Field development efforts that are focused on maximizing efficiency and economic value and bringing maximum recovery of hydrocarbon reserves require an accurate and reliable tool to predict the effects of operational decisions on the performance of the reservoir, wells, surface production gathering network, booster compressor stations, and central processing facility. The ability to accurately predict various scenarios is key for a successful field operations and management system.

The impact of interference in a hydrocarbon production system and processes needs to be continuously analyzed. Without the ability to provide simulations and predictions, decision making is based on reaction to current field conditions, and the achievement of economic targets is erratic at best.

Predictions and forecasts should be based on an integrated live model of the reservoir, geology, surface production systems, and processes—the Integrated Dynamic Field Model (IDFM), which incorporates interdependencies of the reservoir and production engineering facilities.

The IDFM enables a continuous field development management cycle that includes top and bottom adjustment levels (Fig. 1). Management at the top level is established through a Field Development Automated Control System (FD ACS), which is based on the IDFM and provides complex analysis and forecasting (short-term, intermediate, and long-term), design, and optimization of the wells’ operating modes, loops, and surface processing equipment. The optimum operating modes are then transferred to the bottom management level.

The bottom management level provides real-time monitoring and adjustment of well performance modes, loops, and facilities within defined parameters and for emergency shutdowns. This management level is applied through the Field Process Automated Control System (FP ACS).
The structure of the FD ACS is shown in Fig. 2.

Integrated Field Development Model

The IDFM includes mathematical field models and modeling aids as well as an advanced software system for examination, production, and analysis of targeted field results. The integrated field model provides field development modeling that takes into consideration the continuity and interdependency of system components: reservoir, wells, surface production gathering network, booster compressor station, central processing facility, interfield gathering line, and field economics. The model also includes system performance, technology and economic process integration, identification and solution of bottlenecks in the gas field system, improvement of overall production efficiency, reduction of energy consumption, and processing facilities optimization.

The IDFM includes the following elements:

- geological reservoir characterization, which forms the basis for simulation
- reservoir simulation model for the design of reservoir fluid flows
- well models and a surface production gathering network for the design of hydrocarbon production and pipeline flow
- hydrocarbon processing facilities model (gas separation unit, compression plant, drying unit, etc.) to design the processing process
- economic model coupled with the IDFM to ensure the economic benefit of the production and processing scenarios.

Field Development Data Bank

The Field Development Data Bank is an automated data retrieval system for central storage and data sharing of geological, geophysical, field production, and technological information. It provides data storage, processing, and searching capabilities.
This unified data bank manages the data needed to make decisions in field development and exploitation control. The centralized system reduces the time required to make optimum decisions in geology, geophysics, field development, production, transportation, and hydrocarbon processing, using an information space common to the overall gas production operations with the option for quick access to the Master Database from all hierarchy levels within the enterprise.

The data bank provides initial information storage for interpretation and simulation results, as well as for other related information such as economic data, capital investment, project performance, status of available resources, infrastructure data, and key performance indicators (KPIs).

**Information Analysis System**

The Information Analysis System (IAS) provides data acquisition, processing, display, and distribution that characterize field development objects. The IAS provides accessibility to all geological and technological information required for conducting integrated geological field data, geophysics, engineering, and other data studies according to gas field production indices analysis. It may also include:

- faster acquisition of necessary gas field information (designed, factual, modeling results) for decision making in the operations management of gas extraction and preparation divisions
- technological, geotechnical, and environmental monitoring during the entire field development cycle

The information analysis system has the following elements:

- modeling and results analysis system
- text and graphic report generator
- complex development analysis system
- geographic information system (GIS)
- 3D visualization center.

It is important that the same IDFM is used by both the operating company and the Field Development Planning (FDP) Centre. The model setup and its history matching should be a joint effort of the FDP Centre and gas operating company experts to bring the experts up to date with current field development problems.

Gazprom dobycha Nadym experts have a range of Schlumberger software products at their disposal. Based on the 3D geological gas production layer models created in Petrel® seismic to simulation software, 3D reservoir simulation models were built in an ECLIPSE® environment and PIPESIM® software was used to model the surface network of the Medvezhye, Yubileynoye, and Yamsoveyskoye fields. The gas production and gathering network system model of Medvezhye field allows gas production rates to be designed per field, depending on the current inlet pressure at the central booster compressor station, the capacity of the compressor stations, or geological and technical constraints of the wells. It also enables optimization of the streams in the interfield gathering main pipeline in the event of gas drying shop shutdowns or compressor station repairs.

The results determined the most effective method for operating the wells, loops, and the entire field. HYSYS® software was used to model the compressor station parameters and gas drying units. Merak® Peep was used for economic analysis and the calculation of project financial and economic KPIs. Integration of these models enabled quick identification and solution of current operational performance problems, including the analysis of interdependencies and impacts between the well operating modes and surface gas network system. Integration results were also used to assess the viability of the long-term strategy.

This step-change in using integrated dynamic geological and technological models for field development management is based on a methodical analysis of the management system (gas field technology, complexity,
separation units, processes), defining management tasks as optimization opportunities within a set of efficient performance criteria common to the whole system. Furthermore, the use of integrated complex physical, technical, technological, and economic-mathematical models of managed objects is key in allowing consolidation of specific management tasks, enabling accurate predictions of possible scenarios, and ensuring optimum management and control.

In 2008, Gazprom dobycha Nadym, LLC conducted a pilot project to create an integrated geological, reservoir, and production system model of the Cenomanian reservoir of the Yamsoveyskoye field.

The entire system—reservoir, wells, surface production gathering network, booster compressor station, central processing facility, interfield gathering line, and economics—was integrated using Avocet® Integrated Asset Modeler (IAM). Within the scope of the project, the reservoir model and gas gathering network were used to develop a gas production model, integrating the producing well and surface gas production network models. The complexity of integrated model implementations, however, is that the measurements processed by gas fields to operate in continuous gas flow rate control mode are not always available in all wells.

The integrated model performed forecast analysis of production indices for the period from February to October 2008. The simulated field model allowed the design of reservoir pressure distribution and water drive into the gas reservoir, near-wellbore gas movement processes, gas-liquid flows in producing wells, gathering system and field gas preparation, and drying and gas compression processes.

Forecast results are shown in Fig. 3 and Fig. 4. Given cumulative gas extraction levels and pressure in the main gas pipeline, the mean average deviation of design data was 0.6 kgf/cm² in the reservoir pressure, 0.3 kgf/cm² in the surface pressure, and 10% in forecast for three months of actual data in gas flow rate in the wells. It was therefore possible to use the integrated model to forecast KPIs for field development.

![Figure 3. Comparison of actual and modeled pressure on the wellheads.](image-url)
Figure 4. Comparison of modeled and actual gas rates on the wells.

The results enabled the modeling of several options for field development up to the year 2020, distinguishing gas production levels (taking into account seasonal irregularity), and demonstrating the model’s effectiveness in forecasting field development indices. The integrated model also set the parameters within which the data can change, as shown in Fig. 5; if the volume of gas production increases, the production life of the gas field decreases.

Figure 5. Modeling of different gas production scenarios.

The main features of the pilot were as follows:

- The project included two integrated model versions: the first using a 3D hydrodynamic reservoir model (for long-term forecasting), the second using a table of reservoir pressure dependence for each well versus produced gas volume.
• Work to improve well productivity was performed in the 3D model to determine optimum modeling reproducibility and results were received in the initial well model (PIPESIM).

• This was the first time that Gazprom dobycha Nadym, LLC developed and used working engineering models of gas treatment processes using the HYSYS software system.

• The integration of the gas production and gathering system (PIPESIM) model with the gas drying plant (HYSYS) ensured correct water volume handling during production and allowed refinement of the gas gathering model.

• Indices calculations of the Yamsoveyskoje field development were developed for the period from February to January 2008. This forecast showed a successful correlation of modeled and actual data.

Teams of various experts used calculated modeling results to define the impact and highlight the interdependencies of the producing reservoir, pipeline networks, and gas preparation and processing facilities systems. Engineers gained insight into potential system bottlenecks, using multiple scenarios to develop optimal problem-solving decisions. Integrated gas field models were clearly shown to empower understanding of the range of available opportunities, providing a common, collaborative platform for multidisciplinary teams to increase field management efficiency and results.

This was the first time that a Russian gas industry created an integrated gas field model as a unified network of gas producing, gathering, and conditioning. Implementation of a similar integrated model is planned for other fields developed by Gazprom dobycha Nadym, LLC. The positive pilot project results will be taken into account when preparing engineering documentation and choosing software to create a geological and reservoir model of the Bovanenkovskoje field.

Computer facilities and software modeling of gas production and gas gathering systems enables the creation of effective control systems for hydrocarbon field development. The integrated modeling system implementation will empower the development of hydrocarbon fields with peak efficiency and minimal environmental risk.