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SMART oilfield GIS: Application of GIS for economic and environmental monitoring of oil and gas fields

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Abstract

TNO-NITG has recently developed an extensive exploration and production (E&P) database system, thereby providing a practical and very cost-efficient alternative to the systems existing on the market. Two different approaches were taken: one using licensed software with built-in components, and another using open source software. In this article the merits of both approaches are discussed.

Introduction

With ever growing possibilities in data gathering, processing speed and storage capacity, the amount of information that can be derived from oil or gas field data has grown enormously over the past decades. A few vendors developed software systems capable handling these complex data streams and their relationships. However, due to the complexity of matters to deal with, they are expensive with respect to the costs of their license and maintenance. At the same time these systems suffer from the 80-20 syndrome: only 20% of the functionality is used while the remaining 80% contributes to the total product costs. This jeopardizes the effectiveness of the users' software investments.

TNO-NITG, being the National Geological Survey of the Netherlands, has developed an E&P database and GIS application that can compete with this off-the-shelf software in functionality and speed. At the same time TNO-NITG žs system is cost-effective with respect to development costs, maintenance and customisation. It is a flexible, scalable solution for managing a wide range of information on exploration and production activities of a company, as well as environmental monitoring data. Two national oil companies have already been using this new E&P database system.

System Design

The distinguishable features of the systems are the open source and modular structure. Thanks to these, the system is highly customisable to meet the requirements of a particular client and it is easy for the customer to maintain the software.

The E&P system includes three main modules:

- E&P Data Manager (the core database management module)
- E&P Reporter (intelligent tool for data mining and flexible reporting)
- E&P Spatial Modeller (E&P GIS)

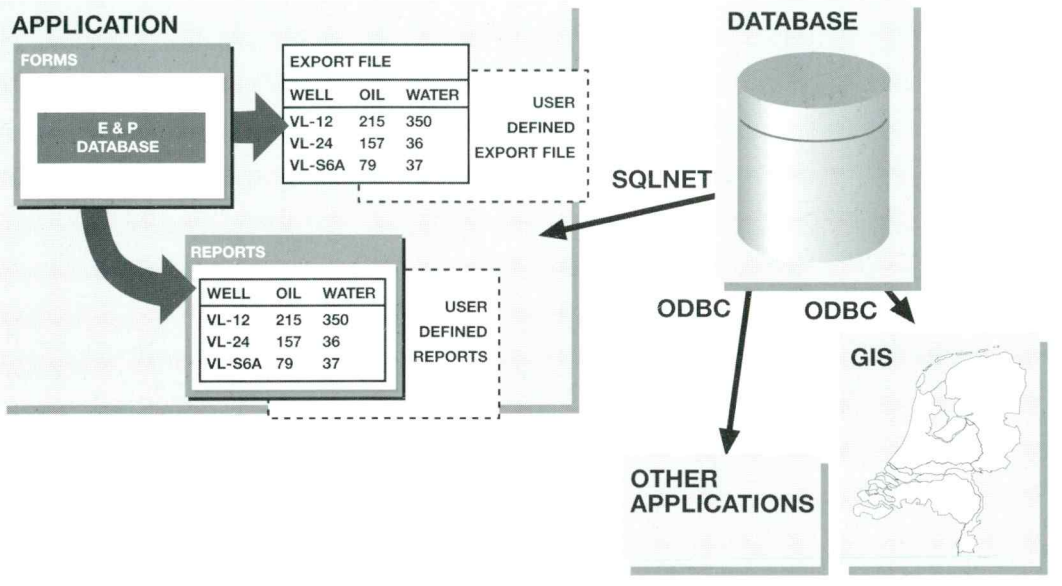

Figure 1. E&P Data Manager

E&P Data Manager

The E&P Data Manager (Figure 1) module includes:

- E&P DATABASE management system with POSC-compliant database model
- E&P FORMS for data input and analysis
- E&P REPORTS for creating standard reports of company activities

The most important component of the E&P Database management system is the TNO-NITG's E&P data model, which comprises all aspects of the E&P enterprise. The TNO-NITG model is based on a subset of the Petrotechnical Open Software Corporation's (POSC) Epicentre data model, which allows users to store and extract all forms of data and metadata related to E&P: seismic, petrophysical, geological, reservoir engineering, well, borehole, facility, pipeline, rock and fluid sample, and field data.

An added benefit is that the database can be easily integrated with other software. Users can thus get hold of any relevant E&P data when performing supplementary analyses or drafting reports on particular topics. The types of data that might be of interest for such purposes are statistics or facts and figures about hydrocarbon production and contouring.

The system also incorporates an authorisation function with respect to users. They are assigned specific roles for specific groups of data. This distributes the responsibility for the import and quality control of the groups of data among various users. The E&P database manager is responsible for the referential and application data, and therefore also for the user roles

E&P Reporter

TNO-NITG has extended the E&P database's functionality by incorporating Oracle Discoverer into the system. Being an intelligent tool for data mining and flexible reporting, the new E&P module is of particular interest to geo-scientists and production engineers involved in the analysis of oil and gas field performance (Figures 2, 3,4).

The module gives the E&P database a number of additional advantages relative to other oilfield management systems. For example, a new report can be created via dialogues similar to those in Windows Explorer. This makes it quite simple for an oil specialist to create a new report tailored to personal requirements and spares the user from having to learn the complex relational data-

WELL STRATIGRAPHY

Page Items: Area name: TA-58 ▾ Wellname: 3S24 ▾

	Top Depth	Bottom Depth	Thickness	Stratunit nm	Age	Stratunit Par nm
11				Seal		Average water saturation
12				Seal		Average Porosity
13	1178	1208	30	T2-Sand	Paleocene	Average Porosity
14				T2-Sand		Average water saturation
15		1247	69	T-Sand	Paleocene	ResistivityFeet
16				T-Sand		Porosity feet
17				T-Sand		Net feet
18			69	T-Sand	Paleocene	HC feet
19				T-Sand		Estimated bopd
20				T-Sand		Average water saturation
21				T-Sand		Average Porosity
22	1219	1247	28	T1-Sand	Paleocene	Average Porosity
23				T1-Sand		Average water saturation

Figure 2. Analysis of well geology

TOTAL THICKNESS OF STRATIGRAGHIC UNITS PER WELL

Page Items: Area name: TA-58 ▾ Wellname: 3S131 ▾

	Stratunit nm	Layer thickness
1	Seal	54
2	T-Sand	39
3	T1-Sand	9
4	T2-Sand	9

Figure 3. Netto sand thickness calculations per well

Monthly Oil Production per Field

Page Items: Abbr of the area: BS ▾

	Date	Wellname	Oil Production
90	**Sep-1992**	SS062	659
91		Z20	959
92		Z25	1,092
93		Z151	512
94		Z181	928
95		Z19	309
96			**Sum: 4,459**
97	**Oct-1992**	SS062	701
98		Z19	346
99		Z181	959
100		Z151	530
101		Z25	1,153
102		Z20	855
103			**Sum: 4,544**

Figure 4. Monthly Field Production Report

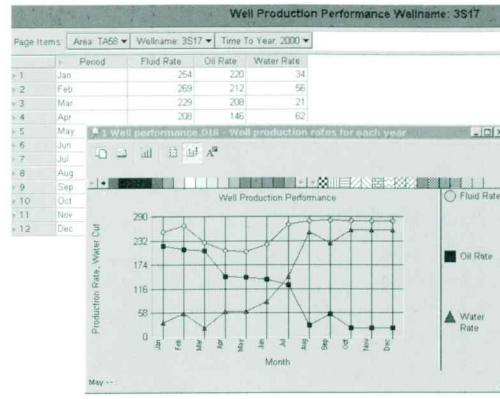

Figure 5. Well productivity analysis by means of E&P Reporter

base structure. Once a report has been produced it can be shared with other colleagues.

As Discoverer reports have an Excel-like interface, their contents and layout can be easily customised by users, including field geologists and production engineers. The extremely flexible report construction tools allow for in-depth data mining that employs the end-user's professional expertise. Moreover, the use of dynamically updated graphics significantly simplifies the analysis of production and geological data. All in all, the module has proved itself to be an effective tool for data quality control. Finally, the module can export the E&P data to a large number of external formats (incl. ASCII, Excel and HTML) enabling more sophisticated oilfield analysis using advanced computer simulators (Figure 5 & 6).

E&P Spatial Modeller (Oilfield GIS)

The GIS module stores information about oil and gas fields as a collection of thematic layers that can be linked together by geography. It is able to visualise the geo-referenced data stored in the E&P database and automatically update the information each time while opening a new session. Moreover the module enables selecting geographically (interactively on the screen) and updating the environmental and field operation data whenever it is necessary (Figure 7).

The module allows mapping both technical and environmental data as well as studying relationships between contamination and

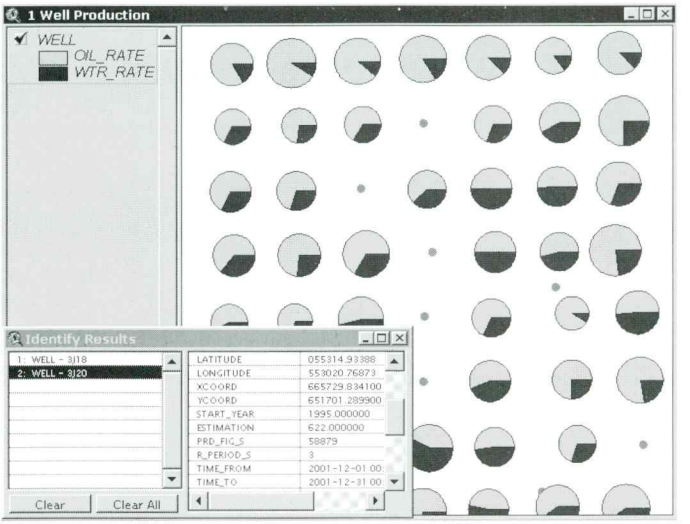

Figure 6. Well map showing oil/water production rates. *The radius of the circles is proportional to the fluid production rate for each well. The exact data on a particular well can be obtained by clicking at it with a mouse.*

facilities (Figures 8-9). Furthermore, multispectral satellite and airborne images integrated into the GIS module can provide a company with independent information on environmental changes in the production area (Figure 10). The integrated Web-technologies make the Oilfield GIS a perfect tool both for environmental self-audit within the company as well as for reporting on the environmental performance to the government or public.

Prospect development towards SMART E&P

The approach discussed above is based on extensive use of conventional, licensed software components. However, not every E&P company has the same set of requirements with respect to the complexity of the analysis wanted, the software development budget and the like. With the growing amount

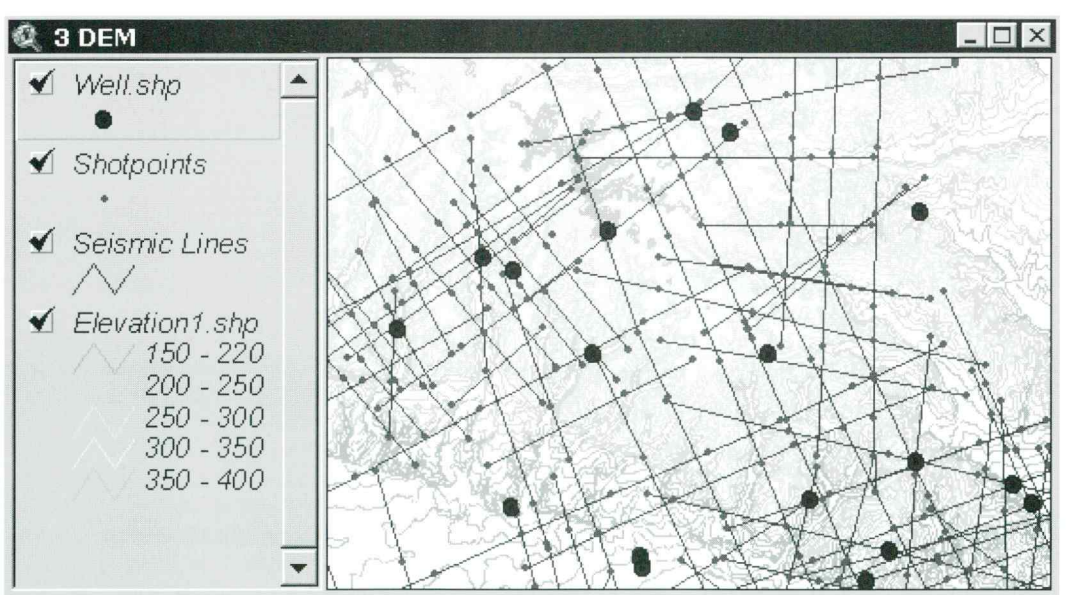

Figure 7. Well map combined with a few survey maps as well as digital elevation model (DEM)

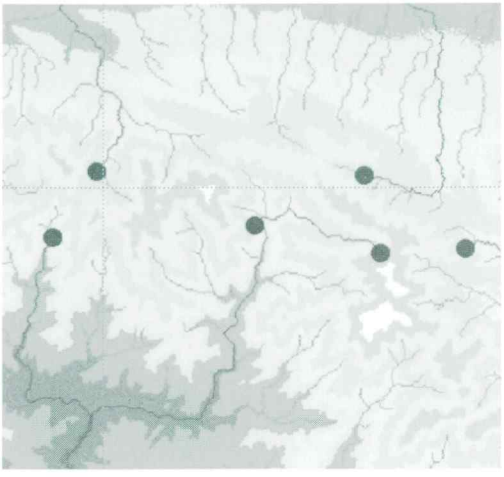

Figure 8. Defining surface water streams that can be potentially effected by oil spill from the wells

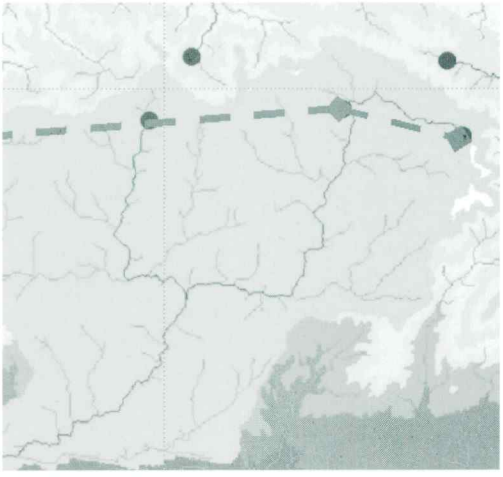

Figure 9. GIS modelling of potential environmental risks from pipelines

of open source software projects, other software customisation and implementation approaches came within reach. The TNO-NITG solution comprises a template CORE E&P database whose generic data model is applicable throughout the oil and gas industry and easy to customise (Figure 11 & 12).

SMART E&P is a trajectory that involves local people in customisation, maintenance, and upgrading of the CORE E&P database system. In this approach the software is to be developed in mixed teams of TNO-NITG consultants and trainees using open source software for the database, the GIS and the application server. When desired, the use of licensed software like Oracle and ESRI is also possible.

In the course of time, TNO-NITG's involvement decreases to zero, while the level and involvement of the local trainees increases. In this way, former trainees can do the maintenance, future customisation and training completely on their own. As the result, both the responsibility for data and the

Enhancement scenarios on TNO-NITG's CORE E&P database

	Open source software
Development by TNO, including training	**SMART E&P**
Development exclusively by TNO	**CUSTOM E&P**

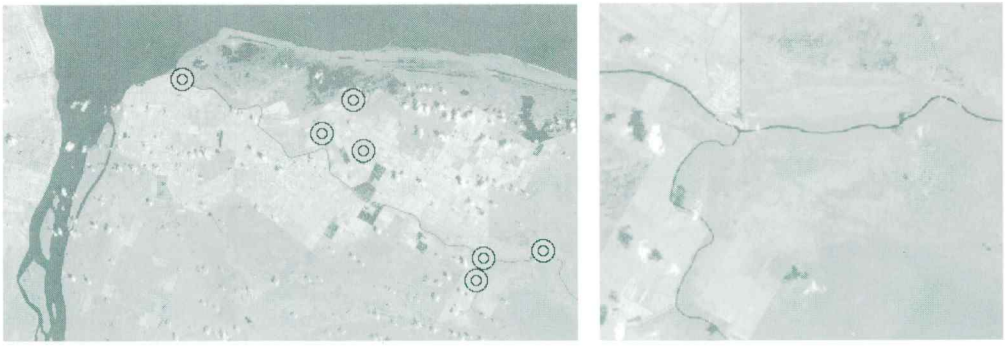

Figure 10. Environmental management by means of GIS and remote sensing

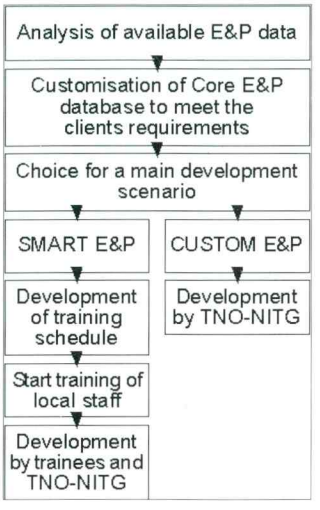

Figure 11. Workflow diagram

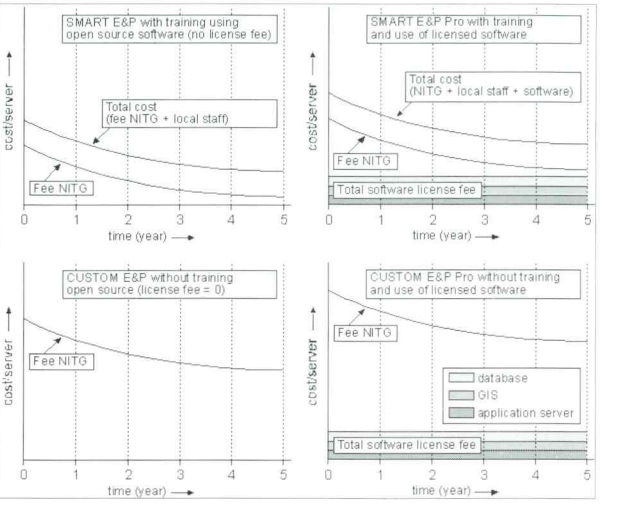

Figure 12. Cost trend for the four enhancement scenarios on TNO-NITG's CORE E&P database. *Note that the costs of the customisation of the CORE E&P database are not included.*

means to transform this data into crucial information are in the hands of their owner – the client.

The proposed scenarios are listed in Table 1, while a schematic project workflow is illustrated in shows cost trends for development and maintenance for the different scenarios.

Conclusion

The modular structure of the E&P database allows a customer to select only necessary elements of the application and customise them according to his particular needs. This significantly enhances the efficiency of the investments into the software. Moreover all modules of the standard E&P System are based on conventional software components, such as Oracle Server, Oracle Discoverer and ARC GIS (ESRI). Thus the licenses existing in a company can be used.

Alternatively a Smart solution can provide similar functionality using open source software components. This cuts license costs, however can increase expenditures for development and implementation. This disadvantage can be compensated by involvement of less costly, though not less professional personnel on a client site. The local personnel granted the E&P application source would be capable to further maintain and extend the core application.