

Using a Digital Platform to Model Interaction between Oilfield Service Market Actors

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Abstract

One factor that determines timeliness of the research topic is that the modern society where knowledge is a priority feels that, nowadays, the use of digital technologies should be a standard practice for interaction between actors of the Russian market for oilfield services. Considering the above, this paper is aimed at working out interaction methods for those oilfield service market actors who are involved in equipment reconditioning and renovation. In their research the authors mainly relied on systematic analysis, integrated analysis and economic mathematical modelling. This approach allowed them to develop comprehensive and realistic algorithms for and models of effective interaction between oilfield service market actors using digital technologies. Materials presented in the paper are of practical value for researchers and experts who deal with problems arising from the use of state-of-the-art technologies for better interaction between oilfield service market actors and managers of companies operating in oil and gas sector who outsource certain business processes of equipment reconditioning and renovation.

Keywords

Actors, Interaction Algorithms, Business Processes, Equipment Reconditioning and Renovation, Oilfield Service Market, Digitalisation.

Introduction

The use of digital technologies for interaction between the actors of the Russian oilfield service market is a topical line of research. In his Address to the Federal Assembly of 2017 president Putin of the Russian Federation set the task of building a digital economy. As a result, a programme called *The Russian Federation's Digital Economy* has been developed and launched.

Certain Russian oil companies have already been using digital technologies for some time, but, for the most part, their use is limited to the main business processes. The authors of this paper believe that companies representing the oil and gas sector should rely on specialised oilfield service providers to ensure flawless operation of their equipment. The oilfield service providers implement supportive business processes such as reconditioning and renovation, which are essential for operating oil equipment smoothly. The process of interaction between the customer and the contractor providing oilfield services also needs to be digitalised. The goal of this research is, therefore, to work out algorithms for digital-technology-based interaction between oilfield service market actors, and its tasks include setting forth the theory and methodology of the process and giving practical recommendations regarding its implementation.

“The system of dynamic capabilities, originally developed to improve understanding of strategic flexibility in high-tech companies operating in the high-speed market, has shown that it is relevant to the oil and gas sector in the field of exploration and production in the context of five changes in the industry” (Shuen, Feiler & Teece, 2014) [1].

Digital technologies have long since become part of the best practices of oil and gas companies outside of Russia in their interaction with business partners. Oilfield service providers abroad have built up considerable experience in digitalizing business processes and turning the use of digital technologies into their daily routine. “Exxon Mobil's chief computational scientist is quoted as saying, the “oil patch's digital transformation will be comparable to horizontal drilling's tech revolution” (Carvajal, Maucec & Cullick, 2018) [2]. “Each company has found its own way to use digital technologies in its business processes”. Given below are short descriptions of digital management systems used by different oil companies:

- *Shell* uses *Smart Field*, ‘a production management system allowing, on the one hand, to increase oil and gas production, and, on the other hand, to minimize energy consumption costs’ (Yeremin, 2008) [3]. Technological solutions called “smart wells” and “smart fields” are used in the oil industry for almost two decades. They are aimed at improving the knowledge about the processes of oil production and thereby to increase the efficiency of operations (Redutskiy, 2017) [4].
- *Chevron* uses *i-Field*, ‘a management concept that uses information on various processes and allows moving from local optimization of particular processes to optimisation for the entire oil field’ (Cherkasov, 2016) [5].
- *BP* uses *The Field of Future*; Halliburton, a software package with real time operations, which ‘includes a number of computer applications for describing the behaviour of a particular oil field’

- *Schlumberger* uses *Smart Wells*, ‘a system which controls and monitors an oil well during its entire life span – from cementing to abandonment’ (ITPS "Digital Transformation, Digital Production Platform AVIST") [6].
- *ADCO* uses the Integrated Asset Operation Model (IAOM), “a model with a digital twin for each asset, which enables prediction and optimisation of the entire production process, as well as operations and resources, based on real-time data”. The model meets various production optimisation challenges such as well surveillance, production and injection optimisation, forecasting and allocation and field development planning. International companies that operate on the Russian market have partially digitalised the main business processes of prospecting, exploration and production. The main challenge is development and adoption of digital technologies for supportive business processes – particularly the ones related to reconditioning and renovation of oil and gas machinery and equipment – and for interaction between the customer and the contractor (service provider). The oil and gas industry has struggled for years with massive amounts of data, “but Big Data is a relatively new concept that can significantly reform the industry. Perrons & Jensen (2015) [7] examined existing data management practices in the upstream oil and gas industry, and compared them to practices and philosophies that have emerged in organizations that are leading the way in Big Data”. Speaking about the world economic development, “Chinese oil companies are moving forward “in the process of digitizing, so the ability to prevent and handle emergencies is becoming increasingly urgent, when the oil fields are faced with different risks of major unforeseen security incidents” (Zhilin & Lei, 2011) [8].

Lately Russian scientists have also been discussing the need for oil and gas companies to extend their use of digital technologies. According to A.M. Kornaukhov (Kornaukhov, 2017) [9], ‘in oil and gas prospecting business process’ ‘nothing can be better for the industry than improving the research quality at the prospecting stage through intensive digitalization of the main business processes and quick introduction of the big data processing technology, which, in turn, can significantly improve managerial decision making and engineering solutions. Large companies that do not systematically analyze voluminous geological data often make big and costly mistakes’ (Volkodavova & Tomazova, 2016) [10].

A. Alekseyenko, Director General for Russia of *Teradata* company (Alekseyenko, 2018) [11], is sure that ‘digitalisation helps oil and gas companies to increase capital efficiency, lower oil production cost and cut operation costs of those business functions which are not involved in the company’s main activity’ (“19th International Exhibition for Equipment and Technologies for Oil and Gas Industries”, 2018) [12].

A.N. Dmitrievsky, V.G. Martynov & L.A. Abukova (Dmitrievsky et al., 2016) [13] have carried out ‘the systematic analysis of the main trends in the development of digital and intellectual oil fields. New step-ahead solutions have been found for different activities such as geological exploration, drilling, field development and exploitation. Best practices of creating digital and intellectual oil fields by companies based in Russia and other countries have been studied’ (“Portal ITIC. "SAP PM: Maintenance and repair of equipment”) [14].

Methods

The research used the following methods:

- Systematic analysis which made it possible to study, at the problem-setting stage, functional interaction between oilfield service market actors, as well as all such departments and divisions of a given oil and gas producer that are responsible for reconditioning the oil field equipment in the period when digital models and digitalisation algorithms are adopted for its repair and post repair maintenance
- Integrated analysis which made it possible to cover numerous aspects of using digital technologies for planning and implementing the equipment reconditioning processes for oil and gas producers in Russia and abroad
- Economic mathematical modelling which can be used to justify the choice of criteria for making managerial decisions regarding interaction between oilfield service market actors whenever they discuss plans for reconditioning, repair or upgrading of equipment or have to choose some digital technology to implement such plans
- The concept of market actors’ rational behaviour which helps to choose the best digital product package and the best digitalization method whenever it is necessary to recondition equipment, extend its life or improve the quality of repair.

In choosing methods of research, the authors relied on the best practices of oilfield service providers operating outside of Russia.

Trial resources were provided to the researchers by Russian oil and gas companies.

Results

In this paper, the researchers present an algorithm and models for digital-technology-based interaction between oilfield service market actors engaged in reconditioning or renovation of oil and gas production equipment.

To achieve their goal, the authors

- (1) proved the timeliness of using digital technologies for supportive operations such as reconditioning and renovation of oil and gas production equipment,

- (2) worked out the typology and described the main features of those business processes related to reconditioning and renovation of oil and gas production equipment, which are subject to digitalisation on the Russian market of oilfield services,
- (3) worked out economic mathematical models for choosing
- an organization to which the business processes of reconditioning and renovation of oil and gas production equipment can be outsourced and
 - the best scenario of reconditioning or renovation of oil and gas production equipment;
- (4) worked out algorithms digitalizing interaction between oilfield service market actors.

1. *The timeliness of using digital technologies for supportive operations* is proved by the following circumstances:

- the need to solve systemic problems of supporting the physical infrastructure of Russian oil and gas companies, that is, problems such as equipment deterioration, the lack of targeted support from the government, the lack of innovative technologies, the lack of transparency in relations between the customer and the contractor and competition, which have existed for quite a long time and cannot be solved without taking a totally new approach;
- the urgent need to digitalise interaction between actors of the Russian oilfield service market. It is worth mentioning that automation and computerization of the main and supportive business processes linked to the functioning of property, plant and equipment of oil and gas companies started back in the 1970s when managers of each particular company collected data on the condition of its mechanical facilities and, based on those data, made decisions about the future of the company's fixed assets.

The first Russian work stations for processing oil field data were set up as early as in the Soviet time. Using those stations increased oil production by one per cent. In the early 1990s oil companies managed to achieve a 40% reduction in their prospecting costs by using computers to design seismic models for the prospecting business process. The use of computers in drilling operations increased penetration rate by the factor of 1.5 (VGON Consulting, 2018) [15].

Nowadays, Russian oilfield service companies provide a range of services which include:

- geophysical work and seismic exploration,
- well drilling,
- well servicing and workover,
- oil recovery factor improvement,
- providing utility vehicle services, and
- manufacturing, maintenance and repair of oil field equipment.

Considering the above, one can see that, in Russia's oil and gas industry, digital technologies have been used primarily for business processes related to prospecting, development and production of carbohydrates. Those digitalised processes took the form of the so-called *smart wells* or *digital oil fields*. As for business processes related to reconditioning and renovation of oil production equipment in Russia, very few of them have been digitalised. Most of the processes that have been computerised are software applications for collecting data on work capacity or durability of labour instruments (plant and machinery). Of the imported Enterprise Asset Management (EAM) systems that are used in Russia these days the most demanded ones are SAP PM and IBM Maximo, the best known domestic ones are Galaktika's TORO (Equipment Maintenance and Repair Management), TRIM (Targets Related Infrastructure Management), and 1C: Enterprise 8 "Management of equipment repair and maintenance" (1S Enterprise 8: *Equipment Repair and Maintenance Management*) (Stepanets & Akopyan, 2018) [16].

2. *The authors worked out the typology of business processes for supportive operations carried out during reconditioning and renovation of oil and gas production equipment.* Presented in Figure 1 is the typology of those business processes related to the Russian market of oilfield services, which are yet to be digitalised.

In the business process called *Repair and Maintenance* the authors single out four key components: one of them consists in providing maintenance services, while the other three assist in managing various kinds of repair – minor, medium and capital (overhaul). All of these components are part of the planned preventive maintenance system use by oil and gas industry.

The business process called *Modernisation* can be broken down into three components – three sub-processes which can be outsourced to maintenance service providers: diagnostics of mechanical facilities, partial modernization and complex modernization.

The *Renovation* business process has two key components: equipment replacement and equipment upgrading. Digitalisation of all business process components (sub-processes) presented in Figure 1 will make it possible for managers of oil and gas companies to accelerate decision making and eventually ensure fail-free operations of machinery and equipment.

3. *The authors worked out economic mathematical models for choosing the best company to recondition or renovate oil and gas production equipment.*

The proposed economic mathematical models allow optimising interaction between oilfield service market actors when there is a need to pick the best company to which supportive operations of equipment reconditioning can be outsourced or when it is necessary to validate the chosen renovation scenario.

The economic mathematical model for choosing the best provider of repair and maintenance service allows oil and gas company managers to choose the best intermediary to organise supportive business processes related to equipment repair and maintenance. The criterion for choosing the best intermediary is the lowest price charged for the service provided:

$$P_{\text{cond}} \rightarrow \min$$

The model has the following limitations:

T , years of operation on the oilfield service market: no less than 10;

Q_r , number of certified repair business processes: no less than 4;

Q_m , number of certified modernisation business processes: no less than 3;

t_r , failure-free operation time after minor or medium repair: no less than 2 years;

t_c , failure-free operation time after capital repair: no less than 5 years;

t_m failure-free operation time after equipment upgrade: no less than 3 years.

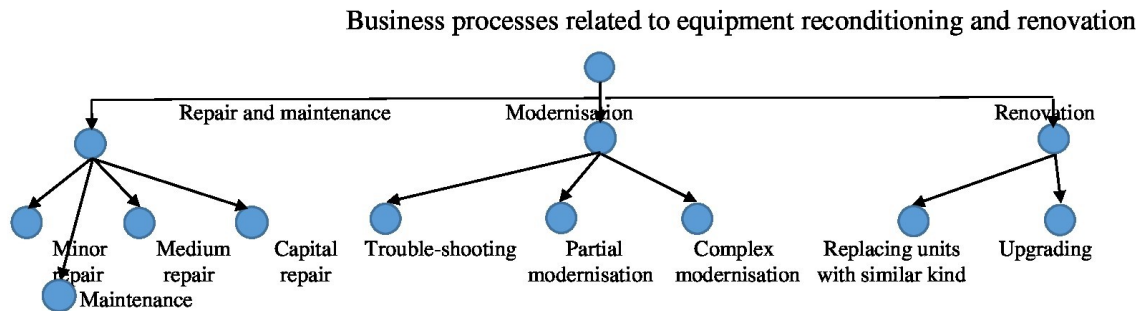


Fig. 1: Business Processes to be Digitalised on the Russian Market of Oilfield Services

Source: Author's Development

For equipment renovation we proposed a model which helps to validate the choice of a particular renovation scenario which allows contracting a particular service provider.

In the case where an economic mathematical model is used for validating the chosen renovation scenario for a particular type of equipment, the validation criterion is the lowest price (the lower the purchase price of equipment, the better the scenario is):

$$P_{\text{equip}} \rightarrow \min$$

The model has the following limitations:

T , equipment lifespan: no less than 10 years;

n , number of innovative operations which a given unit of equipment allows to perform (this number depends on the design of the product manufactured and types of processing operations performed on its parts): no less than 1, ..., N , where N is the maximum number of operations that scheduled manufacturing of a particular part, unit or product in a particular work place (shop, work station) may require;

4. Algorithms of using digital technologies for better interaction between oilfield service market actors.

In Russia, the main barrier to successful digitalization of oilfield services is their high dependence on imported technologies in a situation where the industry is under anti-Russian sanctions. At the same time, there is a whole range of systemic problems which hinder the development of domestic technologies: the lack of motivation for investment in R&D, the underdeveloped capital market, the absence of venture capital infrastructure, competitive weakness of Russia in the global market of oilfield services, and administrative barriers.

Russian oil industry has long since got everything ready for extending the range of its digitalised business processes, both main and supportive. The main reasons why business processes require digitalisation are:

- creating large sets of economically important industry-specific and cross-industry data for the processes of production, refinery, transportation and sales of oil and gas, and
- increase in the social impact of communication technologies and *internet of things* (a system which enables everyday objects to send and receive data through computing devices embedded in them) – new technologies which lay the groundwork for more accurate evaluation and prediction of economic development.

Thus, as people, businesses and equipment are getting closer interconnected by the common digital space format, digitalization creates vast opportunities for using new decision-making models which will form the basis for changes in the current global social and economic processes. Those changes require using new models of business operations, customers' behaviour and social services.

One of the key digitalisation goals for oil and gas industry is adopting digital technologies for reconditioning of oil production equipment. This process has two main objectives: increasing the turnaround interval by a factor of 2 to 4, and adopting new production technologies for repair and maintenance of oil and gas production facilities.

The term *new production technologies*, or *advanced production technologies*, covers technologies, processes, machines, devices, instruments and any pieces of equipment that have embedded microchips in them or are computer-controlled and can be used for designing, manufacturing, processing or delivery of products.

Shown in Figure 2 is a scheme of interaction between the customer and the service provider chosen to recondition and/or renovate oil and gas production equipment. The scheme suggests using the economic mathematical model (EMM) proposed by the authors of this paper.

The model consists of three function units:

- Unit 1. The main business processes currently used by Russian oil and gas companies, which have already been successfully digitalised.
- Unit 2. Supportive business processes with a special focus on equipment reconditioning and renovation, which need to be used on a broader scale and require more extensive digitalisation.
- Unit 3. A technological platform with the focus on the digital technologies which, according to the authors, can solve the problem of the lack of digitalised supportive processes for reconditioning and renovation of equipment used by oil and gas companies.

To decide whether the equipment needs reconditioning or not, the oil company's management uses the mechanism of scheduled preventive maintenance procedures. Once the decision has been made, they validate their choice of the service provider that will do repair work. That can be done either by using the proposed mathematical model (this method is only applied for contracts under 99,000 rubles since, according to the Russian law, that is the maximum contract amount allowing work to be contracted without putting it out to tender), or by putting the work out to tender (in the cases where the service costs 100,000 rubles or more).

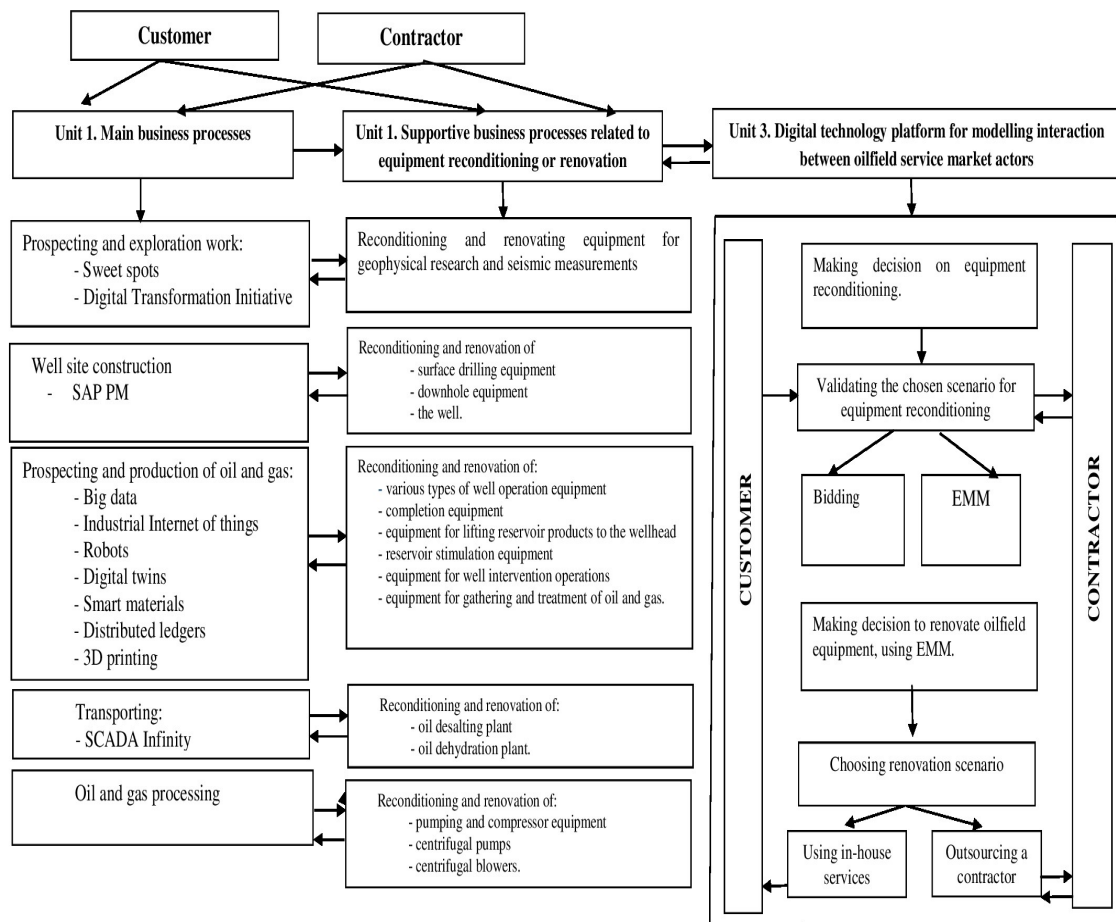


Fig 2: Interaction Model of the Customer and Contractor Services in the field of Restoration and Renovation of Equipment of Oil and Gas Complex

Figure 3 presents the flowchart of the proposed algorithm for interaction between the customer and the contractor (service provider) at the stage of validating the chosen scenario for equipment reconditioning. The flowchart shows the sequence of related business processes and indicates digital technologies used for each process.

Interaction Algorithm

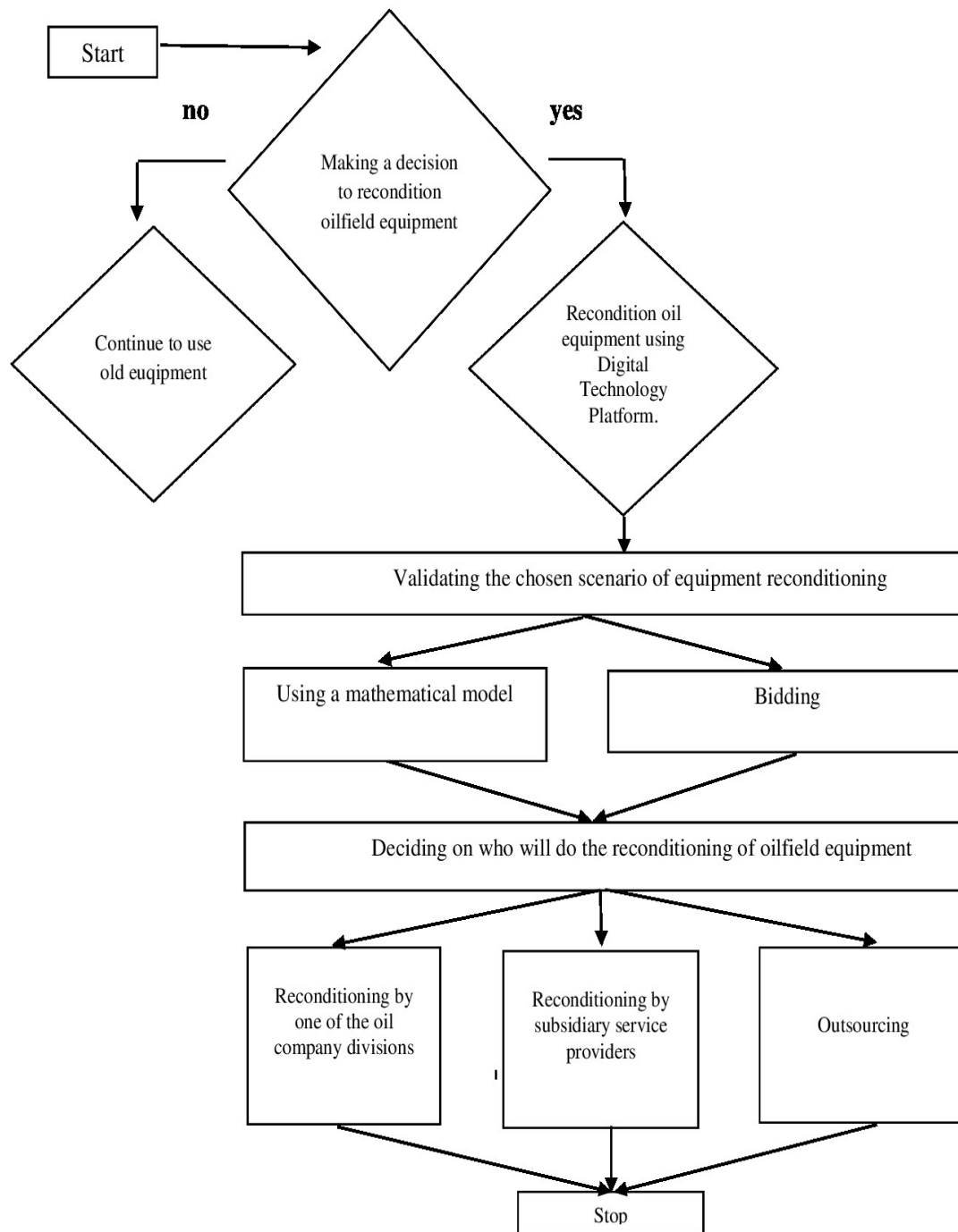


Fig.3: An Algorithm of Deciding Who Will Implement the Business Process of Equipment Reconditioning
Source: Author's Development

When the decision on how to renovate equipment is made, using an economic mathematical model in which the optimisation criterion is the lowest purchase price for repair and maintenance equipment, the model allows choosing between the following two scenarios: (1) the equipment is purchased by a special department within the company, (2) the equipment is purchased by a contractor.

Figure 4 presents the flowchart of the proposed algorithm for interaction between the customer and the service provider at the stage of implementing the business process of validating the chosen scenario for equipment

renovation. The flowchart shows the sequence of related business processes and indicates digital technologies used for each process.

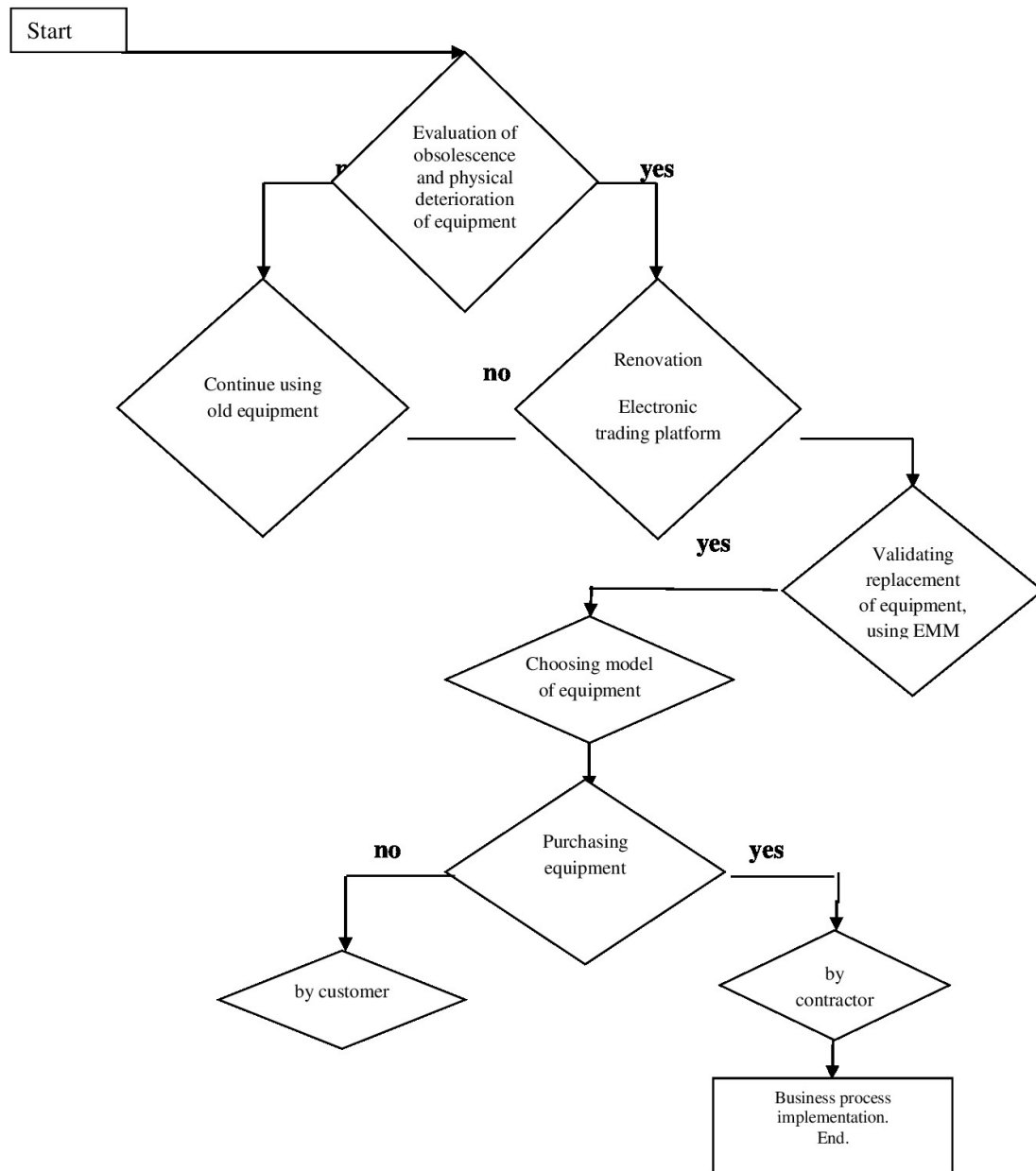


Fig.4: Equipment Renovation Algorithm
Source: Author's Development

Discussion

While developing business process algorithms and application tools for digital technologies to ensure the best interaction between the actors of oilfield service market in the current business climate, the authors of this paper studied the best practices of service providers outside Russia.

The largest international oil corporations such as *Shell* and *ExxonMobil* were among the first ones to start using digital technologies to control oil and gas project development, using mobile devices.

Back in the early 2000s *Shell* Oil Company started using *Smart Fields* technology “to enable real time measurement of the oil field conditions to control centres on land and monitor oil production, and continuously send information which is necessary for faster decision making and accelerating response to any problems” (NEFTEGAZ, 2018)

[12]. *Chevron* Oil Company uses artificial intelligence – the digital product called *Sweet Spots* – to identify the best places for drilling new wells. The application is used for prospecting and exploration of hydrocarbons.

For handling the same business process, *Halliburton* company came up with a package of solutions for predicting the depth of penetration on the basis of data supplied by navigation equipment and geological information system. Based on the implicit knowledge obtained from the system, the DecisionSpace module that analyses Invisible Lost Time identifies potential troubles in the drilling process and makes recommendations on what needs to be done. It takes powerful high-speed computers to build invisible lost time models”.

Russian oil and gas production companies use the SAP PM (Plant Maintenance) module to optimise work of managers, economists and process planners of maintenance units, purchasing departments and production units. SAP PM module performs the following activities:

- takes stock of equipment, recording the number, types and configuration of units
- keeps records of repair and maintenance history, as well as equipment configuration changes
- assesses equipment integrity, taking into account operation time
- makes schedules for inspections, repair and maintenance, indicating the type of work to be done as well as personnel and materials required
- keeps statistics on failures and idle time periods
- manages the maintenance process
- predicts costs and accounts for expenditures
- monitors workload/availability of personnel (“Development of digital economy in Russia”, 2017) [17].

According to D. Kozlova and D.Pigarev [18], all large oil companies operating outside of Russia use digital technologies in oil and gas production. The key technological trends of oil industry on which *Industry 4.0* focuses include:

- *Big Data*, tools and methods used to organise, store, process, handle or calculate huge bulk of data (10–15 Petabyte)
- *Industrial Internet of Things*, a system of interconnected computer networks linked to physical objects (“things”) with embedded sensors for collecting and exchanging data, which can be remotely controlled in an automated fashion
- *Robots* including drones, which help automate processes, carry out dangerous manipulations, perform visual or tactile inspection of hard-to-get objects such as submarine wells or underwater production equipment
- *Digital twins* (a digital twin is a virtual model of an oil field production equipment or infrastructure element), which can be used for testing or predicting the effect from using particular options/solutions, and for visualisation of results in a user-friendly format
- *Smart materials* including nanocoatings and smart liquids, a class of solid or liquid materials each having a particular parphysicochemical property that reacts to changes in their environment (the external conditions that change the property may vary and can be extreme)
- *3D printing*, which oil companies use for prototyping development projects, laying out oil fields and making parts for sensors, controllers, pumps and other oversized equipment
- *Distributed Ledger* (a blockchain system), a decentralized public domain application for doing accounting, which can bring safety of a system to a high level (Kornaukhov, 2017) [9].

According to L.Yu. Stepanets and E.A. Akopian [16], “the USA oilfield service market is the largest one in the world. At the moment its main development trend is bringing investments in shale gas field development” (Aleksenko, 2018) [11]. They are sure that extending the network with wireless technologies at Eagle-Fort shale oil field enabled cost reduction of about 60 per cent. In addition to transmitting data within an automated control system which controls the technological process (Supervisory Control And Data Acquisition, SCADA), the newly built network supports voice communication through the Internet protocols (Dmitrievsky et al., 2016) [13].

Schlumberger oil company, which uses the initiative of *NExT* training company along with advanced tools such as HubToolkit, the tool called MindShare which is used for collaboration and gaining knowledge, a software package called Knowledge Management suite, and oil field classifier, built a knowledge management system which can control the processes of data collection, validation and publishing.

Nowadays the terms *digital economy* and *digitalization* are widely used not only by economists, but also by managers of production and other processes. Oilfield service market is no exception. Considering the history of oil and gas field service business development, we would like to focus on adoption and use of digital technologies in the field service industry.

“Digital oil field, developing the technology evolved from a reactive to a proactive approach. In the last decade was installing DOF devices such as sensors, in the field for data collection. Now he has passed on the data visualization dashboards, monitoring and improving the efficiency of operations” (Chanana, Soni & Bhakne, 2016) [19].

Of all services offered by oil industry, drilling and maintenance of oil and gas wells are the most capital intensive ones. Considering such factors as low current price of oil, reduced oil production volumes (the decision to reduce it was made by OPEC+), and limited access to technologies from abroad, the issue of digitalization becomes vital for oil field operations.

Listed below are operating activities related to various business processes relying on those new digital technologies that are currently available and have been partially adopted by Russian oilfield service industry:

- cable-free 4D and HD technologies: seismic data acquisition
- interpretation: advanced data processing
- training on sets of hydraulic fracturing simulator
- laboratories that experiment with simulations of various processes
- remote control system for modern hydrofrac fleet;
- continuous monitoring systems.

Conclusion

The programme entitled “*Development of Digital Economy in Russia*” [17] points out that “in digital economy, which is highly competitive and cross-border, the key factor of success is not new technologies, but new technology management and data management techniques (or ‘models’) that enable quick response to changes and modelling future challenges/problems for governments, businesses or civil society” [17, p. 22].

The authors believe that their model of digital-technology-based interaction between actors of the Russian market of oilfield services and the use of the proposed economic mathematical models will contribute to success in the development of such processes as reconditioning and renovation of production equipment used by Russian oil and gas companies.

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