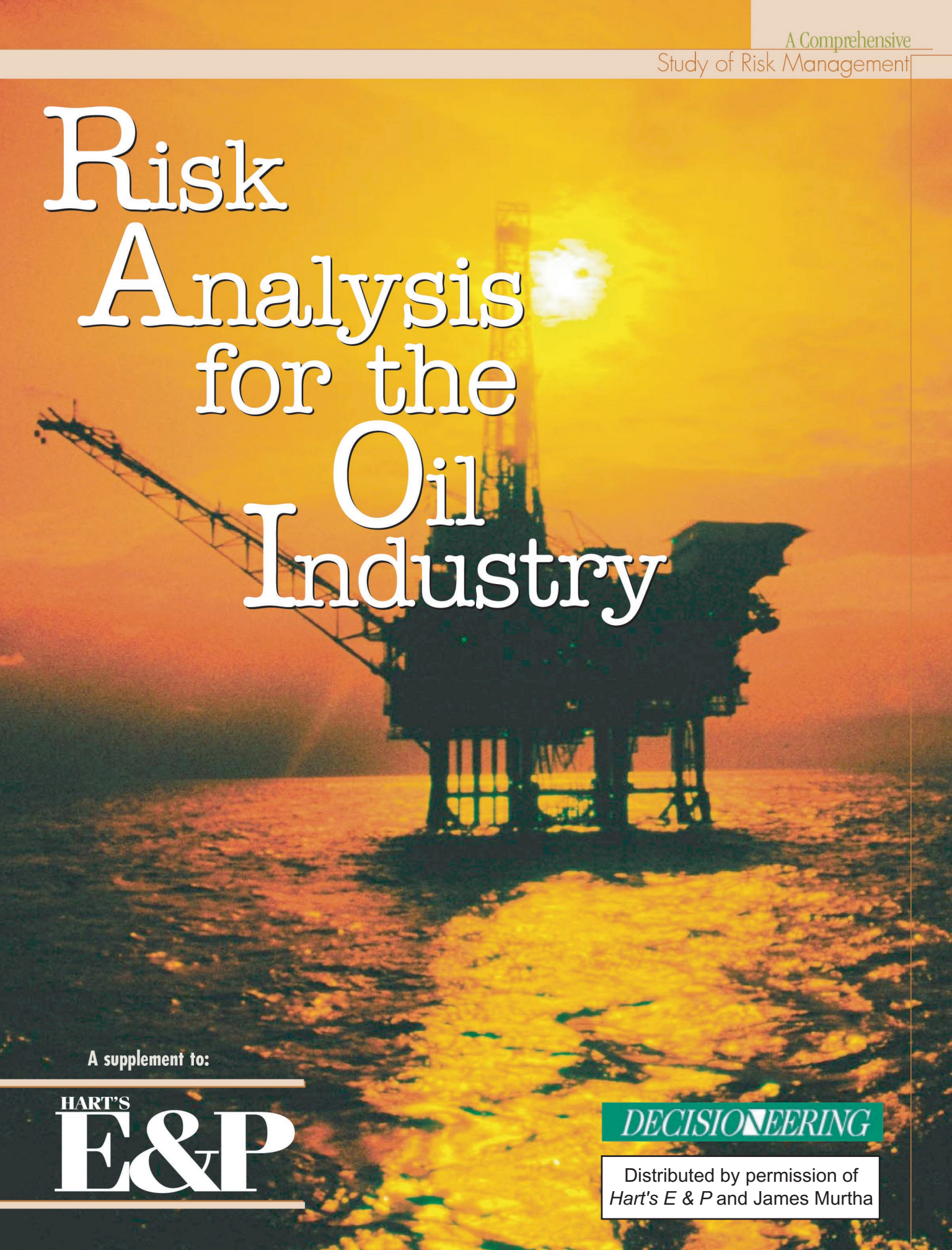
A Comprehensive
Study of Risk Management

Risk Analysis for the Oil Industry

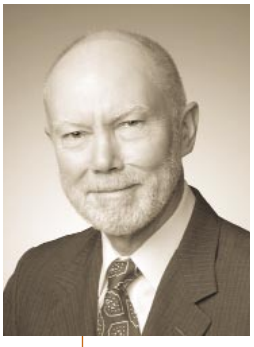


A supplement to:

HART'S E&P

DECISIONEERING

Biography



Jim Murtha, a registered petroleum engineer, presents seminars and training courses and advises clients in building probabilistic models in risk analysis and decision making. He was elected to Distinguished Membership in SPE in 1999, received the 1998 SPE Award in Economics and Evaluation, and was 1996-97 SPE Distinguished Lecturer in Risk and Decision Analysis. Since 1992, more than 2,500 professionals have taken his classes. He has published Decisions Involving Uncertainty - An @RISK Tutorial for the Petroleum Industry. In 25 years of academic experience, he chaired a math department, taught petroleum engineering, served as academic dean, and co-authored two texts in mathematics and statistics. Jim has a Ph.D. in mathematics from the University of Wisconsin, an MS in petroleum and natural gas engineering from Penn State and a BS in mathematics from Marietta College. ◆

Acknowledgements

When I was a struggling assistant professor of mathematics, I yearned for more ideas, for we were expected to write technical papers and suggest wonderful projects to graduate students. Now I have no students and no one is counting my publications. But, the ideas have been coming. Indeed, I find myself, like anyone who teaches classes to professionals, constantly stumbling on notions worth exploring.

The articles herein were generated during a few years and written mostly in about 6 months. A couple of related papers found their way into SPE meetings this year.

I thank the hundreds of people who listened and challenged and suggested during classes.

I owe a lot to Susan Peterson, John Trahan and Red White, friends with whom I argue and bounce ideas around from time to time.

Most of all, these articles benefited by the careful reading of one person, Wilton Adams, who has often assisted Susan and me in risk analysis classes. During the past year, he has been especially helpful in reviewing every word of the papers I wrote for SPE and for this publication. Among his talents are a well tuned ear and high standards for clarity. I wish to thank him for his generosity.

He also plays a mean keyboard, sings a good song and is a collaborator in a certain periodic culinary activity.

You should be so lucky. ◆

Table of Contents

A Guide To – Risk Analysis

Risk and decision analysis was born in the middle of the 20th century, about 50 years after some of the necessary statistics became formalized. Pearson defined standard deviation and skewness in the late 1890s, and Galton introduced percentiles in 1885.

The term Monte Carlo, as applied to uncertainty analysis, was mentioned by *Metropolis and Ulam: the Journal of the American Statistical Association* in 1940. D.B. Hertz published his classic *Harvard Business Review* article in 1964. A couple of years later, Paul Newendorp began teaching classes on petroleum exploration economics and risk analysis, out of which evolved the first edition of his text in 1975, the same year as A.W. McCray and 2 years before R.E. Megill wrote their books on the subject. Ten years later, there was commercial software available to do Monte Carlo simulation.

During this 50-year period, decision analysis, featuring decision trees, also came of age. Raiffa's classic book appeared in 1968. By 1985, there were several commercial applications of software on the market.

These developments, in many ways, paralleled the development of petroleum engineering, with the basics appearing in the 1930s, mature texts like Craft and Hawkins appearing in the late 1950s, and reservoir simulation and other computer based methods emerging in the 1970s and 1980s. Similarly, reservoir characterization and geostatistics came along in the second half of the 20th century.

Oddly, the oil and gas industry remained skeptical about risk analysis throughout most of this development period, usually limiting their acceptance to isolated departments within organizations. Managers were notoriously unwilling to embrace results that presented probability distributions for reserves and net present value (NPV). Consultants offering services and software vendors know too well these levels of resistance.

Now, finally, there seems to be broader acceptance of probabilistic methods, although as I write, my SPE Technical Interest Group digest contains strong negativism from traditionalists about probabilistic prices. Nonetheless, consider these items:

- the three most recent and five out of the last seven recipients of the SPE Economics and Evaluation award have been strong proponents of risk analysis;
- whereas the index to the last edition of the *Petroleum Engineers' Handbook* only had two references to "risk," the forthcoming edition will feature an entire chapter on the topic;
- my first paper on Monte Carlo simulation was presented at the Eastern Regional Meeting in 1987 and summarily rejected by the editorial committees for not being of adequate general interest. (It was a case study dealing with the Clinton formation, but the methods were clearly generic and used popular material balance notions). Ten years later, I published *Monte Carlo Simulation, Its Status and Future* in the Distinguished Author series;
- the most popular SPE Applied Technology Workshop focuses on probabilistic methods;
- SPE, SPEE and WPC are working on definitions that include probabilistic language; and

The oil and gas industry **remained skeptical about risk analysis throughout most of this development period.**

We need to encourage **papers and presentations by people who have applied the methods for several years.**

- the largest service companies acquired smaller companies that market probabilistic software.

So, we advocates of Monte Carlo and Decision Trees should be jumping with glee that the rest of the world has caught up to us, right? Well, sort of…

The problem with this newly-found technique is that we are still learning things by our mistakes. Like anything else that evolves into widespread use, risk analysis requires more maturation. Only now do we have the critical mass on proponents to refine our applications, to discover what works, to eliminate faulty logic, and to test our ideas by papers, courses, books and forums.

I have:

- discovered things during the past 5 years that make some of my papers out of date;
- proposed methods that are too difficult to explain and therefore impractical in an organization;
- stumbled on limitations of the software I use that force us to change procedures;
- witnessed numerous misuses, misquotations, and misinterpretations, many of them in technical papers; and
- had ongoing unresolved arguments with reliable colleagues.

All this spells opportunity for the larger community interested in risk analysis. There should be better papers and more of them, and good discussions and improved software. More people doing day-to-day modeling should come forward. I know of several companies where the high profile spokesmen are far less knowledgeable and less experienced than some of their low profile colleagues.

I am reminded of an experience while on my first sabbatical at Stanford in 1972, studying operations research and management science. The university granted me full access to all the libraries, and I read more papers in 12 months than any 5-year period before or since. I discovered the early years of what were two journals then, *Management Science* and *Operations Research*. Many of the authors had later became famous. Many of the papers were lucid, expositions, rather than arcane dissertations. Often they raised unanswered questions and stimulated others. It was clear that these people had been mulling over these ideas and discovering them in fields that were still immature. Once the publications came into being, they exploded with their knowledge.

We have made some progress toward this exposition as one can see by the increased number of papers at several of the SPE and AAPG meetings. But we need to encourage papers and presentations by people who have applied the methods for several years, testing and improving, discarding ideas that do not travel well from the cloister to the hearth, comparing alternative solutions, providing case studies, documenting lookbacks, citing success stories within organizations and touting benefits of company-wide probabilistic methods.

SPE and AAPG have provided ample opportunities with forums, workshops and conferences for the general ideas to be promulgated. A natural next step would be to hold workshops for advanced users.

About the articles in this publication

This publication is in part a challenge to review some of our assumptions and check our language. It is intentionally provocative and open ended.

Themes articulated:

- everyone should use probabilistic not deterministic methods;
- fallacies abound in both deterministic and probabilistic methods;
- teach people how to ask questions whose answers require probabilistic methods;
- we often abuse the language of probability and statistics;
- increased use of risk analysis presents more opportunity to do things wrong; and
- in order to talk about real options and optimizations (buzzwords de jour), we need to do probabilistic cash flow properly. ◆