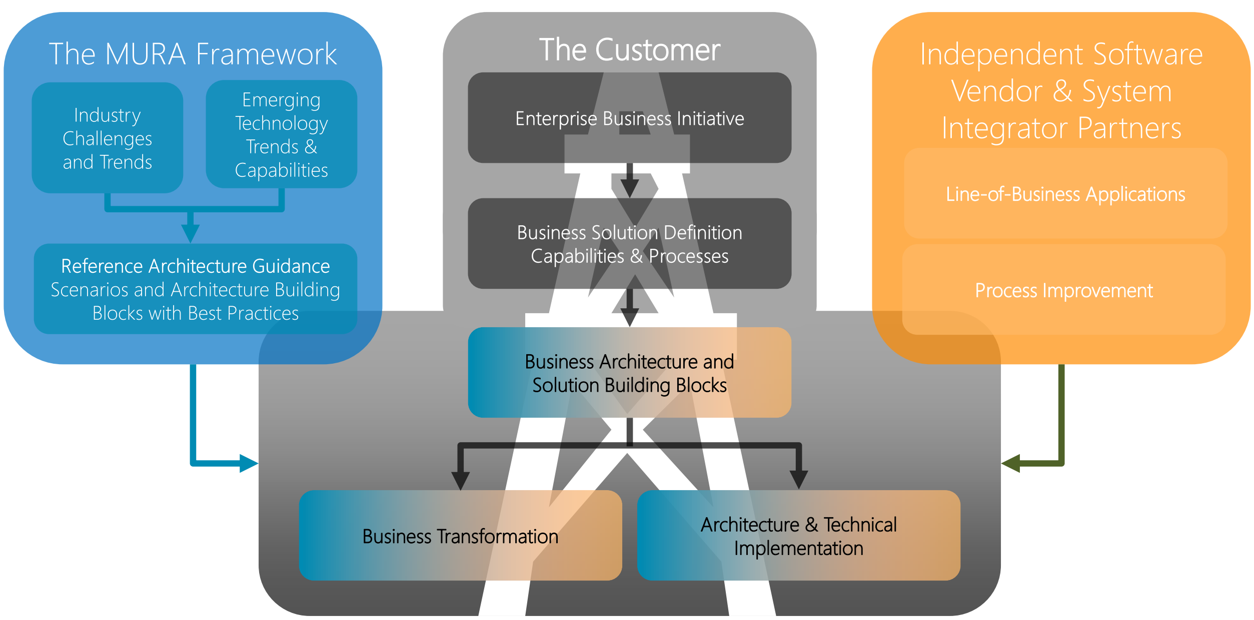


Figure 5 - MURA informs Enterprise Business Initiatives

Figure 5 shows how the MURA framework can be applied to customer initiatives when a business is evaluating the capabilities needed to meet business requirements and selecting the appropriate solution components. The framework also provides guidance for collaboration between Microsoft and its partner networks, so final solutions deliver the highest value and performance to customers with the minimum of effort and cost.

Microsoft Technology Underpinning the Reference Architecture

Today there is a large and wide-ranging selection of leading-edge technologies from Microsoft that oil and gas companies have access to. It is important to understand how industry solutions that apply the MURA principles relate to the Microsoft technologies that underpin them.

A detailed diagram in **Figure 6** illustrates all the Microsoft technology currently available.

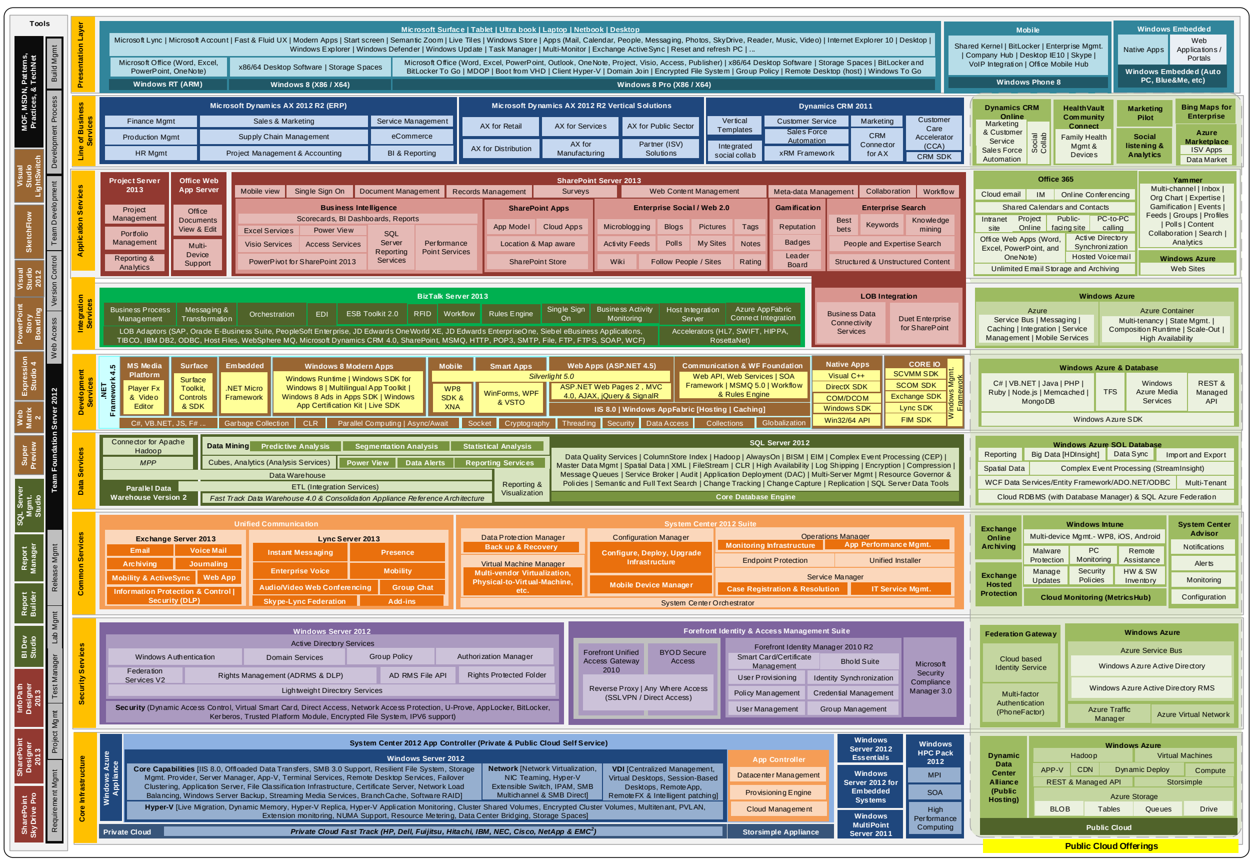


Figure 6 - Microsoft Technology (Detailed View)

Technologies in **Figure 6** are separated into the following two groups:

- Private cloud (on-premise) solutions
- Public cloud solutions

Solutions built on Microsoft technology within private cloud can be classified under the following horizontal designations:

1. User Experience
2. Line of Business Services (i.e. CRM)
3. Application Services
4. Integration Services
5. Development Services
6. Data Services
7. Common Services
8. Security Services
9. Core Infrastructure

A summary view of **Figure 6** is shown in **Figure 7** - Microsoft Technology (Summary View). The horizontal areas shown above are indicated numerically for clarity.

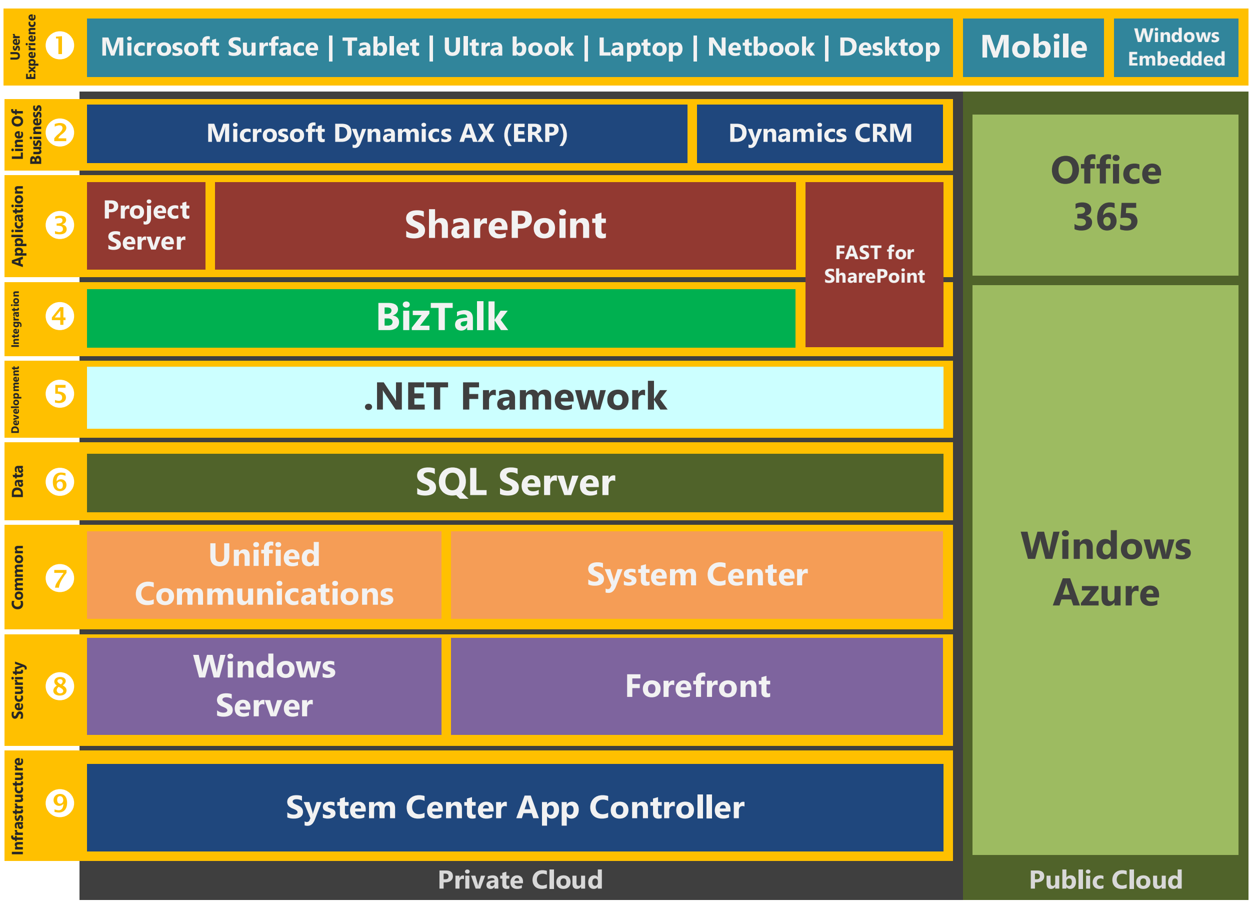


Figure 7 - Microsoft Technology (Summary View)

These technology building blocks underpin a MURA solution built upon Microsoft technology.

A role of the MURA Guiding Principles, described in the following section, is in choosing which of the many Microsoft products and technologies available within these technology blocks might be best suited to any given business need. Each Principle in the following section maps back to particular technology from Microsoft.

MURA - Microsoft Technology View

It is useful to understand how the building blocks described in the previous section map to the Guiding Principles of MURA. This is illustrated in **Table 1**, below.

Table 1 - Mapping Principles to Microsoft Technology

Pillar	Guiding Principle	Microsoft Technologies
Role-Based Productivity & Insights	**Real-Time Analytics**	SQL Server, SharePoint, Windows Azure Business Analytics
	Complex Event Processing	StreamInsight, SQL Server
	People, Process & Information Integration	BizTalk Server, Windows Azure Service Bus Relay, Dynamics CRM
	Self-Serve Business Intelligence	PowerView, PerformancePoint, Data Explorer, PowerPivot
Enhanced User Experience	**Rich Interactive User Experience**	Windows 8 Modern UI, Silverlight, Windows Presentation Foundation, Direct3D, RemoteFX, Kinect
	Smart, Connected Devices	Windows 8, Windows RT, Windows Phone, Windows Azure Mobile Services, Windows Embedded
	User-Culture Localized	Windows 8 Modern UI, Silverlight, Windows Presentation Foundation
	Simplicity & Ease-of-use	Windows 8 Modern UI, Silverlight, Windows Presentation Foundation, Kinect
Social Enterprise	**Collaboration & Knowledge Sharing**	Lync, Office 365, SharePoint, Dynamics CRM, Lync, Yammer, Skype, Office 365, SkyDrive Pro, SharePoint, Project
	Mobility	Windows 8, Windows RT, Windows Phone, Windows Azure Mobile Services, Windows Embedded
	Geolocalization	SQL Server, Bing Maps, Windows 8, Windows RT, Windows Phone,
	People & Expertise Search	Lync, Office 365, SharePoint, Dynamics CRM, Lync, Yammer

Pillar	Guiding Principle	Microsoft Technologies
Connected Business	**Industry Standards**	Windows Communication Foundation, SQL Server, BizTalk Server
	Published Interfaces	Windows Communication Foundation, Azure Marketplace, SharePoint, Office Web Apps
	Information Models	Entity Framework, LINQ to SQL, SQL Server
	Secure	Active Directory, Windows Azure Active Directory
	Workflow, Process & Information Integration	Windows Workflow Foundation, BizTalk Server, Dynamics CRM
Secure, Scalable, High-Performance Infrastructure	**Scalable**	Windows Server, HPC, SQL Server PDW, HDInsight Server, Windows Azure
	Secure	Active Directory, Windows Azure Active Directory, Security Development Lifecycle, BitLocker, AppLocker, Forefront Identity Manager, U-Prove
	Location Agnostic	Hyper-V, Windows Azure
	Manageability	System Center
	Integration	BizTalk Server, Windows Azure Service Bus, Windows Communication Foundation
	Domain Specific Infrastructure	Windows Embedded
	Global High Availability	Windows Azure
	App & Data Marketplace	Windows Azure Marketplace
	Software as a Service	Windows Azure, Dynamics CRM, Office365, Yammer, SkyDrive Pro

MURA Framework Overview

Figure 8 shows the MURA that reflects a service-oriented computing environment and encompasses the integration of domain applications, business productivity tools and back-applications, all hosted in a traditional on-premise format. **Figure 9** shows the MURA when deployed to the cloud.

By following the service-oriented architecture (SOA) approach for interactions between components on different layers of the architecture, upstream businesses, technology vendors, system integrators, and other Microsoft partners can realize the full benefits of this environment.

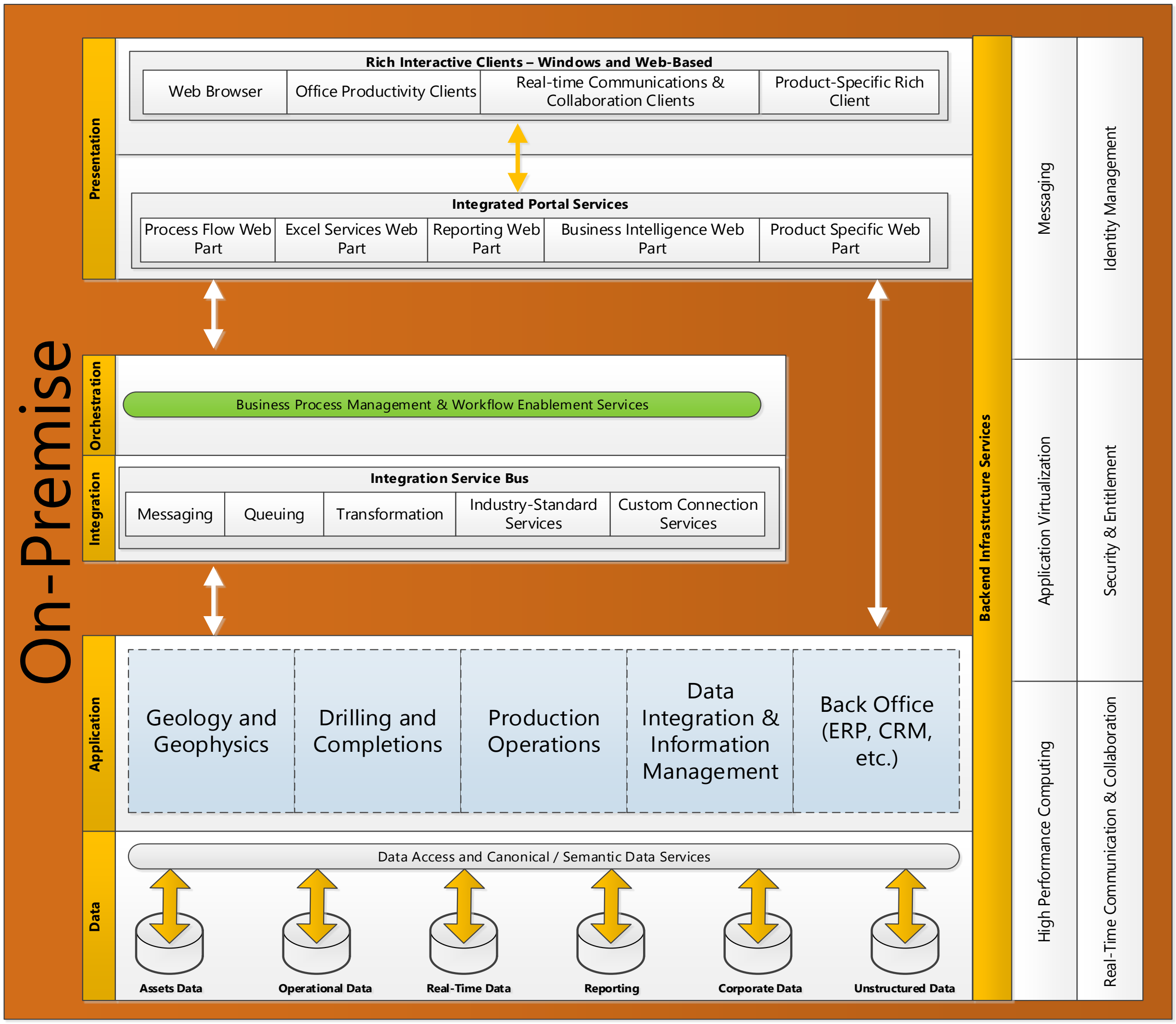


Figure 8 - MURA On-Premise

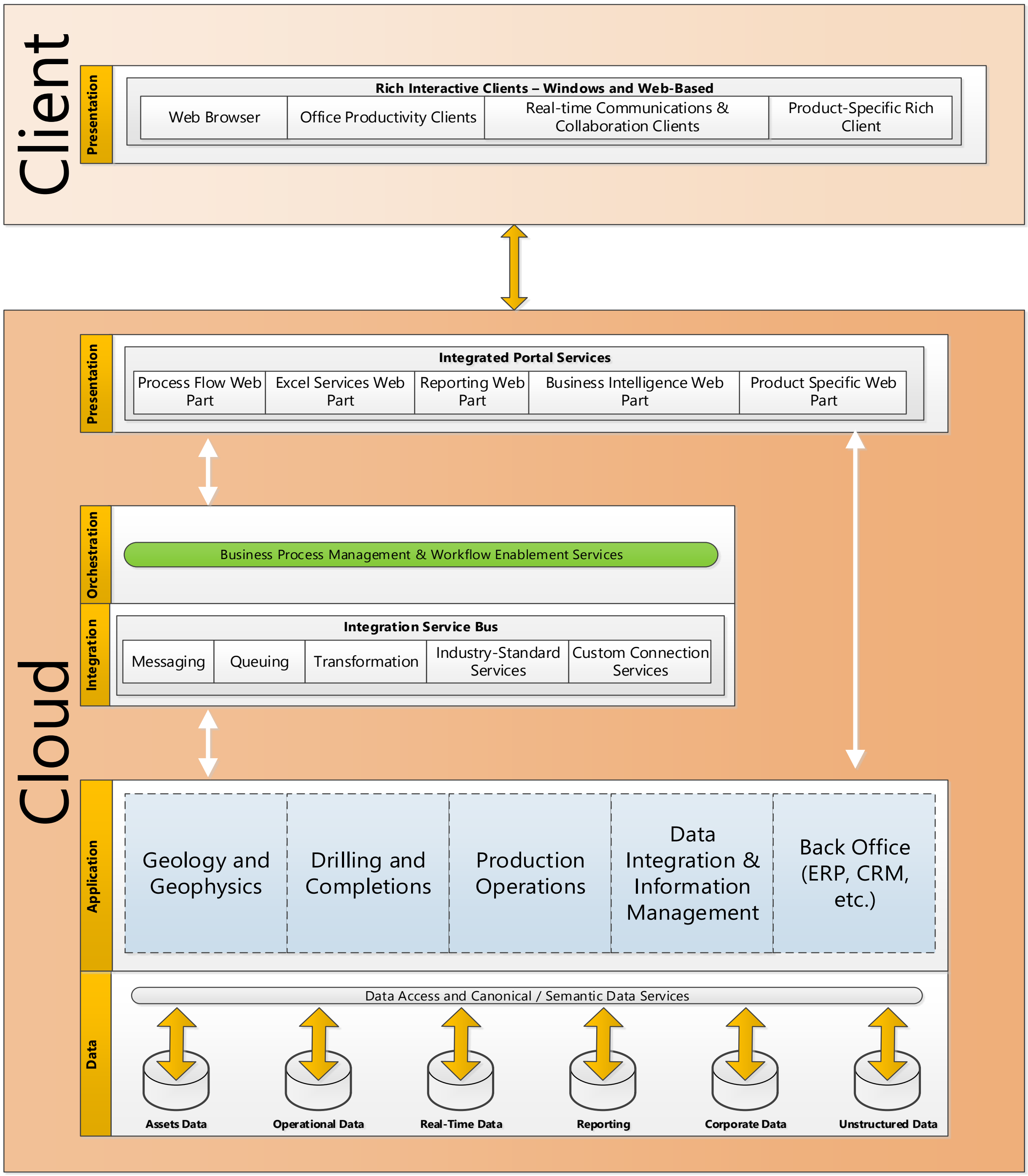


Figure 9 - MURA Deployed to the Cloud

The next sections walk through some key aspects of the MURA and discuss the interactions that would take place between the components after implementation either on-premise, in the cloud, or as a hybrid solution (partially on-premise, partially in the cloud), as described above. Scenarios serve as examples and show how a solution can be delivered by leveraging the various components of this architecture.

Rich Interactive Clients

Both Windows and Web-based Rich Interactive Clients (**Figure 10**) form the presentation layer of the architecture for the business user, who, for a device, may be using a Workstation PC, a laptop, a touch-tablet, a smartphone or a varied combination of some or all of these at different times as the users' needs and/or location dictate.

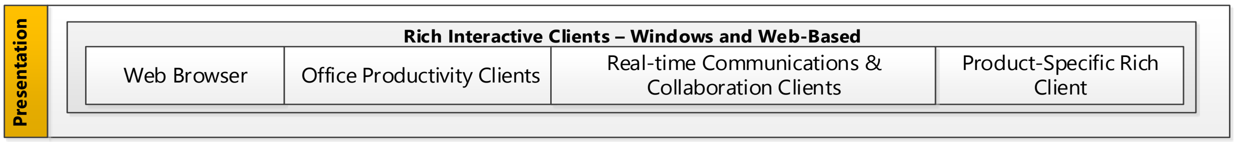


Figure 10 - Windows and Web-based Rich Interactive Clients

Integrated Portal

The Integrated Portal (**Figure 11**) functions as a common platform where geoscientists, engineers, and managers access IT-based domain work processes of all types. The Portal establishes a single location where authorized employees find and use a wide range of data, including dashboard-based KPIs, technical applications, such as those used for the interpretation of seismic data, log files, field studies, scout reports, rig activity, and business intelligence systems.

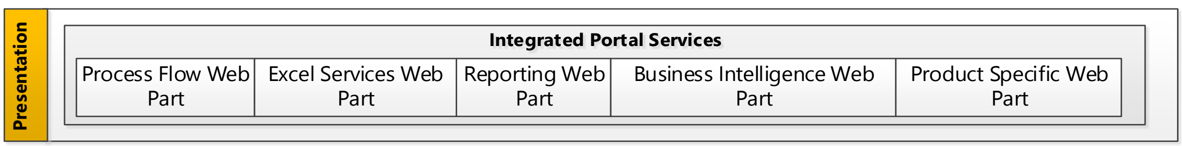


Figure 11 - Integrated Portal

This Web-based portal also provides mechanisms that support blogs, wikis, and corporate social networks like Yammer used to establish and maintain cross-domain collaborative systems. Rather than logging on to a specific system (such as SAP to access a work order), users simply log on to the Integrated Portal to access work orders, KPIs, analytic, and other exploration or production related systems.

This portal-based approach allows all disciplines and managers to focus on drilling assets, technical resources, and reserve replacement ratios, instead of working to locate data in multiple siloed applications. For example, if a problem arises with a drilling rig, a drilling engineer or operations personnel can quickly and easily use the tools available through the portal to drill down and see all pertinent data relating to that rig in order to analyze the problem and make a timely operational decision.

Data Integration

The Data Integration and Business Process Management components (**Figure 12**) are in many ways the heart of a more effective IT architecture, providing a central mechanism for the movement of data between systems, equipment, and other elements in the IT infrastructure using technology such as BizTalk or Azure Service Bus.

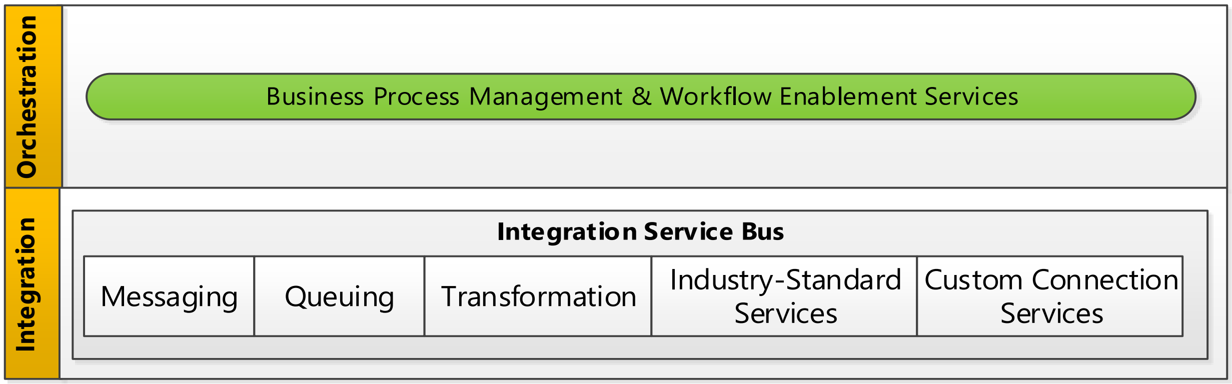


Figure 12- The Business Process Management Components

Figure 13 shows how the Data Integration and Business Process Management component provides a centralized repository for incoming data from log analysis and from work management, spatial, production, and financial systems. Using defined business rules, this component orchestrates the movement of data between various systems, including the seismic data store, operational data store, and the economic evaluation applications used to model the expected ROI of lease opportunities.

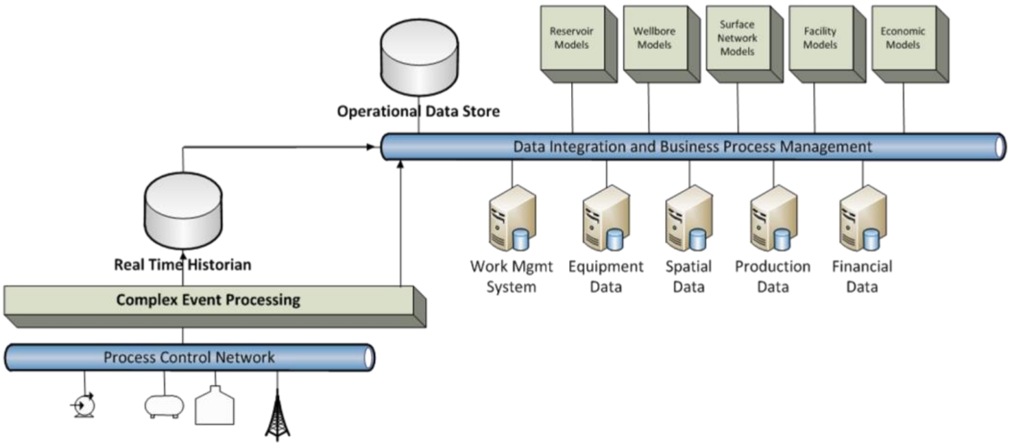


Figure 13 - Data Integration and Business Process Management

The Data Integration and Business Process Management components also serve to synchronize hierarchical and metadata across systems to ensure operational coordination and reporting accuracy. This capability addresses a number of common issues in dynamic upstream operations. For example, when a lease evaluation or other type of work process is initiated, the intelligence built into this component identifies the correct source of all data needed for that activity. The data is then collected and packaged into an XML file (or other standardized format) and forwarded to the application used to handle the economic evaluation or other work process.

By establishing a common path for all relevant field data, the Data Integration and Business Process Management components also measurably reduce the time, cost, and complexity of deploying new applications.

Industry standard interfaces (such as WITSML and PRODML) ensure interoperability and the smooth flow of information throughout the entire architecture.

A Canonical/Semantic Data Services component (**Figure 14**) serves to translate and present data in logical and familiar, domain-oriented terms that make sense to G&G, engineering, and other upstream professionals.

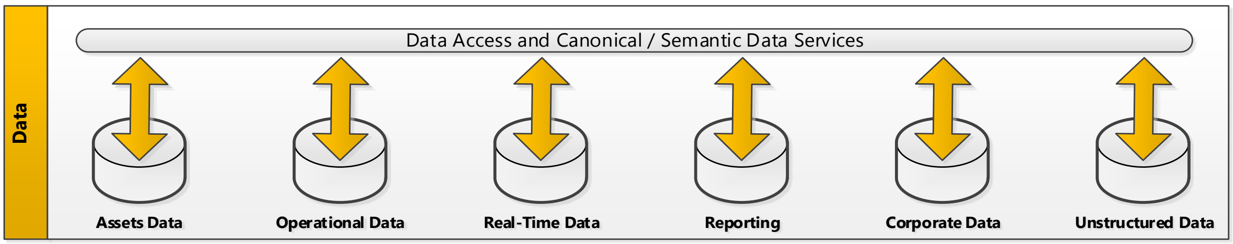


Figure 14 - The Canonical/Semantic Data Services Component

The Orchestration Layer (**Figure 15**) delivers data to the simulators used to run various models, as well as to the visualization tools, reporting systems, and business intelligence systems accessed through the Integrated Portal. This Orchestration Layer also coordinates activities in a business process workflow. For example, when a work process, like a lease review, is initiated, this service pulls a list of wells, all relevant work orders, production data, well tests, and other required information. The component then packages the data and serves it to the appropriate application(s).

Figure 15 - The Orchestration Layer

When deployed on premise, Security and Entitlement Services (**Figure 16**) allow organizations to provide convenient, role-appropriate access to enterprise data. For example, an engineer might be given access to rock properties, well production histories, and rig schedules related to a specific set of wells, but not to reservoir data that is proprietary to the business. This service is used to manage security and entitlement for employees, partners, and others involved in a project or venture. *(More information on this topic is available in the Security in Upstream Oil & Gas white paper.)*

When the architecture is deployed to the cloud, these Security services should be delivered by the hosting cloud service.

Backend Infrastructure Services		
High Performance Computing	Application Virtualization	Messaging
Real-Time Communication & Collaboration	**Security & Entitlement**	Identity Management

Figure 16 - Security and Entitlement Services

Forecast Model Synchronization

The ability to update and synchronize forecast modeling applications is crucial to the success of a dynamic upstream oil and gas operation. This is a key capability within the Data Integration and Business Process Management Components of this architecture to ensure synchronization of data for reservoir, wellbore, surface network, facility, and economic modeling applications.

Here is how model synchronization works in this architecture: If a geologist makes a change in an earth model that reflects new rock properties from core data, that employee then re-runs the reservoir model to update the reserves estimates. Then, model synchronization automatically pushes those changes to all other affected models. In this example of a reservoir change model (refer to **Figure 13**), synchronization ensures that updated and accurate data is pushed to the surface network, facilities, and economic models. Thus, users of all those modeling systems are working from a single, updated set of forecast data.

Managing and Processing Mountains of Data

The exploration process is the most data intensive of all the upstream processes. Seismic data constitutes one of the fastest growing and the largest data type by volume. Online storage requirements are approaching multiple petabytes (1 petabyte = 1000 terabytes) for most large oil and gas companies. Offline storage requirements are even larger and can be augmented using the cloud.

To continue accessing data sets greater then 100Tb in size and make informed investment and management decisions concerning exploration opportunities, the oil and gas industry needs high-performance computing solutions (**Figure 17**) for its computational and data-driven problems. Ideally, the high-performance computing solutions should integrate with the MURA and provide the capability to leverage the expertise of geoscience experts worldwide and from its vendor community.

Backend Infrastructure Services		
High Performance Computing	Application Virtualization	Messaging
Real-Time Communication & Collaboration	Security & Entitlement	Identity Management

Figure 17 - High-Performance Computing Solution

When the MURA is deployed on-premise, high-performance computing (HPC) cluster server environments, powered by Windows HPC Server and perhaps extended to Windows Azure, provide an easy-to-access HPC platform that makes the analysis of large data sets easy for the non-expert user to schedule and run. With Windows HPC Server, users can deploy, manage, monitor, and maintain an HPC server-based cluster with the same tools already used to manage existing Windows Server systems.

When the MURA is deployed to the cloud, these services would make use of the 'elastic compute' capabilities from the cloud (e.g. Windows Azure HDInsight), providing much greater flexibility and computational power but only when needed, saving time and money.

Operational Data Store

The Operational Data Store (**Figure 14**) serves to aggregate hierarchical data and metadata across the entire architecture. Here data is also optimized for different purposes and synchronized for use in a wide range of exploration- or production-oriented applications. For example, well lists are maintained in the Operational Data Store, and when a change of any kind is made to that list, the change is pushed out to every system, whether it is on premise or the cloud, that includes or relies on an accurate, up-to-date well list.

In this architectural approach, data is stored in a domain-based data model like PPDM, rather than being identified and organized by the system that originates the data. As noted elsewhere in this paper, this domain-oriented method of handling data allows engineers and other employees to relate data more directly to everyday oil and gas exploration and production activities.

Also important to note: The Operational Data Store does not create another system of record. Information is stored here only for reporting purposes or to be presented through the Integrated Portal or as metadata needed for data management purposes.

Securely Collaborating with Partners

This architecture also provides for highly secure and convenient collaboration between an operator and various partners. An external network, or cloud like Office365, establishes a secure location where partners can log in, store data, share, and collaborate as needed.

Federated security capabilities allow operators and partners to establish secure user groups and identifications. For example, employees from Contoso Oil Corporation log in using their Contoso identities, while employees from partner Fabrikam log in to the same external network using their own corporate security credentials.

The result is a convenient yet secure external network designed specifically to serve collaborative partnerships in the upstream oil and gas industry.

Getting There

How can oil and gas businesses best realize the MURA framework and the solutions built upon it, as described in this paper? Microsoft urges companies to consider the following factors when seeking to create a modern, more flexible and proactive IT infrastructure.

When building solutions, start on the cloud. Companies considering building new solutions should look to the cloud as the platform of choice to host them, as it is only there that maximum flexibility and interoperability can be achieved now and in the future.

When evaluating solutions, prefer the cloud. Companies considering the purchase of a solution that conforms to the MURA will find that those solutions built on the cloud are the best fit across all four of the pillars of Guiding Principles, and will maximize interoperability via secure Industry and technology standards.

When integrating solutions, consider the cloud. As proposed by this paper, optimal flexibility and performance going forward will only be achieved by using the cloud as a platform for tomorrows' solutions. However, there will always be a requirement for integrating legacy solutions that run on premise, or between cloud-based solutions, or both. This, therefore, should be an important consideration for companies looking to this future.

Focus on business processes and work to incorporate robust data management into those processes. If a process includes data on a well to be drilled in the future, formulate a cloud-based solution that transfers that updated information to any other cloud-based application that uses data on well counts, production volumes, or other relevant metrics. If the process is exploration focused, concentrate on the search, discovery, and collaboration aspects of the process to enable a robust discussion and consideration of the various insights and innovation that each discipline, partner or vendor brings to the dialogue.

Use the vocabulary of your business when creating a solution. Build data models in the cloud that use and present information in ways that engineers and geoscientists understand—not based on the systems that generate that data.

Maintain a cloud-based "system of record" for data. It makes little sense to create additional on-premise databases or to gather all data into a temporary data warehouse to support daily work processes. Rather, seek to establish a single, integrated, cloud-based data model that easily accesses needed data from other cloud services or secure on-premises sources, and serves up that information efficiently to systems, employees and managers. Create data warehouses only when they can deliver and improve the speed and performance of the end user experience.

To deliver faster insights and make better decisions, IT solutions must enable visibility and collaboration. Microsoft has created a robust partner ecosystem designed to help oil and gas businesses transcend traditional barriers, accelerate decision making, and drive efficiencies. Our partners' upstream software solutions can help companies gain the full benefits of a more effective IT architecture.

The MURA described here and the process of transitioning to this more efficient, cloud-based future state can be applied to address the real-world needs of oil and gas upstream operations.

About the Microsoft Upstream Reference Architecture (MURA) framework

Microsoft is at the forefront of new technology advancements including cloud services, apps, mobility, social computing and platforms that unlock the potential of Big Data. Through the Microsoft Upstream Reference Architecture (MURA) framework, Microsoft is leading the industry and its global oil and gas industry partners to ensure that the latest versions of these technologies provide the foundation for all their oilfield solutions. All of these solutions apply key guiding principles, which ensure consistency and technical integrity for the solutions built on the Microsoft technology platform. In turn, global oil and gas companies can realize maximum value from their existing investments in Microsoft technology – helping them save on further IT costs.

For more information or questions, visit www.microsoft.com/mura or send an email to Adam Hems, the Worldwide Industry Technical Strategist for Oil & Gas at Microsoft.