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GeDIg: Petrobras Corporate Program for Digital Integrated Field Management

G.V. Moisés, SPE, T.A. Rolim, and J.M. Formigli, Petrobras

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Abstract

Foreseeing near future opportunities for oil and gas fields, Petrobras created a corporate program dedicated to study, develop, and implement Digital Integrated Field Management (GeDIg) among its production assets.

Over the last three years, Petrobras has been developing a pilot strategy based on multiple scenarios to evaluate the technology level of digital oilfields. Six assets were chosen, taking into account the diversity of production processes (heavy oil, offshore, onshore, brown, and green fields) found all over the Brazilian fields. Two different approaches were implemented: in-house development and partnership with integrated companies.

Petrobras program is supported by three fundamental elements: people, process, and technology. Humanware, workflow processes, and change management are the key factors for new technologies implementation such as collaboration centers, intelligent completion, and fast loop artificial lift optimization.

After the pilots first year of operation, lessons learned will be gathered to guide the expansion of the digital oilfield concept for other Petrobras assets. The objective of this work is to describe the methodology applied in the six pilots and how Petrobras is going to improve its digital way of work and add value to its assets with Digital Integrated Oil and Gas Field Management.

Introduction

E&P is moving towards a new digital era, where technology supports new workflow processes, and Petrobras, foreseeing the near future opportunities for oil and gas fields, created a corporate program dedicated to study, develop, and implement Digital Integrated Field Management (GeDIg) among its production assets. Petrobras defined a pilot strategy based on multiple production scenarios, taking into account its production processes diversity (heavy / light oil, brown / green, offshore / onshore fields). The main goal of the pilot strategy is to evaluate the benefits of digital oilfield implementation, combining production scenarios with asset intelligence level. Six assets were chosen and different approaches were considered. In each pilot, the digital fields are being designed with real time operation, data base integration, and collaborative functional model to achieve faster decisions based on concise and reliable information. To implement the new digital way of work, humanware, workflow processes redesign, and change management become important tools to transform the processes into its TO BE form.

The methodology applied in the pilot strategy is presented in the next section, followed by the detailed description of each pilot. At the end, the lessons learned from the GeDIg program will be presented.

Pilot Strategy

Digital Integrated Field Management (GeDIg) is E&P integrated management for production processes to add value to oilfield through personnel training and right time information access (automation, modeling and simulation). In addition, GeDIg aims real time monitoring and control, production and cost optimization, pursuing ultimate reservoir recovery augmentation. Besides digital oilfield benefits evaluation, GeDIg program expects to design the best strategy for a multi-production scenario in broad digital field implementation.

To achieve its primary goals, Petrobras developed an internal study of potential digital oilfield gains associated to its multiple production scenarios. Since Petrobras produces oil and gas all over Brazil, a huge diversity of offshore and onshore fields with different oil characteristics, geological structures, and exploitation time frame needed to be considered in this analysis. Another criteria that was key for this analysis was the intelligence level of the asset which measures the complexity of monitoring variables and process control:

Level 1: Surface monitoring & control, permanent downhole monitoring, and intelligent completion;

Level 2: Surface monitoring & control and permanent downhole monitoring;
Level 3: Surface monitoring & control;

Combining production scenario, intelligence level, improved oil recovery (IOR) method and potential digital field gains, six assets were chosen as part of the pilot strategy to implement digital integrated field management. Table 1 presents the GeDIg pilots and its main features:

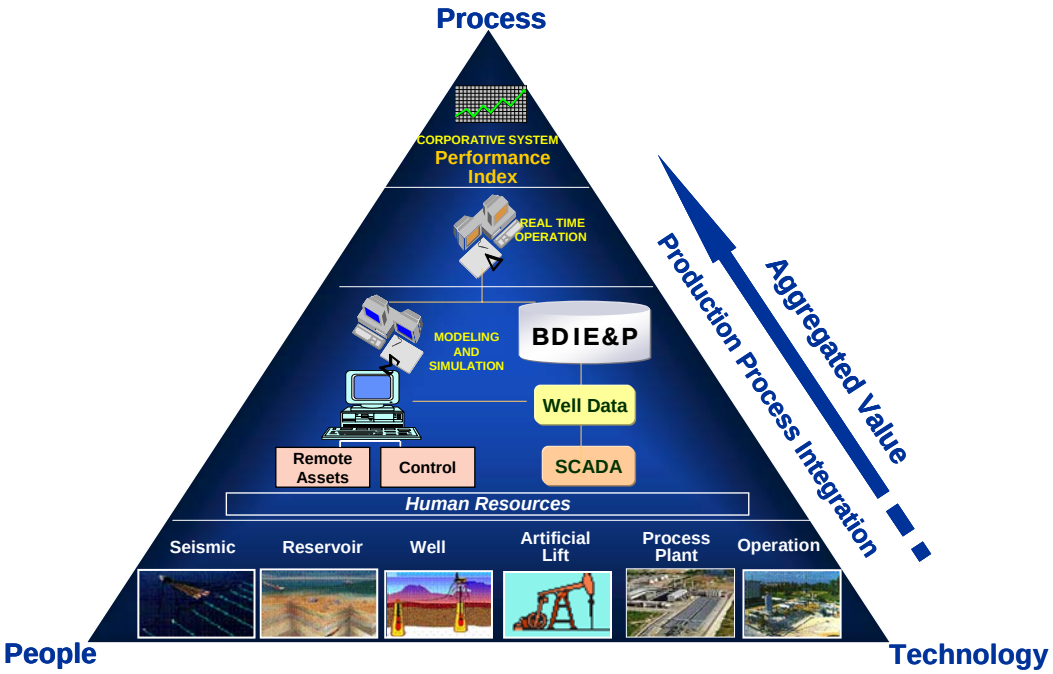
Table 1: GeDIg pilot and its characteristics.

GeDIg Pilot	Location	Exploitation Time Frame	Oil	IOR method	Intelligence. Level
Alto do Rodrigues	Onshore	Brownfield	Heavy	Steam injection (Continuous)	3
Carmopolis	Onshore	Brownfield	Light	Water injection	1
Cidade de entre Rios	Onshore	Greenfield	Light	Water injection	1
Fazenda Alegre	Onshore	Brownfield	Heavy	Steam injection (Cycle)	3
Carapeba	Offshore (Shallow water)	Brownfield	Light	Water injection	1
Barracuda Caratinga	Offshore (Deep water)	Greenfield	Light	Water injection	2

The multi-scenario pilot projects are representative samples of Petrobras production panel and allow the evaluation of technology application on different processes and workflows.

To completely integrate production chain, data needs to flow bottom-up in the asset pyramid structure as shown in figure 3. The pyramid base contains all monitoring variables and in its way up, after signal processing and simulator coupling, data becomes more valuable for decision makers. In different levels, information is used to interfere in the process by adjusting control variables to keep the indicators in a range around its set point or goal. The responsibility increases as the decisions are taken from higher levels and tends to affect more processes. Usually, data is restricted to knowledge islands and the interaction and communication among these islands is noisy and intermittent. To avoid flaws and misunderstanding between production actors, it is necessary to integrate data and people to increase operational efficiency and to create synergy bounds between them and aggregate value to information as it flows from the base to the top of production process pyramid.

Figure 3: Aggregated Value Pyramid.



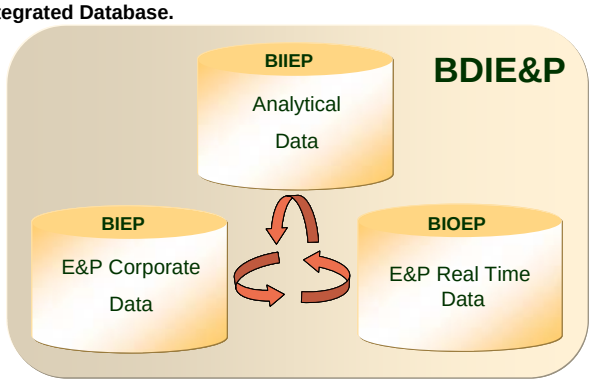
People, process and technology are three main elements of GeDIg. To achieve right use of technology in people and process integration, a few requirements were considered in the implementation of the pilots: GeDIg collaborative functional model, database integration, and process modeling.

GeDIg collaborative functional model (Figure 1), first requirement, is related to process and people integration, taking in consideration, at least two collaborative environments virtually connected by IT infrastructure (video-conference, application or portal). The new decision making environment provides the connection between the field (daily operational procedures) and headquarter (expertise consultant) environments.

Figure 1: GeDIg collaborative functional model.

In respect to database integration, Petrobras IT group developed an E&P Integrated Database that integrates pre-existing databases (production, geology, well intervention) with real time information from the sensors in the oilfield. This E&P database (Figure 2) exposes an abstract layer of business objects which provide transparent access to various software applications. This architecture allows access of data from multiple software applications, segregating inner databases from the application itself. Integrated E&P database provides access for multiple applications from different companies and shields inner database, avoiding unnecessary future application upgrade.

Figure 2: Schematic view of E&P Integrated Database.



Another important tool to improve people and process connection is process modeling. Due to different production scenarios, each asset has a specific way of working. To design new workflows more efficiently, it is necessary to have a complete understanding of the asset business processes. The AS IS process mapping combined with asset technology availability and critical analysis helps the TO BE workflow design that pursues cost reduction, recovery factor augmentation and operational efficiency improvement. The process mapping allows the benefits and impacts evaluation and guides the change management action plan.

In Petrobras learning path of how to design, implement, work and evaluate GeDIg, two implementation strategies were considered: in-house development and partnership with integrated companies.

In-house development pilots

Three onshore pilots were considered for in-house development: Alto do Rodrigues (ARG), Carmópolis (CP), and Cidade de Entre Rios (CER). Similar production features and business structure allowed the development of a common production integrated analysis and optimization application called SOLAR (Remote Production Optimization and Analysis System).

This application is used to help improve the production process by integrating the diverse production aspects of an oilfield. The information centric approach adopted in SOLAR allows users to combine all that information in the same representation structure, like a map, chart, or spreadsheet. It can be used as an effective tool for interactive collaboration in multidisciplinary production decision meetings as well as for storing and sharing information among members of asset teams in the organization. It integrates all information in the production chain, from operational data that comes from the fields to the KPI's and other indicators used by managers to measure the progress of the asset as a whole. There are also new modules being developed in the application that are going to provide continuos status for process workflows like production losses or steam injection management. SOLAR is implemented on an open component and services oriented architecture which offers an environment that simplifies the integration of new modules for both in-house developers and independent software vendors.

In order to increase the potential use of information provided by automation equipment and GeDIg collaboration environments, it was necessary to model, examine, and propose new ways of working [1]. Since information from sensors

installed in each well makes it possible to evaluate oil and gas production on real time, some objectives of this work were the identification of which data must be shared and how this information should be presented by applications, in order to improve decision making. To have this work done, some business processes needed to be reviewed and/or introduced, which required business process modeling (BPM).

The improvement comes from the combination of explicit knowledge and the discussion about current (AS-IS) process models with all involved participants. The new (TO-BE) processes must be planned and explicitly defined to become part of people work [2].

Furthermore, to develop Information Technology (IT) applications accessing integrated production information it was necessary to be aware of where and how this information comes from, and by whom they are consumed and produced during the work processes. Business processes modeling activities can be used as the starting point for the identification of business requirements, business rules and information.

Alto do Rodrigues Pilot

Alto do Rodrigues (ARG) is an onshore heavy oil brownfield with continuous steam injection as IOR method located in the Rio Grande do Norte and Ceara Business Unit in the Northeast of Brazil. Management and technical teams from ARG are geographically dispersed among two different locations 350 km apart: its facilities and logistics base near Açu city and its business unit headquarter in Natal city.

The main goal of this pilot is ultimate reservoir recovery improvement. Real time continuous steam injection system monitoring, including reservoir, steam generation facilities, and injection and production well control, and new workflow implementation are important tools for better reservoir management, artificial lift optimization and downtime reduction [3].

Cidade de Entre Rios Pilot

In Bahia Business Unit, Cidade de entre Rios field was chosen for ultimate intelligence level field with intelligent completion in all 10 wells (7 producers and 3 injectors). The strategy for this pilot was to evaluate the benefits of a fully automated field applied in onshore greenfield. This project is under early stage of development.

Carmopolis Pilot

Carmópolis is an onshore brownfield in the northeast region of Brazil where water-flooding is its main IOR method. The review of water-flooding operation through improved reservoir characterization and flow simulation showed that declined production trend could be reversed by zone selectivity waterflood management.

In IOR Carmopolis scenario, an integrated intelligent well system was developed considering artificial lift automation and intelligent completion with three sets of hydraulic/hydrostatic packers and flow control valves and associated to four pressure and temperature optical fiber sensors [4]. Inverted five spot network was considered for the pilot to ensure benefits of reservoir and production optimization effectiveness and well performance. Many optimization techniques have been applied in conjunction with commercial reservoir simulators with detailed multi-segment well model to improve ultimate recovery.

The equipments were developed to be low cost with moderate service condition specifications to satisfy availability and reliability demands. Standardization of the connectivity between automation of the intelligent completion and artificial lift is necessary for a vendor-independent integration, which becomes more cost-effective by using open industry standard protocols. This also allows the use of different supervisory software, reducing the impact of changing systems already in use without losing the flexibility of choosing a solution that has some custom features or that are cheaper.

Partnership Pilots

One onshore field and two offshore fields were considered for partnership pilot development: Fazenda Alegre (FAL), Carapeba (CPB), and Barracuda e Caratinga (BRC).

Fazenda Alegre Pilot

The Fazenda Alegre (FAL) field is an onshore brownfield which produces naphtenic heavy oil from 59 wells where cycled steam injection is used to increase its production. Management and technical teams from FAL are geographically dispersed among three different locations: logistics base in Sao Mateus city, business unit headquarter in Vitoria city and FAL facilities located 210 Km North from Vitoria and 40 km south from São Mateus.

The FAL pilot [5] is developed in a partnership between Petrobras and Accenture. The integrated partner company was responsible for the AS IS process mapping, change management and design of collaborative tool and environments. New technical solutions and business process revisions were conducted by the partner company oriented by asset team such as KPI panel, downtime analysis and real time alert system. Moreover, the FAL pilot includes the design, construction and commissioning of three collaborative environments for real time monitoring associated daily production and process analysis.

Carapeba Pilot

Carapeba (CPB) is an offshore brownfield located in the Northeast area of the Campos basin, comprising of 3 fixed platforms with 41 wells producing from three zones (all dry completion and equipped with Electric Submersible Pumps) and 4

water injection wells and was selected as the Campos Basin Business Unit pilot. The CPB pilot is developed in a partnership between Petrobras and Schlumberger.

Carapeba GeDIg pilot [6] comprises end-to-end seamless integration, spanning across various functional groups of the asset, integrating operational processes. It provides a toolset that gives the ability to make better informed decisions by multi-disciplinary teams in a specially designed collaborative environment for planning, monitoring and controlling operational processes, making asset teams more agile. The solution is delivered through a portal platform which integrates information from Production Operations, Geotechnical and Financial systems, providing an information hub for the entire asset operations, shielding the complexity of the underlying sub-systems from the end-users and empowering them with the right information in-time. This is supported by field automation, smart simulation and optimization tools which integrate the well-bore, surface facility networks, reservoir, process and economic models. This level of integration provides more transparency to understand engineering and economic impact of various field development decisions.

Barracuda/Caratinga pilot

The Barracuda-Caratinga (BRC) is an offshore greenfield that is being developed by two FPSO platforms of similar characteristics. This pilot is being developed in partnership with Halliburton.

The Barracuda-Caratinga GeDIg pilot [7] aims to implement real time operation technologies, which enable asset teams to effectively execute workflows related to well production testing, production test validation, production estimation, production losses control, plant efficiency and KPIs management. The adopted workflows are enabled through change management processes in addition to innovative technologies. Reliable and time-effective workflows for production surveillance and testing, continuous performance modeling, and sharing consistent and validated data across multi-disciplinary teams provides better control of operations for the asset management.

Lessons Learned

Due to multiple management structures inside oil companies, an asset should be the smallest cell to digital field implementation. Asset structure must reflect all processes related to facilities, wells and maintenance under single asset management coordination responsible for production, investment and costs. Asset manager represents the driving force in GeDIg pilot implementation because he is responsible for goal achievement; action plan coordination, and control of multiple actors related to process mapping, new workflow design and change management. If the asset manager understands digital field benefits and applies GeDIg concepts to asset goals, he will be able to lead successfully the asset team to digital oilfield.

Petrobras during the pilot's development experienced problems related to non-use of this best practice. Some pilots coordinated by non asset manager faced multiple problems related to governance power and divergence objectives that delayed the projects and cause overhead work. Another problem was GeDIg application over a particular field in assets with multiple fields under a unique asset team responsibility. In this case, the asset team got confused because during the process mapping phase they realized that they will deal at the same time with old and new workflows applied in different platforms (hardware and software). On the other hand, pilots under asset manager coordination achieved more successful results due to well oriented goal strategy dissemination.

To provide GeDIg scalability inside an oil and gas company, a set of requirements must be defined by corporative group. Two main strategies can be considered: open architecture (multiple vendors) or vendor partnership. Dependency and robustness analysis need to be done to support the company strategy in medium and long terms. In Petrobras open architecture, database integration and minimum collaborative functional model were considered. If production scenario among assets of a single business unit is very similar, it is possible to consider business unit standardization such as interconnected module structure where each module represents a specific process.

First step in GeDIg implementation is to establish specific business goals for digital oilfield to guide the TO BE process design. These goals need to be aligned with corporative view defined in the company strategy plan. The asset manager must be committed to the program, fully understanding its benefits and playing leadership role through the entire solution development cycle. If the asset manager is not aware of the main asset problems, an initial assessment is necessary to point out the key processes for goal achievement. The assessment based in interviews and workshops can be done by an integrated company, consultant or corporative group and represents the first contact of asset team to digital oilfield concept. Conceptual products related to the primary goals are conceived as assessment results. With economical value judgment over conceptual product collection, the asset manager is responsible for products development priority list definition.

The products priority list should define process mapping direction. The first product workflow should be developed taking into account the production actors (supervisor, engineer, manager and technician), input and output variables (charts, reports, KPI) to allow the fully understanding of process interaction. The process mapping should be oriented by the process and not by areas (artificial lift, reservoir and plant process) to increase synergy between different actors. The process mapping in Alto do Rodrigues pilot started oriented by areas and it caused a huge expectation among actors that required solutions that weren't in the priory products list. Besides, processes with multiple actors were described differently due to the fact that actors tend to focus in their areas.

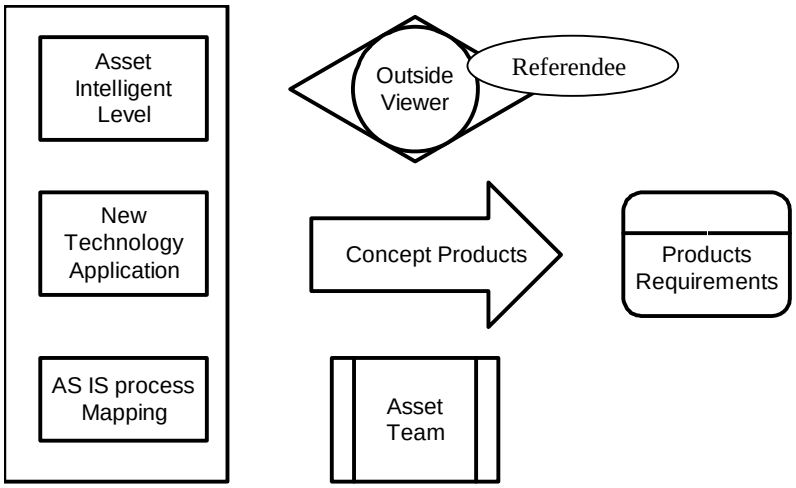
Before the new workflow design, it is necessary to determine new technology applications. It is worthy to emphasize that an economical analysis is required to determine use of new technology. Collaborative environment, intelligent completion and portal tools impact the workflow design methodology, normally, guided by best practices. The innovations bring a different

element that is not well understood among asset actors. Without the correct guidance, the asset team tends to apply the new technologies in the AS IS workflow instead of creating new processes. This new technology misuse causes operational inefficiency and compromises pilot's results.

To avoid this problem, as lesson learned, a referendee consultant with process expertise in technology application is indicated to work with asset team as a catalyzer in the new workflow design. The process best practices combined with innovation guarantee a better performance of digital oilfield.

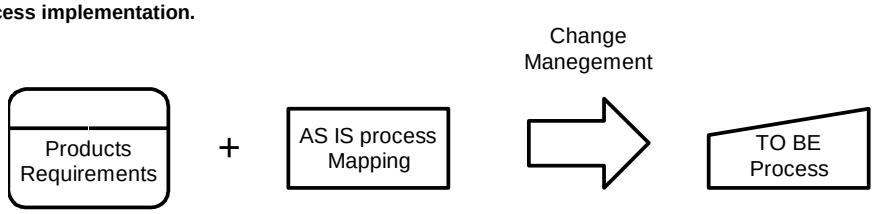
Oriented by conceptual products, new processes can be designed by the asset team over referendee consultant group guidance taking into account AS IS process mapped and new technology applications. At this point it is possible to define the requisites for software and hardware specification (Figure 4). The asset team plays the most important role in the process mapping and new process design because they represent the process knowledge. Both activities consume hours of asset team work in interviews, meetings and documents validation.

Figure 4: Products requirements definition.



After product requirements definition and validation, implementation (software and hardware) phase begins. With all the specified products it is possible to draw the new processes. As development time goes by, it is necessary to define change management plan to minimize side-effects of new workflow implementation (Figure 5). Although asset team has made part of group design, most of them are not prepared for that. The plan must contain training sessions in the new tools and environment. If there is an overlap between different tools for similar tasks, it is necessary to have a gradual try and trust procedure to provide a comfortable use of the new tools before eliminate the old ones. At this point asset manager leadership is very important because their enthusiasm and beliefs disseminate through all the asset structure, reinforcing digital field implementation benefits.

Figure 5: TO BE process implementation.



After hardware and software commissioning, change management quest begins. Even following the change management plan with lectures, training and benefits explanation, changing work environments and tools can create rejection problems. The new process engagement will depend on how the employee reacts to change in technology and for each different reaction, a strategy need to be addressed.

Conclusion

Petrobras pilot strategy for Digital Integrated Field Management (GeDIg) allows evaluation of digital oilfield development in a multiple production scenarios. Due to different approaches, many lessons were learned during pilots' implementation. Change management and benefits metrics evaluation remain as important issues to be addressed in broad digital oilfield dissemination.

E&P must pursue processes efficiency and ultimate reservoir recovery augmentation through real time operation, right time decision support and optimal workflows to assure Digital Integrated Field Management.

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