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Competing in the New Era of Knowledge-based Petroleum Companies

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As an exploration & production (E&P) information technology supplier, Landmark tracks industry trends to make sure we're developing the kinds of software, systems, and services that our customers need to compete more effectively. This white paper captures my personal vision of what it will take for oil companies to succeed in the coming years. This vision guides our own company's strategic planning.

I believe the industry is entering a new era of growth in which better decision-making, business advantages, and exponential gains in productivity will depend on a company's ability to integrate the collective knowledge of the entire organization. Leveraging knowledge, therefore, will be the new core competency. Successful companies will do so through significant social change, assisted by a wide range of integrated E&P information technologies.

As technology development and adoption cycles continue to shrink, executives will have less and less time to contemplate change. The ones that embrace technology early will reap the greatest rewards. They will, in effect, pluck the "low-hanging fruit"— much of it by the end of this century. Laggards may not survive the first decade of the next century.

Entering A New Era

Since 1981, when oil prices began to drop from a peak at $34/barrel, the industry has passed through an era focused primarily on re-engineering for cost savings. Companies have examined their business processes to increase efficiency. But most of the cost savings have come through consolidation and reducing headcount — "cutting the organizational fat." Industry employment peaked in the U.S. at about 700,000 in 1982, and has dropped continuously for 13 years, returning to pre-1980 levels. Oil prices have leveled off below $20/barrel. And there is widespread consensus today that, barring any disruption in supply, prices will likely remain flat into the next century.

In addition, the technical challenge of finding and producing remaining reserves of oil and gas grows more complex every year. The size of new discoveries continues to decline, with larger reservoirs found in deeper waters and more hostile frontiers that cost more to produce.

On the other hand, recent studies suggest that global demand for oil and gas may increase dramatically over the next few years. Economic improvement and population growth, especially in developing countries and the former Soviet Union, are fueling much of this demand. According to a U.S. Department of Energy report (June 1995): "Oil demand is rapidly expanding and projected to grow by 30 percent by 2010." That means the industry will have to increase oil production by an amount roughly equal to the current output of the United States, North Sea and Saudi Arabia combined. The need for natural gas may be even greater. Where are these additional reserves going to come from?

Obviously, for some companies, market conditions hold significant potential for growth. The challenge now is not just to cut costs, but to increase revenue. I believe the industry is quickly moving from an era of cost reduction to a new era of re-tooling for growth. To make money in this new era — with flat prices, lower headcounts, greater technical barriers, and growing demand — many E&P organizations have concluded that they must become far more productive. They are looking for ways to leverage their knowledge assets more successfully than competitors — to work smarter, not just harder. How will they accomplish this?

David Simon, Group Chief Executive of British Petroleum, recently stated: "The oil and gas industry is now being driven by technology" (New York Times, June 1995). Petroleum companies have long employed technology, but in the 1970s they were driven primarily by higher price expectations, and in the 1980s and early 1990s by lower costs. Today, success depends on harnessing new technology to reduce cycle time and increase productivity.

Some technologies increase productivity incrementally, others through sudden leaps. But accumulated small gains can add up, over time, to dramatic changes. A decade ago, it took perhaps 30 to 45 days to drill a 10,000 foot well in the western United States. Now, that well can be drilled in about five days. Why? A hundred small technical improvements: Better drill bits, mud programs, crew organization. But each gain has been incremental, shaving off a few days every year.

Other kinds of new technology initiate dramatic leaps in productivity and efficiency. In our industry, there have been two major leaps due to technology since the early years of the E&P Information Age. And a third is just beginning (Figure 1).

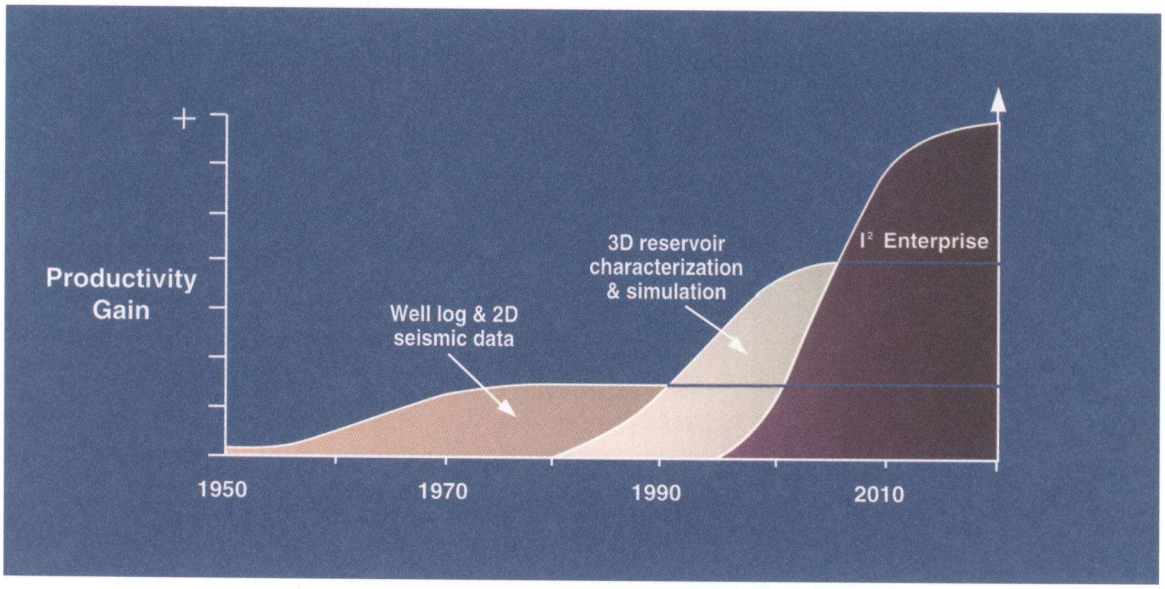

Figure 1. Three Productivity Leaps of the E&P Information Age.

The First Leap

In terms of finding and managing petroleum reservoirs, the first significant impact on productivity probably came in the late 1950s and 1960s with the widespread use of well logs and 2-D seismic data. Together, these technologies greatly improved structural interpretation of the subsurface — one through direct measurement, the other through indirect imaging. They were as important to E&P professionals as exploratory surgery and X-rays were to physicians.

Productivity improvements from this first leap peaked during the 1970s, with only incremental gains since that time. Logging tools and 2-D seismic processing have been refined, but the basic science has changed very little. As the first leap leveled off, the second began.

The Second Leap

With the introduction of 3-D seismic technology in the early 1980s, the industry took an even greater leap in productivity. From the beginning, 3-D seismic was enabled by computers. Acquisition required computing technology in the field just to record the digital data; processing required powerful systems in the computing center; and interpretation and visualization of large data volumes required a new breed of interactive workstations in the office. To date, the primary use of 3-D seismic has been focused on better structural interpretation of faults and horizons.

Companies that pioneered this technology since the 1980s have experienced tremendous productivity benefits, and now recognize 3-D seismic as a key ingredient to success. Companies just discovering 3-D seismic today are already late adopters of the technology, even among the independents. In terms of 3-D structural interpretation, I suspect that gains will be mostly incremental from here on. But that doesn't mean the second leap is complete.

Over the next five years or so, I believe the industry will see additional dramatic productivity improvements building on 3-D seismic technology. But the focus is shifting from pure structural interpretation to 3-D — and even 4-D — reservoir characterization and simulation. Integration is the key to this shift. That is, in addition to defining the structural "container," E&P professionals are integrating 3-D seismic with all available data — geologic, geophysical, and engineering — to better model both rock and fluid properties of whole stratigraphic intervals.

Integration of data not only allows oil companies to characterize static properties of the reservoir today, but also to simulate dynamic flow through the reservoir over time. The fourth dimension, therefore, is time. Already, some companies are acquiring so-called "4-D seismic"— multiple 3-D surveys shot over a field at different times — to monitor and improve recovery efficiency. By the year 2000, as these techniques become widespread, productivity increases associated with the second leap will probably taper off.

Speed of Change

An important observation, especially for executives and senior managers, is that the rate of change due to new technology is rapidly accelerating.

The first leap (well logs and 2-D seismic) took more than 20 years to peak; the first stage of the second leap (3-D structural interpretation) took perhaps 15 years; and the second stage (integrated reservoir characterization and simulation) could take less than 10 years.

The speed of technology adoption in our industry reflects a larger phenomenon, described in a recent study by CSC Executive Roundtable. In general, during the 1940s and 1950s new technologies used in various processes (from industrial manufacturing to building a house) took between 10 and 20 years to develop; and the processes affected by those technologies changed over a period of 15 to 20 years. Both individuals and organizations became accustomed to working in certain ways for long periods of time. By the 1980s, however, technology development cycles took only three to five years; and processes changed in less than eight years. Currently, technology life cycles last one to two years. Processes, which are far more complex now, change almost continuously.

This trend suggests two things to me. First, decision makers cannot afford the long technology assimilation cycles of the past. Competitors may overtake them, or they may simply become unprofitable. Second, to manage change more effectively in the future, petroleum companies will have to collaborate more tightly with technology developers. Only then will they guarantee that rapid advancements in E&P information technology will fit the needs of continuously changing business and scientific processes.

The Third Leap: The I² Enterprise™

I believe a third major technology leap has only just begun. A few of the most visionary companies, the early technology adopters, are already looking beyond integrated reservoir characterization and simulation to the next long-term business advantage. This third leap extends integration from a single process to an entire E&P enterprise. I call such companies "I² Enterprises," because they multiply "Informationalization" by "Integration" to increase enterprise-wide productivity — exponentially, not just incrementally.

The Two "I's"

For years now, the petroleum industry has been "informationalizing" many aspects of the business, investing literally hundreds of millions of dollars in computing technology. Many executives, however, haven't seen the productivity gains they had expected. One reason is that most organizations have only applied information technology to specific tasks, rather than whole processes. Instead of significantly changing the way they work, they have simply automated old methods. Informationalization, therefore, is necessary but not sufficient to achieve dramatic improvements in productivity. Integration, on the other hand, requires whole new ways of working.

"Integration" simply means concurrently combining raw data and information from all parts of an organization, and connecting different peoples' perspectives, expertise and ideas to make better business decisions in less time. Three of the most important information technologies that enable integration are: desktop systems powerful enough to handle complex technical analysis; client/server computing for access to shared resources; and distributed databases. These enabling technologies no longer come from niche players, as they did a few years ago. Now they are developed by large horizontal market suppliers such as Silicon Graphics, Sun, IBM, Oracle and many others. As a result, price/performance ratios of computing technology are constantly improving.

Every phase in the typical life cycle of an oil field (Figure 2) requires various E&P professionals to integrate field operations (data acquisition, drilling, enhanced recovery) with "knowledge work" (data processing, analysis, interpretation). Quality and productivity improve in each phase where people collaborate and have easy access to all the information they need. Ultimately, integration across all phases of the life cycle will yield even greater gains than integration within any particular phase.

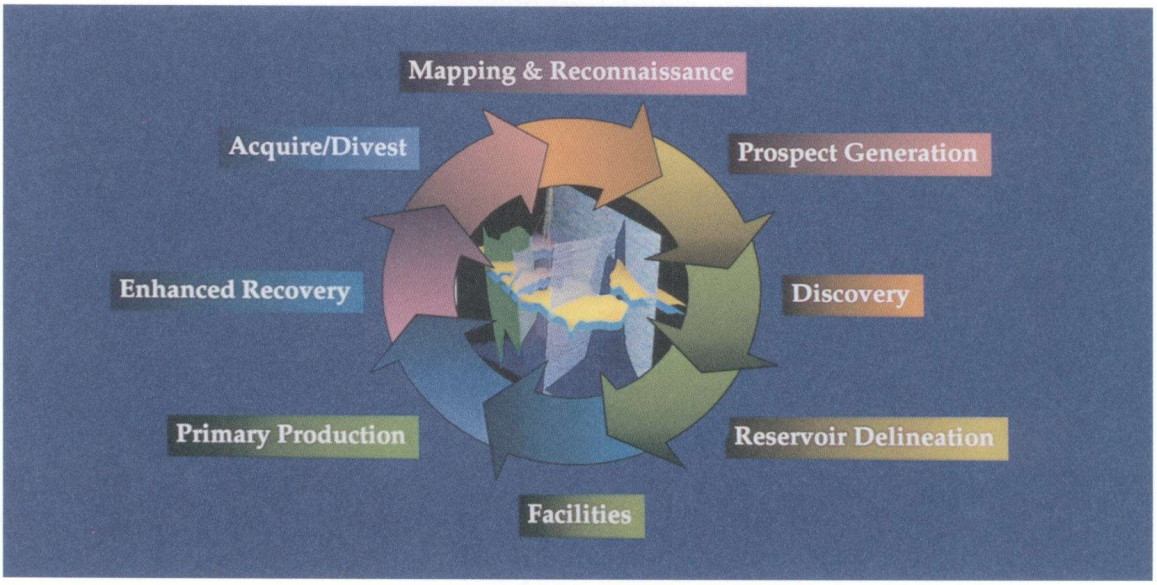

Figure 2. Eight Phases of a Typical Oil Field Life Cycle.

Cutting "Decision Fat"™

Given all the changes in the industry, how much room actually remains for improvement in this new era? Oil companies have cut virtually all of the "organizational fat" from their technical staffs and operating budgets. Where else can they lose weight? I think most of the remaining fat can be found in inefficient decision-making processes. Many technical and operational decisions are flawed not because people lack intelligence, but because they lack information. The goal of the I^2 Enterprise is to eliminate this "decision fat" by leveraging the company's collective knowledge more effectively.

I've been asking senior executives in the industry what percentage of the total E&P expenditures they feel is wasted through poor decision-making every year. In other words, how much "decision fat" remains? Their intuitive estimates range from 15 to 50 percent, with an average of 25 to 30 percent. According to a recent study by Salomon Brothers (July 3, 1995), publicly-traded companies worldwide will spend nearly $60 billion for exploration and production this year. If the executives I spoke with are correct, $15 to $20 billion may be wasted. If enterprise-wide integration could eliminate even a fraction of that amount, the payoff would be tremendous.

The Hierarchy of Integration

I believe oil and gas companies have a hierarchy of integration needs, much like the hierarchy of human needs postulated several decades ago by Abraham Maslow, the social scientist. Maslow noted that people can move up the hierarchy only when their more basic needs are met. For example, unless a person's survival needs — air, water, food, shelter—have been met, he or she cannot even consider "self-actualization," which Maslow identified as the pinnacle of human need. In our industry, I've observed four distinct levels of integration needs (Figure 3): (1) data integration, (2) integration of workflows within teams or operating groups, (3) integration of processes across different operational groups, and (4) company-wide resource allocation. A true I^2 Enterprise would address all four levels of integration with the aid of advanced E&P information technologies.

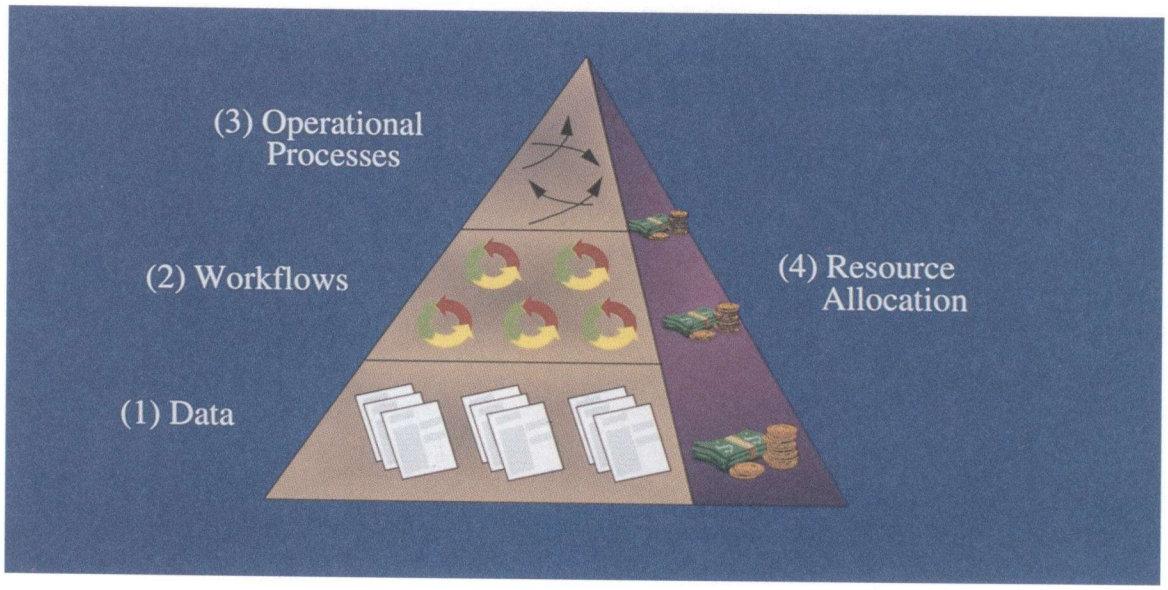

Figure 3. Four Levels of the Hierarchy of Integration.

Level One: Data

The most basic need industry professionals have today is "mechanical" integration of all the data within their organizations, in digital forms that facilitate more efficient work at every phase of the oil field life cycle. The ultimate goal is to provide "just-in-time" information to all knowledge workers. Millions of dollars have been spent to develop standard E&P data models and some basic integration technology. While considerable progress has been made, the industry has not fully attained level one integration.

The problem is enormous. Companies store huge amounts of "legacy" data in numerous incompatible forms (from paper to digital) and electronic formats. What's more, the quantity of new data being acquired is growing rapidly. It has been estimated, for example, that the total amount of well log and seismic data acquired during the 1980s averaged less than 100 terabytes per year. During the 1990s, that number has jumped to an average of 500 terabytes per year. By the end of the decade, it could be nearly 1,000 terabytes per year. The industry is experiencing a data explosion.

In addition to raw physical data — well logs, seismic surveys, pressure tests, production rates — companies would also like to capture, and integrate, accumulated knowledge about a reservoir over its life span. That knowledge, however, is stored in the minds of the geoscientists and engineers who convert raw data into a better understanding of the reservoir. Unfortunately, the people who start the process usually do not carry it through the life cycle, since that cycle often spans decades. Along the way, increasing amounts of knowledge are lost as people change jobs or leave the company. To capture that knowledge will require more than a "data management" system; it will require new types of "knowledge management" technology as well.

Lack of basic data integration costs the average E&P professional a considerable amount of time. According to various estimates, geoscientists and engineers spend from 20 to 30 percent of their total project time searching for, loading, and formatting data. Obviously, significant productivity gains are still locked up in organizations that do not have level one integration.

How long is it likely to take before the industry achieves "just-in-time" data? Currently, I estimate (and this may be optimistic) that about 20 percent of oil companies have some type of level one integration. By the year 2000, however, 75 percent of the industry may have achieved this level (Figure 4). That means most companies can expect tremendous productivity gains over the next five years.

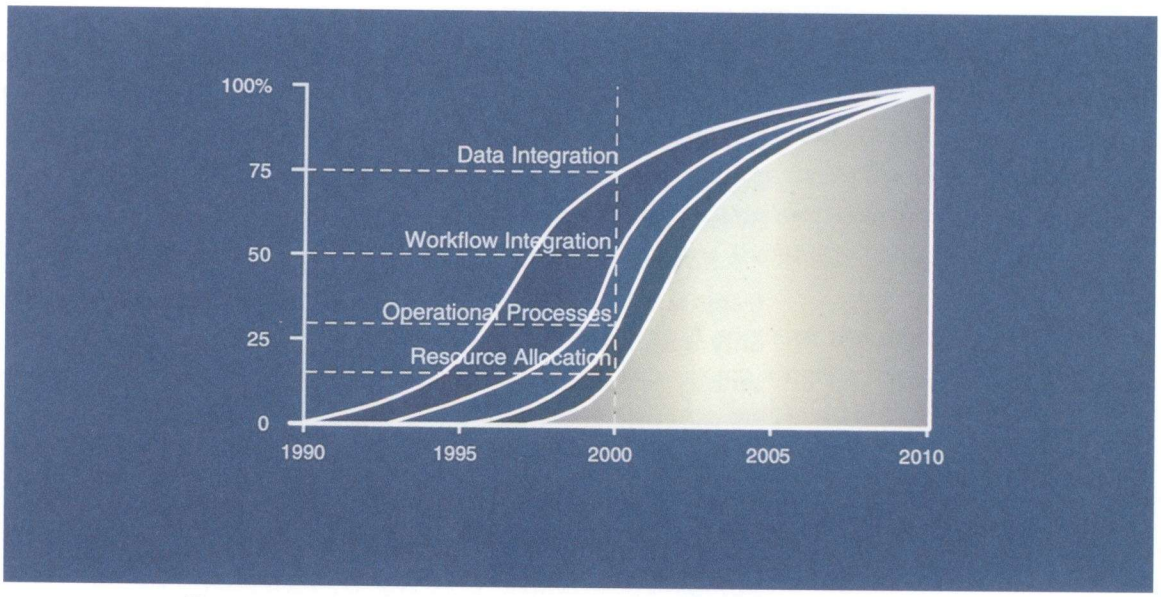

Figure 4. Diffusion Curves of the Four Integration Levels.

Level Two: Workflows

As E&P organizations begin to achieve data integration, then they can move up the hierarchy. Today, many are reorganizing work processes around multidisciplinary teams within their operating divisions. Most teams focus on one or two phases of the oil field life cycle, such as prospect generation or reservoir development. Then they hand off to another team. But a few companies are starting to view the life cycle of assets as a whole.

Turning a collection of individuals into a high impact team requires certain enablers — some social, some technical. Socially, they must be launched with a holistic view of the business objectives, as well as clearly defined roles. An interdisciplinary team may be chartered, say, to increase reserves 40 percent, or reduce cycle time by 25 percent. Each team member's role and priorities, then, would be determined within the context of such objectives.

To integrate their workflows, high impact teams also require four technical enablers. First, they need access to data "just-in-time," which can be defined as "right when they need it." Waiting for data interrupts the workflow and consumes valuable time. Second, they need integrated software applications that share data easily and build bridges across the gaps between disciplines. Geostatistical software used in modeling complex reservoir properties would be an example of an integrating application. Third, teams must have a highly interactive computing environment, so that every time they change a variable, the effect can be seen immediately. Finally, they need 3-D modeling and visualization technologies to display the team's collective results. Each team member may think about the reservoir differently, but modern visualization tools enable them to integrate all the information in a common 3-D (or 4-D) model.

When professionals work concurrently rather than sequentially to solve problems, they often collapse cycle times and boost productivity dramatically. The U.S. Air Force, for example, found that concurrent workflows reduced engineering cycle times by as much as 40 percent. One of Landmark's

customers — a multidisciplinary team with a major oil company — cut its interpretation cycle time on one project about 65 percent using integrated geoscience applications and a shared database. More importantly, however, interactive testing of multiple reservoir scenarios improved the quality and accuracy of their final interpretation. As a result, the team increased reserves by several million barrels, and extended the field's productive life by 20 years.

So how long will it take for oil companies to reorganize around high impact teams and integrated workflows? Despite advancements in technology, probably only half of the industry will achieve level two integration by the end of the century (see Figure 4), largely because of social and cultural barriers to change.

Level Three: Operational Groups

Once a petroleum company has integrated team workflows within operating groups, the next level would be integrating operational processes across groups. For example, reservoir characterization teams need to work closely with drilling groups and facilities planning to reduce long field development cycles. But each of these groups operates quite differently. Unless they can share common information quickly and easily, the company could make extremely costly errors, such as over-engineering production facilities for a new offshore field. Because expenditures tend to be much higher at this operational level than at the team level, gains in productivity could have enormous economic impact.

One of the challenges of integration at the operational process level is that, in so-called "virtual corporations" not all of the "groups" are in-house. And in the future, even more work may be outsourced to service companies, consultants and vendors. Seamlessly integrated information systems across organizational boundaries will be vital to success. That means companies will have to find innovative ways of breaking down communication barriers while maintaining the security of proprietary information.

Considering the challenges involved, I suspect that only 30 percent of the industry will successfully integrate across groups by the year 2000 (see Figure 4).

Level Four: Resource Allocation

Throughout the life cycle of a typical oil field, managers at all levels make business decisions that can set millions of dollars into motion. Decision-makers need interactive access to the collective wisdom of an organization, so they can understand how to allocate limited resources more wisely. For example, if they have 50 good prospects, but only enough budget to drill 20 wells, what is the best way to optimize the selection process? Effective resource allocation requires integration of information from all across the company: Reservoir size and risk, cost of production facilities, location of pipelines, regulatory restrictions, market status, and so on. For this reason, level four integration cannot be achieved until the first three levels are essentially complete.

Some companies and universities have begun experimenting with different approaches to resource allocation, replacing ad hoc decisions with statistical approaches similar to those used in investment portfolio management.

By applying such an approach, one major oil company increased the net present value of its investment portfolio by $20 million and cut capital expenditures by $20 million, for a net benefit of $40 million. In most cases, however, these new approaches are hampered by lack of enterprise-wide information technologies needed to support significantly better decision-making. Eventually, managers and executives will have software tools designed specifically for resource allocation, giving them the ability to locate, integrate and visualize an enormous variety of data.

This level of integration may yield some of the greatest productivity benefits of all, but it will probably take much longer to realize them. Not only must level four build on the previous three, but it will also require considerable changes in management style and philosophy. By the year 2000, probably fewer than 20 percent of the companies in our industry will achieve fully integrated resource allocation (see Figure 4). Clearly, this technology will be in the very early adoption stage during the next five years.

Conclusion

Once an oil company has completely informationalized and accomplished all four levels of integration, it will be an I^2 Enterprise. It is doubtful that any true I^2 Enterprises exist today, but some are well on their way. Which companies will get there first? The ones that are focusing now on the second stage of the second great productivity leap: Integrated 3-D reservoir characterization and simulation. Of course, companies differ widely in size and style. So not all I^2 Enterprises will look exactly the same. But they will share a common goal: Eliminating "decision fat" from their organizations.

Using knowledge to compete will be the new core competency. I^2 Enterprises will deliver data "just in time," form high impact teams, improve intergroup cooperation, and optimize resources. In the process, they will make much better decisions faster, and achieve exponential gains in productivity.

The Author

Robert P. Peebler has been president and chief executive officer of Landmark Graphics Corporation since 1992. Previously, he held executive positions including chief operating officer, president of Landmark's seismic products division, and vice president of marketing. Before joining Landmark in 1989, Mr. Peebler was president of his own marketing/management consulting firm. He was also employed in the oil field services business for 18 years. Mr. Peebler graduated from the University of Kansas with a degree in electrical engineering.

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