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The Integrated Collaboration Environment as a Platform for New Ways of Working: Lesson Learned From Recent Projects

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Abstract

Upstream oil and gas organizations continue to face challenges to prove that the digital oilfield will improve decision-making, achieve higher quality analysis, and effectively use smaller pools of skilled resources. Both corporate and business unit champions recognize that an Integrated Collaboration Environment (ICE) can be the integration platform to support various digital oilfield and performance improvement initiatives. Initially, some companies took a "Field of Dreams" approach, expecting that once video-conferencing and visualization workspaces are built, their professional staff "will come." Increasingly, even these companies now recognize that successful projects must develop a plan to integrate people, process, technology, and facilities to enable new ways of working.

This paper proposes a framework to realistically diagnose performance requirements against a company's digital oilfield or integrated operations strategy, and to chart an ICE development path to match. In addition, we share some lessons learned from recent ICE implementations projects for drilling, production operations, and/or optimization. Whether for new or legacy assets, we are learning that success depends on (a) engaging objective, third-party consultation to help the management team articulate a shared vision for collaboration, integration, and real-time support; (b) investing time and resources in a participatory conceptual design phase that focuses on the user experience; and (c) a design/implementation methodology that addresses all the dimensions of change—process, organization, people, technology, and facilities, inclusive of a professional project management with experience leading joint internal/external teams to deliver complex system integration projects.

By clarifying the performance vision framework and applying some of the lessons learned from early adopters, we see that a well-designed and professionally implemented ICE can resolve inefficiencies, "handoff" disconnects, and communications gaps between the field and the office. Better yet, the ICE will generate a step-change improvement in "real-time" surveillance, interpretation, decision-making, and quality execution, embedding it as the new and "natural" way of working.

Introduction:

Over the last five years, upstream oil and gas companies are increasingly viewing the Integrated Collaboration Environment (ICE)[1] as a critical component of their "digital oilfield" programs. Early designs for "collaboration rooms" were simply derived from the concept of a central Operations Control Room where a team could monitor and communicate in real time with remotely located operations personnel. Other collaboration room concepts were visualization-oriented, constructed to allow large groups to view data-intensive 3D seismic and reservoir model images on high-resolution screens.

Today, although some of these rooms still show the ill effects of what we call the "Field of Dreams" approach, (*i.e.*, "if you build it, they will come"), most companies now understand the ICE as a complex integration project that requires careful

[1] "Integrated Collaboration Environment" or ICE is the naming convention used by Kongsberg Intellifield. In English, other companies have coined similar names and acronyms to describe the generic concept of physical spaces to enable collaboration: Real Time Operations Center (primarily for drilling operations), Collaborative Work Environment (CWE), Advanced Decision Environment (ADE), Asset Collaboration Environment (ACE), or simply Collaboration Center.

assessment, design, and implementation planning to ensure that it becomes a platform to improve communications, support decision-making, permit higher quality analysis, and effectively use smaller pools of skilled resources.

Even with this understanding, corporate digital oilfield teams and individual business units continue to face challenges in getting the ICE "right." Why does an ICE work well in some companies and in others fall short? Why have some business units within some global companies surged ahead in building their capabilities while the rest of the organization lags behind? In spite of a working ICE, why are related "digital oilfield" initiatives languishing?

Often the gap lies between the corporate vision for performance improvement and the practical circumstances, needs, and development plans of the business unit, project, asset, or support function that uses the ICE. We propose a framework to sort ICE visions into three tiers according to the performance improvement sought by the organization: Foundational, Comprehensive, and Transformational. We believe this framework helps to provide some context to the lessons and "legends" that are circulating in our industry. Both early and new adopters of the ICE can use this framework to realistically diagnose their performance requirements against their digital oilfield or integrated operations strategy, and chart an ICE development path to match.

Since 2002, whether driven by corporate "digital oilfield" initiatives or at the request of individual business units, Kongsberg Intellifield has studied the feasibility, designed, and implemented over 200 collaboration and/or visualization spaces for drilling, production operations, production optimization, logistics, and emergency/business continuity centers in some twenty upstream oil and gas companies. The proposed framework is a result of our experience with recent ICE projects, as well as structured and unstructured dialog with a wide range of companies and partners with whom we have had a working involvement. Our reflections draw upon emerging practices and ideas in the areas of "digital oilfields" and "integrated operations," specifically on the challenges oil and gas companies face in orchestrating diverse objectives, disciplines, data streams, and timescales.

What is an ICE?

Early adopters of the ICE concept for upstream oil and gas—Conoco Phillips in Norway, Statoil, NorskeHydro[2], Shell, Chevron, BP—in concert with a range of vendors and service providers, have all contributed significantly to developing what is now a commonly accepted description of an Integrated Collaboration Environment. An ICE can support drilling, production operations, production optimization, service or "expert centers." It is a *dedicated work space* that:

- enables *physical or virtual proximity* between decision-makers on the rig/field/platform and the office;
- facilitates *improved communication between technical, engineering, operations, and support disciplines* that are responsible for project and/or asset performance; and
- provides *ready and easy access to tools and applications* for "show and tell," analysis, and decision-making.

The ICE dedicated work space is designed to enable required functionality with advanced hardware and software, including audio/video-conferencing, digital displays and screens, computing devices, mobile cameras, real-time data management tools, connectivity and switching systems, meeting and work space layouts and furnishings, and programmed user consoles. Reliable telecommunications and network infrastructure must be available or installed to ensure a "best in class," high-performance ICE, *i.e.*, high utilization, high presentation and image quality, high stability and reliability, user-friendliness, and ease of maintenance.

In a "digital oilfield" or "integrated operations" environment, all of the dataflow, workflow, and decisions for drilling project or field management plans are at play simultaneously, in real-time, and at a much higher frequency than any one person, team, or system is experiencing in a conventional drilling or field management environment. The ICE, therefore, is designed not only for enhancing communications between individuals and in meetings, but to be the "mass collaboration" platform that orchestrates the data, computing, and human elements to monitor, analyze, and make coordinated decisions in spite of different timescales and decision horizons, (*e.g.*, drilling progress in real-time, fluid flow in seconds, well tests in hours, reservoir interactivity in months/years).

Specifically, the ICE platform is intended to deliver, share, and distribute both static and dynamic data and information to many participants regardless of location, allowing them to contribute to the work of the project or asset in a simple and efficient manner. The evolution of the internet and Web 2.0-based solutions, technologies such as SOAP and XML, and acceptance of data standards (*e.g.*, WITSML for drilling data) by nearly all major oil and gas service companies makes the concept of mass collaboration achievable to every oil and gas company. Already, collaboration platforms for real-time drilling environments can allow equal access to all data by all contributors to the decision-making process, including operators,

[2] Statoil and Norske Hydro, now merged as StatoilHydro, each launched and implemented successful collaboration center projects to support integrated operations prior to their merger as early as 2002.

drillers, geoscientists, engineers, support functions, partners, service providers, managers, and other experts to make timely and informed decisions during the project. While not as mature, the same mass collaboration approach can be applied to production and support centers as well.

Across the industry, as new and better data from the drilling or production environment becomes accessible at a higher frequency to multiple users in dispersed locations, new and collaborative ways of working will need to be practiced to ensure high quality analysis, interpretations, and decision-making. An ICE is the catalyst to support new work models.

The State of the ICE for Upstream Oil and Gas

While the technology and technical know-how is available to allow all of the functionality described above, companies that are adopting an ICE continue to face a number of challenges to achieve their business and operational performance objectives: reduction in development costs, reduced NPT (non-productive time), on-target drilling projects, increases in production and ultimate recovery, *etc*. As a result, we are seeing some patterns emerge in the types of requests from upstream companies for ICE services. First, while there remains a demand for simple Audio/Visual installations, upstream organizations now appear to recognize the difference between a simple meeting room installation and an Integrated Collaboration Environment to enable new work practices.

In addition, some of the early adopters—either driven from a corporate "digital oilfield" team or within a business/performance unit or asset team—are requesting support to develop and implement new strategies and/or plans to upgrade or reconfigure their ICE facilities to address the performance gaps. Finally, learning from these early adopters, there is an upsurge in recognition from new entrants, both public/independent and national oil companies, to approach the ICE as a *complex integration project* that requires thoughtful design, implementation, and management of the process, people, organizational, and tools/applications issues as well as the facility.

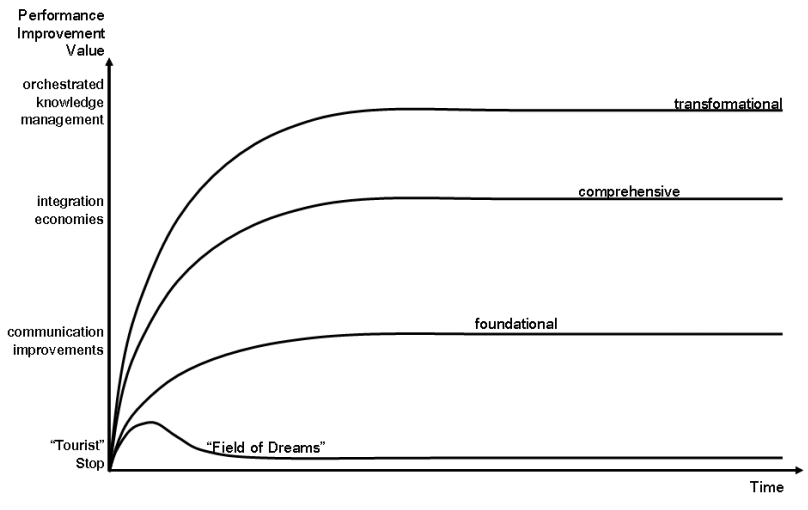
The graphic in Figure I illustrates a proposed framework for understanding three tiers of performance value associated with three ICE design and development curves: Foundational, Comprehensive, and Transformational. The lowest "Field of Dreams" curve should not actually be considered an ICE tier, but is included to explain the evolution in thinking about A/V supported meeting rooms. These installations often generate some early enthusiasm through special gatherings, but after a short time, the performance improvement value tends to be negligible, with the meeting room highly underutilized. Customers tell us that these rooms end up included in the company meeting room portfolio, are used by a variety of groups for multiple purposes, and because they are often attractively designed with high-tech screens and furnishings, continue to have some value as a "tour stop" for visitors.

The other ICE curves indicate intentional design and development meant to address a variety of work practice, work process, and overall performance improvement issues aligned with achieving integrated operations and digital oilfield objectives.

a. <u>Foundational ICE</u>: Focus on Communication Improvement.

An ICE that is designed based on an analysis of current work practices as well as functional and role relationships will very quickly demonstrate benefits associated with *improved communications.* The Foundational ICE removes communications barriers between function and discipline silos as well as between and within the rig/field/platform and office environments.

Figure I. Three tiers of performance value associated with three "waves" of Integrated Collaboration Environments



The Foundational ICE is equipped with *video-conferencing* to enable real-time, face-to-face communication between people in remote locations as well as *data and information sharing tools* so that participants in any location can view the same data, application, report, or image at the same time. Every business unit, functional, or asset team using an ICE today can articulate the following proven benefits:

- Fewer, but more effective and efficient meetings and work sessions that fit more appropriately into the daily or weekly work routines;
- More clarity about the natural workflow and quality of "hand-offs" across functions and workers;
- Improved cycle time and efficiency of early diagnostics and troubleshooting;
- Improved coordination between short-term and medium term activities and interventions;
- Skill and competence improvement by "showing" as well as telling;
- Reduction in HSE exposure by limiting travel and field-time;
- Improved quality execution of drilling projects and production optimization interventions by enabling real time support;
- Increased productivity and morale by merging operations and engineering cultures and aligning teams more closely to their shared goals and objectives.

b. Comprehensive ICE: Focus on "Integration Economies."

The Comprehensive ICE will always be customized to the specific strategic and performance objectives of each upstream oil and gas business unit or asset. Among the best examples of a Comprehensive ICE are some of the advanced "real-time" drilling centers that are proving benefits associated with *integration economies*, benefits derived from the agglomeration and network effect of clustering people, work processes, data, and tools/applications.

While the Foundational ICE is aimed at teams being able to react more quickly to deviations, issues, and questions, the Comprehensive ICE is designed to help the business develop new capabilities for managing the project or field more proactively and preventatively. The Comprehensive ICE often integrates a number of a company's dispersed or parallel technology or performance improvement initiatives, serving as the galvanizing force to accelerate implementation of languishing projects, create sponsorship and ownership for new capabilities, and optimize the full functionality of existing data sources, tools, and technologies.

In addition to video-conferencing and data and information sharing tools, the Comprehensive ICE integrates additional information management and data integration solutions, including data warehouse solutions, data capture and distribution systems, robust alarm and alert systems, and customizable visualization and display tools. Developing the interfaces between these different subsystems, *i.e.*, datastores, tools, applications, hardware, and software, is required to deliver the over-arching functionality of the ICE, providing capabilities to operational and technical professionals that are only possible because of the interaction of these subsystems.

We see oil and gas companies and business units developing and testing the Comprehensive ICE to develop their capabilities for:

- Easy access to and customizable displays of real-time data and information;
- Advanced "exception-based" monitoring and surveillance capability;
- Alarm/alert systems and tools that detect critical-node event triggers based on complex, multi-sensor analysis to provide early warning of spot readings and time-bound trends;
- Strengthening remote control and automation capabilities;
- Developing and calibrating model-based analytical tools;
- Training ground to tap scarce expertise and more rapidly and effectively develop new professionals;
- Deepen team/institutional knowledge and understanding of "the total drilling or production system";
- Improve discipline and compliance to high-performance processes and practices to launch a quality-management culture of "continuous improvement."

c. Transformational ICE: Focus on Orchestrated Institution-wide Knowledge Management

Few examples yet exist of a Transformational ICE in upstream oil and gas which supports *orchestrated and institution-wide knowledge management.* The capabilities developed and supported by a Comprehensive ICE, as noted above, are institutionally supported in a Transformational ICE where information is available about all projects, assets, and well/reservoir changes to all functions at all times, cross-discipline collaboration continually strengthens technical analysis, and individual and team lessons about drilling projects or the field/reservoir become institutionalized. The Transformational ICE is emerging where the integrated operation is:

- highly instrumented for capturing real-time, 24x7 data with "intelligent" wells, facilities, and/or drilling operations,
- thoughtfully designed, repeatable, and measured work processes with automated workflows and dataflows,
- performance/quality measurement systems (*e.g.*, LEAN, Six Sigma) to support a culture of continuous improvement, and
- highly utilized and valued systems to capture and reuse knowledge.

Where is the leading edge for the Transformational ICE? Today, some small operations with largely homogenous well assets that lend themselves to a "manufacturing-oriented" field management approach are implementing Transformational work

environments. Note that the complexity of most fields should not be a deterrent to finding repeatable and automated routines, particularly in the capture, storage, and display of real-time data for monitoring and surveillance and first-level diagnostics.

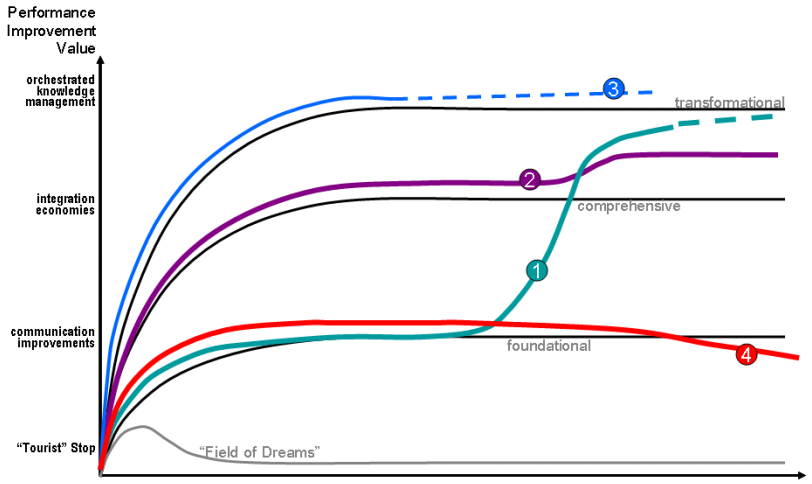
In addition, some global oil and gas companies have identified key Greenfield assets with complex reservoirs, recovery mechanisms, or locational disadvantages that can only be developed using "digital oilfield" technologies. Including a Transformational ICE in these Greenfield development plans is possible since the new asset and team can be unburdened by legacy technology, processes, policies, or organizational constraints, and be the showcase to model revolutionary new ways of working to the rest of the company.

Key Lessons from Recent ICE Engagements

In spite of inspired vision and well-intentioned plans, many oil and gas companies still struggle with launching, developing, implementing, or sustaining an ICE project within their own organization. In the last two years, reflecting upon our experience in recent ICE design and implementation projects with a variety of clients, and conducting a series of structured and unstructured dialogs with existing and prospective management and user groups, we believe the challenge lies somewhere between the corporate vision for performance benefits and the practical circumstances, needs, and development plans of the business unit, project, or asset team that will use the ICE.

As indicated by Path 1 in Figure II, the leading ICE adopters in the industry are intentionally moving beyond the initial, Foundational wave, to reengineer their work processes, develop sustainable data management solutions, and redesign their ICEs to achieve more complex performance objectives or complex project or field development challenges. More recent entrants who are initiating an ICE project, including Greenfield teams, can benefit from the experience of the early wave of implementations and chart their ICE development paths to achieve higher performance value from the outset, as indicated in Paths 2 or 3.

Figure II. Paths 1, 2, and 3 indicate planned and managed growth, expansion, and development paths for ICE programs. Path 4 indicates an ICE project that is not managed for continuous improvement.



Path 4 indicates the possible devolution of performance value if early Foundational improvements are not managed for continuous improvement and growth. In all cases, the framework can allow an oil and gas company to place its ICE project appropriately within its digital oilfield or integrated operations strategy. The framework also provides a context to understand how lessons learned from one company's ICE experience can be applied to another business unit or company.

Based on our project experience, observations, and dialog with both current and prospective ICE teams, several key lessons or insights stand out that could help both existing and new adopters of an ICE realistically chart their ICE development path. These challenges and approaches for addressing them are consistent and common themes raised by both early adopters of the ICE and new entrants into ICE and digital oilfield programs.

1. "Informed Intuition" is the Best Business Case

New entrants into the ICE domain should note that most of the performance achievements that have been communicated by the early adopters were measured *after the fact*. That is, only after the Drilling Center or Production Operations center was completed, was the ICE project team able to determine that they had reduced drilling costs by $14 million, achieved 4% production gains, improved their productivity by 40-50 man-years, were able to bring production back up after a serious weather emergency 10-15 days faster than without the collaboration environment, *etc.* In the words of one ICE champion, "just do it based on a top-level view, and then watch for the savings and benefits."

This insight is very closely linked to the need for visionary and committed leadership to ensure ICE project success. While honest and objective appraisal of the issues and opportunities is required to ensure a well-scoped project, every successful ICE project team credits the combination of visionary leadership with progressive user groups (*i.e.*, drilling teams, operations

teams, subsurface team, development team, engineering and maintenance teams, *etc.*) who drive the project to fruition by recognizing that the ICE is the best catalyst for changing the ways of working.

Successful business cases for ICE projects are rarely made up front by tying the investment directly to lower drilling costs or increased barrels. The business case is largely based on "informed intuition"—management and life experience that acknowledges the critical "intangibles" of an ICE project that will contribute to performance improvements:

- ***Opportunity cost of not changing:*** Given the pending challenges of increased complexity, remote geographies, new drilling advances, new recovery mechanisms, diminishing skills, staff vacancies and turnover, and more real-time data, the opportunity cost of *not* adopting a new, collaborative way of working is greater than continuing with current processes and structures. *"If you do what you've always done, you're going to get what you've always gotten…"*
- ***Value of proximity:*** Most people instantly recognize the inherent value of co-locating people—whether physically or virtually. In the oil and gas industry in particular where platforms and fields are usually remote from the office, issues simply get resolved faster if people are more immediately accessible and can interact face-to-face. In the diverse, international locations in which oil and gas companies are working, different languages, communication styles, and work styles between nationalities and ethnicities can be significant barriers to reaching a common understanding of a problem and, in turn, productivity and performance. Acknowledged—often joked-about—cultural differences between drilling, operations, engineering, geoscientist communities within an upstream oil and gas company can also pose barriers. In the words of one ICE program manager, *"there is something magic about co-location."*
- ***Cross-functional/Multi-disciplinary teams and teamwork:*** With well-crafted goals clearly articulated, composing cross-functional teams and supporting teamwork will lead to increased productivity, innovation, and morale. Most managers realize that you cannot simply "throw people into a room and expect them to be a team," but they also recognize that the upstream industry shift from integrated asset teams back to functional and discipline silos is often a barrier to seamless and efficient work process performance, getting fresh perspectives to generate new opportunities, and overall productivity—*doing more with less.*

The best practice in the industry is to propose a "logical case" rather than a conventional business case. Middle managers—who are often charged with being the standard-bearers of corporate policies, procedures, and guidelines—may press to create a conventional business case with "bottoms-up" calculations of cycle time improvements translated into cost savings or barrels or propose Key Performance Indicators for percent reductions in losses, drilling costs, *etc.* While it may be a worthy exercise for ensuring that the required documentation is appropriately "crossed and dotted," it cannot be relied upon to "sell" and launch the project. Indeed, many ICE projects never get off the ground, languishing in artificial cost and risk calculations.

Instead, an informed "logical" case helps the leadership and champions approve and launch the ICE project. Based on a structured assessment, a logical case clarifies performance challenges that can not be addressed by maintaining the current ways of working, identifies opportunities for improvement; scopes the work processes that can be enabled with new data, tools, and applications; identifies user groups that can benefit from improved communications and collaborations support; and spots dependent or parallel initiatives that can be accelerated by the ICE.

2. Data Integration and Visualization.

In order to realize the full benefit of an ICE, to build new capabilities, strengthen existing ones, and achieve improved performance, the ICE project must address its data management challenges. For a "Foundational" ICE, *data availability and data sharing* should be enabled to support communications improvements. In the drilling domain, the advent of a proven WITSML data transfer standard and web-based tools allows an oil and gas company to easily manage its own secure global infrastructure in which all data from all vendors, service companies, and data providers is gathered in real time into a single server on the rig site and transmitted within seconds to any user in any location. Brownfield assets can now benefit from increasingly inexpensive and self-calibrating sensors to capture and transmit pressure data from field to office. New developments and wells are increasingly "intelligent," with more surface and downhole instrumentation available to monitor production. All data and information from every sensor, component setting, and alarm system can be displayed and shared by all operations and technical users in every location via a range of monitors, display walls, browsers, and other visualization systems. Similarly, digital displays at any size/scale allow data, reports, documents, and video images to be shared in real-time between co-located or remote teams.

A Comprehensive or Transformational ICE goes beyond sharing of available data, and tackles *data integration*. We mean the managed orchestration of real-time, historical, and static data and information so that it is:

- captured and accessible in a timely and secure manner,
- conditioned, synchronized, and validated to ensure integrity and quality, and
- able to be moved and manipulated by any operator, technical professional, or manager as needed.

Proven, commercially available real-time drilling solutions have advanced drilling data integration ahead of production data integration, but the approach for both is the same. Upstream organizations that are leading in their digital oilfield arena and have charted a "Comprehensive" or "Transformational" path for their ICE projects are:

- undertaking detailed process analysis and mapping,
- detailed dataflow mapping from source to sink,
- investing in the underlying data architecture and web-based standards to ease data integration, and
- automating data loading and extraction in/out of the required analytical applications and tools used in the ICE.

Finally, once the underlying data architecture and dataflow issues are addressed, "visualization" capabilities can be optimized. Given the different operational dynamics, timescales, and performance metrics for different operations, engineering, geo-technical, and management teams, it is important that co-located user groups can select and customize the views of the streaming and/or static data and information that is critical for their work. Then, commercially available visualization tools can help all drilling or field data and information from any data store to be viewed, accessed, "rolled up" (*i.e*, all projects, all active drilling, all wells, all zones for one well, all producers, all injectors, all tracers, *etc*.), or disaggregated in whatever combination is meaningful to a specific user group. Compressing and extracting data should be done without removing features or attributes of the data that might be useful to someone else. A Comprehensive or Transformational ICE should aspire to enable any drilling, operations, technical professional, or manager to query the system at any time, drill into any of the data streams, change the view, check the logs for historical events or flags, and/or capture a current set of data streams in a modeling application to simulate alternative scenarios for predicting and planning changes and interventions.

Data management challenges have been discussed and lamented almost since the advent of digital oilfield and integrated operations. In the same way that you cannot simply "throw people into a room and expect them to be a team," an ICE project with its monitors, cube walls, and displays will not yield quality and timely data. The lesson learned is that *integration economies* can only be achieved by addressing *data integration* in concert with the people, process, technology, and facility plans.

3. Advanced Surveillance and Diagnostics

"Once we have access to all of the data, what are we going to do with it?" As commonly defined, the ICE is meant to speed up and improve decision making. In a complicated drilling or production domain, making decisions can often take a lot of time—and operations and technical professionals are often in a position of making a choice between finding the right answer and simply making a decision. Early adopters of an ICE—both for drilling and production—are beginning to tackle the challenge of turning data into information so that decision-making is, indeed, improved.

Turning data into information during a drilling project, for production operations, or overall field management requires teams to have the ability to monitor multiple streams of data, synchronize and flag events or deviations from expected performance, quickly diagnose root causes to determine next steps, manipulate and integrate the data, perform real-time advanced calculations, and log the events and deviations in a structured way so that patterns can be detected to anticipate drilling or production problems in the future. However, as the frequency and volume of available data is increased, monitoring effectiveness is decreased. In an environment where all data is available and viewable in real-time to all users, it is illogical to expect a reduced workforce to track continuous or even intermittent measurements as they are delivered from the drilling rig or the field.

An oil and gas company cannot realize the benefit of its real-time data infrastructure and measurement instrumentation unless there is a structured, 24x7, *exception-based* monitoring capability. Exception-based monitoring and surveillance is only possible by installing a robust alarm system and/or smart alarms to filter and synchronize planned or unplanned events and deviations. A Comprehensive ICE focused on strengthening monitoring and surveillance will require robust (high uptime) alarm detection, alerting, and notification tools or systems with a user friendly interface to:

- capture the parameters that define exceptions or events useful for analyzing drilling information or production issues,
- detect those events within a continuous data stream,
- correlate the event against other events or noise in the system,
- flag events and/or notify appropriate users,
- capture and store the alarm itself as another data source (*i.e*., event logs become important information for pattern detection and understanding asset behavior over time and under different conditions),
- reset itself once the event is acknowledged or resolved, and
- automate all of these tasks simultaneously for multiple streaming, intermittent, static, and interactive data sources.

Once the alarm tools and systems are functional, the ICE is designed to support the variety of assets—data, computing, humans—to come together automatically and rapidly to analyze performance, resolve random and/or systemic issues, and then return to joint surveillance and operations activities. In addition to hosting regular/daily operations meetings and planning

sessions, the ICE can be designed to orchestrate the data, applications, and people for *ad hoc* troubleshooting and analytical work sessions triggered by exceptions that are flagged by the alarming/alerting system. An ICE must be articulated and thoughtfully designed and programmed to support these orchestrated gatherings so that for routine, spontaneous, or unplanned events, the appropriate, pre-defined, cross-functional team members are *automatically convened—located, linked, and looking at the same information*—to respond quickly and effectively to manage the drilling issues or changes occurring in the production system.

4. The ICE Team: Experienced, Empowered, Digital Oilfield Champions

The early adopters who are experienced with the ICE and similar centralized control or coordination centers all acknowledge the impact on their people who are the ICE users and stakeholders. Several important lessons shared by both early ICE adopters and new entrants, in our view, will close any debate about the people who should sit in the ICE:

- ***Supervisors are "owners."*** In the successful ICE, the supervisors, team leaders, project managers, or operations managers who have responsibility for managing the project, asset, or support function must make the ICE their primary work space. Particularly when reducing cycle time for decisions is a crucial factor, the "owner" of the budget or project or loss management should be co-located with the rest of the team in order to validate and approve analytics and decisions quickly. In successful production operations or production optimization environments, the team leaders or supervisors/installation managers are located at the center or lead position of the ICE and view themselves as an accessible resource to the integrated team regardless of where people are located. In a project-based ICE, such as a drilling center, the ICE should be the primary vehicle for the duration of the project in which the supervisor or manager manages the operation, shares information, and communicates decisions with remote teams. The "new way of working" will become embedded if supervisors and managers take the lead and incorporate the ICE into their supervisory, knowledge-sharing, and decision-making routines.

- ***"Competence in the Room."*** Companies that are serious about transforming their way of working, select their *most experienced, high performing* operators, drilling engineers, reservoir engineers, logistics analysts, process engineers, *etc.* to work in the ICE environment. Although finding skilled resources is increasingly difficult in every company, maintaining high standards for the competencies in the room should be in the forefront. If the ICE is at the core of building new capabilities and managing a company's valuable assets, it should not be staffed with trainees. Fortunately, the "high-tech" capabilities of an ICE are a draw for most high performing and experienced operators and engineers—moving into the ICE is seen as a performance incentive. In one case, a senior production engineer, noting all of the process and communications challenges in his operation, said that he would "gladly give up my private office for the new capabilities of an [ICE]." Since the ICE is the core of the virtual collaboration environment, it also allows these experienced professionals to be an integral part of many more of the decision making processes.

- ***"Not a training ground."*** For a select number of young professionals, the ICE is an excellent professional development opportunity. Many new professionals entering upstream organizations, accustomed to web-based social networking, instant messaging, and high-quality visualization and simulation environments via video games easily adapt to the facility and communications technology of the ICE. However, the ICE should not be a training ground as its primary function.

In the end, regardless of who sits in the ICE, in whichever location, the ICE is meant to support a cross-functional, multi-disciplinary team. In the new way of working, rarely does a company need to restructure their organization by bringing these roles and functions together as an ICE work team. While role responsibilities may need to be modified or people's location moved, individuals can usually continue to report to their functional or discipline manager. Different companies are testing how best to empower these new team structures—by pushing more data and information closer to the team, rewarding knowledge sharing and collaboration, and making the team accountable for their analytical choices and decisions. Managers are learning that, if designed well, an ICE can transform individual and team performance by creating an environment where:

- team members have access to each other to benefit from each other's experience and skills;
- the environment is comfortable and informal, allowing spontaneous communications;
- diverse, fresh opinions and ideas are encouraged;
- respect, open-mindedness, and collaboration is rewarded;
- mistakes—and learning from them—are owned by the team.

5. Engage Some External Assistance

Every successful ICE early adopter and more recent ICE project owners confirmed that they engaged some external consulting assistance for some stage of their project, sharing some thoughts about how best to leverage consulting assistance.

a) ***Engage objective, third-party consultation to help the management team articulate a shared vision for the project.*** Regardless of the maturity or sophistication of the company or business unit's strategy, market and competitive position, work processes, or management team, an ICE project will, by definition, require integration of multiple and diverse functions, disciplines, project or performance objectives, and the stakeholders who represent this diversity. An objective, vendor-neutral consulting team can gather and compile multiple views about the challenges and opportunities that could be addressed by an ICE, ensure that all relevant information and views are discussed in an open and productive way, and facilitate the discussions to help the management team make a shared and informed decision about charting the path of their ICE project.

An early ICE assessment will focus on issues and opportunities related to the process and functional challenges facing the organization; the readiness of the asset or project organization to adopt new ways of working; the capability of the organization to execute an ICE project; and the status and feasibility of the technical and physical infrastructure available to support an ICE. In subsequent phases or for a new ICE within an organization, company or business unit stakeholders will have more exposure and experience in assessing the issues and opportunities and can be more specific about the type of information gathering and facilitation support they require from external consultants.

In addition, few managers and stakeholders at the outset of an ICE project can be dedicated full time to the ICE. Corporate teams and business units have found that engaging an external consultant or consulting team that is experienced in compiling, coordinating, and bringing together diverse views and opinions, can help speed up the review and decision-making process. In one instance, a company decided against engaging a consulting team to assist their stakeholder group with a brief, 8-week assessment to refresh the strategy and approach of an existing ICE. More than a year passed, and the 12-15 managers of the stakeholder team were still meeting regularly, unable to come to agreement about strategy or steps to take to improve the utilization and performance of their ICE.

Prospective ICE management teams have found that experienced and objective external consultants can often help make transparent and understandable the less tangible dimensions of an ICE facility. These intangible issues also require careful attention, especially when geography and communications delays will no longer be a barrier, when high value expectations are placed on new technology investments, and when past performance cannot be relied upon to predict the future.

b) Invest time and resources in a participatory conceptual design phase that focuses on the user experience. In every successful ICE, the users themselves have participated and taken a significant role in the design of the ICE. Most early adopter and new ICE project users can boast a significant investment of their own time in designing their new way of working. Indeed, the opposite is also true—where users were not engaged in the design process or user input was not captured and implemented, the ICE or new work environment is underutilized, sub-optimized, and performance improvement aspirations are unfulfilled.

The users—or experienced representatives of the user community—must be engaged in a joint design effort for three principal reasons: (i) the users will know best the hands-on, daily work routines that need to be supported, modified, or changed; (ii) many of the nuisance communications and procedural issues that cross-functional teams suffer are often resolved during the exchange between users in the design process; (iii) ICE champions and "ownership" is born out of a participatory design process, planting the seeds for change management during implementation.

External consulting assistance can be extremely useful during a conceptual design phase for many of the same purposes as described for articulating a shared vision—objectivity, ability to sensitively make transparent diverse or conflicting views, and to keep the project momentum going. Most ICE project managers noted that they engaged a variety of experts, consultants, and teams with different expertise during their design phase, including control room designers, industrial designers, industrial psychologists, design workshop facilitators, and technology experts in order to bring some "out-of-the-box" and industry experience to the design effort. They agree that a critical success factor is choosing external consultants that can bring "best practices" to the effort while remaining agnostic about the outcome. When external consultants have been engaged to help with the conceptual design phase, they were experienced in consciously structuring the engagement, the design effort, workshops, capture of requirements, and dialog with stakeholders and users so that the design could be understood and defended by the users themselves.

c) Engage a partner with an ICE methodology that addresses all integration elements: process, organization, people, technology, and facilities. Regardless of the path charted for an ICE, working with an external partner with a proven ICE methodology can significantly accelerate the design, development, and implementation of a project, while allowing the stakeholders and users to focus on contributing their unique company and technical/operational knowledge and expertise. A robust ICE methodology is based on proven techniques for complex integration projects and "systems thinking" to address the web of people, processes, organizational, and technology changes. It is an amalgam of process design,

systems integration, professional project management, change management, and collaboration facility design and installation.

Most ICE projects tend to pass through three major development phases: assessment, design, and implementation. If external consultants are engaged, each phase should be managed jointly with an dedicated, internal ICE project team:

- ***Assessment*:** A facilitated and iterative information gathering and dialog with stakeholders from a project team, asset team, business unit, IT, and corporate-level leadership in order to develop a common and shared understanding of the process scope, identify some preliminary design criteria, and establish a performance and design vision for the ICE;
- ***Design:*** Working jointly with users, compilation of a comprehensive picture of the current issues and opportunities for performance improvement in order to determine gaps and develop a design concept that addresses them, including user redesign of the in-scope work processes, roles and responsibilities, enabling tools and technologies, facility design, and a high-level implementation plan aimed at achieving the envisioned performance obejctives. Technical specifications for the facility can be developed at this stage to forecast equipment and construction costs.
- ***Detailed Engineering & Implementation:*** Working with user groups, IT and applications support, building facilities departments, as well as contracting and procurement teams, the capture and documentation of a Detailed Design, engineering specifications, and a detailed implementation plan. Execution involves procurement of all hardware, software, and furnishings; construction and installation of the physical facility; implementing the process, tools, applications, data management, and role changes defined in the Detailed Design; training user groups in the revised or new processes as well as the operation of the new facility technology; managing the communication plan with all stakeholders; conducting "team building" activities; ensuring a smooth "cut over" to working in the new ICE, and providing post-operational coaching and support as required for establishing a continuous improvement program.

As ICE projects are usually part of a company's digital oilfield program, external consultants and advisors should have experience with real-time data and technologies, industry trends and domain expertise in the field, and awareness of "best practices" for an ICE to support integrated operations. One such "best practice" for new ICE projects is to aim high with the design concept—at the Comprehensive or Tranformational tier. Allow the implementation plan to accommodate any organizational and technical readiness issues or barriers, by phasing progress from Foundational communications improvements to Comprehensive integration/capability improvements and beyond. Organization change for capability development is easier to achieve if management adopts a high-performance vision; it is less costly to fall back to familiar ways of working in the face of technology, resource, or economic blockers than to overcome them after the fact.

Conclusion

A critical mass of ICE projects have been designed and implemented across the upstream oil and gas sector in the last five years so that, based on observations and dialog with both early ICE adopters as well as prospective ICE project teams, a number of common themes and lessons learned have emerged. If designed well, the ICE is increasingly viewed as a critical element of an upstream organization's digital oilfield or integrated operations program in order to:

- Stimulate collaboration and improve communication across functions and disciplines;
- Improve the speed and quality of the response to drilling/production events and performance issues;
- Strengthen cross-discipline analytics and the quality of remediation/optimization decisions;
- Make transparent the analysis, rationale, and decisions made by the team in order to strengthen organizational learning.

Yet, corporate digital oilfield teams and individual business units continue to face challenges in getting the ICE "right"—that is, fully realizing the envisioned "digital oilfield" or integrated operations value of the investment. We propose a three tiered framework for positioning an ICE project against a realistic performance vision, provide some context to the lessons and "legends" that are circulating in our industry about the ICE, and help a company chart its ICE project path. The three tiers are: *Foundational* for communications improvements; *Comprehensive* capability development to achieve "integration economies," and *Transformational* to achieve orchestrated, institutional knowledge management.

We trust that both existing and new ICE teams will benefit from the lessons learned shared in this paper: to allow a leadership team's "informed intuition" to launch an ICE project; to clarify the underpinnings of data integration, visualization, and advanced monitoring and surveillance capabilities; to fix who the ICE user community should and should not be; and to discern how best to engage external consulting assistance. We hope these reflections will stimulate more structured benchmarking and evaluation of the role of the ICE in the digital oilfield, its contribution to improving "real-time" surveillance, interpretation, decision-making, and quality execution, and its ability to realize both tangible and intangible performance benefits.