SYSTEM DYNAMICS IN DISPUTE RESOLUTION

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ABSTRACT

Since the mid-1970s, System Dynamics has contributed to the resolution of a wide range of business and legal disputes including contract claims and re-negotiations, management prudency hearings for nuclear power programs, and inquiries into the effects of government regulations on various industries. In these settings, a System Dynamics model can provide an objective, "transparent" view of a complex and emotional situation. The model can represent what happened and why, and what would have happened if certain events or conditions had not occurred. It can provide a basis for determining responsibility for delays, cost escalation, poor product performance, reliability and safety problems, loss of market share, and depressed profits. With the help of such models, complex situations are easier to understand and evaluate. The models and analyses become frameworks for debate and settlement.

This paper describes the context, processes, and behaviors associated with many business-related legal disputes. The role of System Dynamics in dispute resolution is discussed in general terms, and then illustrated with a recent example. The example is a large contract claim for "delay and disruption." That term refers to the indirect, secondary, or ripple effects of events or conditions (e.g., design changes) impacting an aerospace, shipbuilding, software development, or similar program. Delay and disruption impacts can be very substantial. They are the most difficult aspect of a change negotiation or claim to handle, and are the source of the most acrimony and disagreement in such disputes. The background of this case, the lawsuit, how the model was introduced into the legal proceedings, and how it helped to achieve a settlement, are described in detail. The paper concludes with a discussion of the practical results obtained from using System Dynamics in dispute resolution.

I. INTRODUCTION

With the recent growth of interest in "alternative dispute resolution approaches," there have been several important articles on the role of models in helping to resolve complex disputes [Nyhart and Samarasan 1989; Nyhart 1988; Antrim 1984]. The common theme of these articles is that models can, and have, made major contributions to the resolution process by:

1. Structuring complex situations so that they are more readily understood;

2. Substituting explicit, objective hypotheses of cause and effect for vague, often self-serving views;

3. Providing a framework within which alternative positions and theories can be evaluated; and

4. Stimulating the disputing parties to take a broader, longer-term perspective on their interests.

The overall effect is to alter the character of the adversarial exchange. Instead of posturing, bluffing, and attempting to intimidate each other, the disputing parties find themselves challenging, debating, and even agreeing on the assumptions in the model and the modeling methodology itself. To the extent that models can make the exchange less emotional and more objective, they substantially increase the likelihood of productive negotiations and ***equitable settlement of disputes.***

System Dynamics is especially well-suited to the dispute resolution process. Indeed, there is a long and successful record of using System Dynamics in a variety of litigation, arbitration, negotiation, and regulatory situations. This work has been pioneered by Pugh-Roberts Associates, starting in the mid 1970s.

For example, System Dynamics models frequently are used to quantify and analyze contract claims in connection with aerospace, shipbuilding, defense electronics, and computer system development programs [Cooper 1980]. These claims arise from such causes as design changes, late or inadequate design information, problems with other interdependent programs, poor vendor performance, and changes in government regulations. System Dynamics models also are used to support negotiations of major contract changes for these types of programs.

Another example is the use of such models to evaluate "management prudency" in the design and construction of nuclear power plants. This question is the subject of hearings before state utility commissions. The outcome determines how much of a plant's costs will be recovered through the price of electric power, and how much will be absorbed by the utilities (e.g., through write-offs against retained earnings).

A further example is the use of a System Dynamics model to quantify a claim by an aircraft manufacturer against a major sub-system supplier. The aircraft company sought compensation for cancelled orders and loss of market share caused by delayed deliveries, unreliable performance, and inadequate servicing of the sub-system in question.

Additional examples involve the use of System Dynamics models to evaluate the effects of government regulations on various industries. These analyses have included airline deregulation in Europe, operation of Chile's privatized social security system, the impacts of fuel economy, pollution, and safety standards on the automotive industry, deregulation of ocean shipping, the effects of regulatory policies on railroad safety, and taxation of the thoroughbred racing industry [Weil 1990; Weil and Veit 1989; Pugh-Roberts 1981; Pugh and Makowski 1979; Pugh-Roberts 1975]. In all of these cases, there were serious, long-standing disputes between the industries and governmental authorities over what regulatory policies were "appropriate."

We hasten to emphasize that these were serious, high-stakes disputes. Very large sums of money were involved; frequently, hundreds of millions of dollars and in a few instances, billions. Far-reaching precedents also were involved in many of these cases, for example, legitimizing the concept that disturbances to a particular phase of a complex design and construction program can ripple through the program, and indirectly cause delays and extra costs in other phases, or even in other programs. Such precedents affect not only the specific disputes where they are established, but many other analogous disputes as well. Once again, very large amounts of money are at stake.

Over the years, there has been steadily growing acceptance that a high-quality model, effectively used, can facilitate a faster, more equitable, less acrimonious settlement of a complex dispute. And there has been a steadily developing body of procedural law on the subject of how models and the results they generate may be introduced into legal proceedings.

This paper describes the context, processes, and behaviors characteristic of major business-related legal disputes. The role of System Dynamics in dispute resolution is discussed in general terms, and then illustrated with a shipbuilding contract claim for "delay and disruption." The example shows how a System Dynamics model was developed and used in this case. It describes how the model was introduced into the legal proceedings, and helped to achieve a settlement. The paper concludes with a discussion of the practical results obtained from using System Dynamics in dispute resolution.

II. THE ROLE OF SYSTEM DYNAMICS

Major business-related legal disputes usually arise from a combination of frustration, desperation, and anger. Frustration, because the other party "refuses to listen to reason;" desperation, because the financial consequences are becoming "backbreaking" or "threatening the very existence of the firm;" and anger, because proud, strong-willed managers "refuse to be intimidated" and "want to vindicate their reputations." The environment surrounding these disputes is highly emotional. Name calling in front of reporters and television cameras is more likely than clear communications and level-headed reasoning.

In order for such disputes to be resolved, a Judge, jury, arbitration panel, regulatory commission, or set of parties engaged in negotiation must reach certain conclusions about:

1. ***Who*** did what to whom;

2. ***What*** were the financial consequences;

3. ***Where*** do the responsibilities lie;

4. ***When*** is a fair settlement possible; and

5. ***Why*** impose or accept a particular settlement.

The prevailing emotions and the complexity of the issues are formidable obstacles to reaching these important conclusions. This is why many disputes drag on and on, often poisoning relationships between parties who should be working together constructively, e.g., as supplier and customer.

A System Dynamics model can provide an objective, "transparent" view of a complex, emotional situation. Specifically, the model can represent what happened in a particular situation, ***and why***. The outputs from the model are the explicit result of the assumptions being used; any interested party can trace through the model's causal structure to see exactly how the outputs are produced. Simulations can show what would have happened if certain events or conditions had not occurred. For example, how much better would the cost and schedule performance of a project have been if the customer had not ordered certain design changes? If a vendor had not delivered key components late? If critical management decisions had been made differently? This ***would have*** capability is invaluable for isolating the impacts of the factors which are the subject of the dispute.

Item No. 4 above often relates to the availability of information. If certain events or conditions can have far-reaching effects, how long must everyone wait until the full impacts are known and a fair settlement is possible? This question is especially important in situations where the time horizons are long, e.g., huge design and construction programs, regulatory changes, oil spills, exposure to toxic materials. Effective dispute resolution is both quick and fair. A System Dynamics model can project the ***future consequences*** of past events and conditions. For example, how much additional rework and inefficiency will result from design changes which occurred several months ago? Such projections are essential for timely dispute resolution, and also for ***dispute avoidance***. More will be said on the latter topic below.

Also essential for quick and fair dispute resolution (and for dispute avoidance) is the capability to compute the full impacts of events and conditions, including so-called ***indirect effects***. In large design and construction programs, these "indirect," "secondary," or "ripple" effects often are referred to as delay and disruption. By any name, these effects are real and substantial. They can involve costs 3-4 times (or even more) the easily identified direct impacts of, for example, design changes, late receipt of important information, problems with suppliers, or changes in government regulations. Indirect effects on productivity, quality, rework, reliability, costs, schedule, delivery delays, market share, and profits are significantly separated in "time and space" from their causes. Because they are very difficult to anticipate, these indirect effects usually are considered only in retrospect. Because they are difficult to describe and prove, these effects are the source of the most acrimony and disagreement in disputes.

A System Dynamics model can represent the complex network of cause-and-effect relationships through which such effects propagate. Thus, the model can be instrumental in explaining the phenomenon and establishing its legitimacy. Further, the model can fully quantify the costs of indirect effects, tracing the impacts back to specific events and conditions. It therefore is possible to isolate the effect of each event and

condition, and to show their cumulating impacts. This is a basic requirement for any formal dispute resolution process. The capability supports negotiation, arbitration, or litigation of individual elements of a complex dispute. For example, legal issues of "entitlement" may disqualify part of a claim; the costs associated with those factors must be excluded. Or the parties may be willing to settle some components of a dispute, while continuing to fight over the rest. Again, it is necessary to attribute costs to specific causes. Perhaps most important, this capability permits immediate quantification of the full cost implications of events or conditions, while there still is an opportunity to affect the costs, and ***before a dispute gets started.***

A key aspect of contract claims and many other business-related disputes is to evaluate the performance of management. This takes on several dimensions. Were "reasonable management practices" followed, especially as problems arose? Were certain bad management decisions made? To what extent did management policies amplify the impacts of various events and conditions? Did management make substantial efforts to mitigate these impacts? Accusations of poor management are almost inevitable. The typical response to a contract claim is: *"Our actions wouldn't have produced any extraordinary problems, except for your inept management. And now you have the gall to ask us to pay for your mistakes!"* The adequacy of a utility's management is the central issue in prudency hearings.

The ***What if...?*** capabilities of a System Dynamics model allow management policies and actions to be evaluated. For example, simulations can compare the performance of a design and construction program based on the decisions management actually made versus the results if management had made certain decisions differently. Would costs have been lower if management had slipped the schedule earlier? What if management had expanded the workforce instead of using a lot of overtime? Did management's responses to specific problems really mitigate their impacts?

Moreover, these What if...? analyses can be forward looking, too. In many disputes, resolution is facilitated by showing ways in which the parties can work together to improve what otherwise would happen in the future. For instance, by agreeing to certain changes in how a program is structured and managed, significant cost savings may be realized. Such analyses show that the future is not "cast in concrete," that the disputing parties can improve the future outlook, and that continuing the dispute will forfeit the opportunity to do so. These are powerful incentives to achieve resolution.

To summarize, System Dynamics models have played several valuable roles in the dispute resolution process:

1. They can provide a basis for determining responsibility;
2. They can identify the strengths and weaknesses of each party's position; and
3. They can show the effects of various compromises, settlements, and management actions.

In the next section, we describe the use of a System Dynamics model in resolving a complex, bitter, protracted contract dispute in the shipbuilding industry. This example will bring to life the real world of high-stakes disputes.

III. THE HALTER MARINE DISPUTE

The first meeting between the presidents of Halter Marine, a highly respected Gulf Coast shipbuilder, and Amerada Hess Corporation, one of the world's major oil empires, suggested that the relationship between the two men and their companies would be a happy one. Meeting for the first time in the suite of Kansas City Chiefs owner Lamar Hunt, Harold Halter and Leon Hess exchanged pleasantries and enjoyed the football game. Neither man reasonably could anticipate that he later would spend millions of dollars litigating a bitter dispute that spanned half a decade. Although the litigation dealt with complicated legal and factual matters, the plaintiff Halter Marine hoped to reduce the dispute to a single question: ***"How much is a man's word worth?"*** The answer to that question depended in large part on a System Dynamics model developed by Pugh-Roberts Associates. A bit of background is appropriate.

The Negotiations

During 1977 and 1978, Amerada Hess and several associated subsidiaries began negotiations aimed toward building a number of ocean-going vessels. Amerada Hess intended to use the vessels to transport oil and related products from its refinery in the Virgin Islands to the eastern coast of the United States. It hired the naval architects J.J. Henry to prepare contract plans and specifications. The resulting bid package was sent to a list of shipyards, including Halter Marine.

The vessels described in the bid package were to be "Catug" integrated tug-barges (ITB's), each made up of a tug and a barge joined with a rigid connecting device to form one unit. Amerada Hess adopted this design concept instead of a standard ocean-going oil tanker for two reasons. First, Amerada Hess believed that the Coast Guard would treat these vessels like any other large tug; this would permit a lower level of manning and less stringent safety equipment than required for an ocean-going tanker. Second, Amerada Hess anticipated significantly less expensive construction costs with the new design.

Although Amerada Hess and J.J. Henry thought about a number of shipyards as potential contractors, by early 1978 all negotiations were with Bethlehem Steel and Halter Marine. Bethlehem Steel was to be prime contractor for construction of the combined units; and Halter, subcontractor for the tug portion. The parties negotiated through a number of drafts of the specifications and the contract. Subsequently, some of that negotiated language surfaced as key issues in the litigation.

For example, Halter later claimed that throughout the precontract negotiations, it emphasized to Bethlehem Steel, Amerada Hess, and J.J. Henry that it was an experienced builder of large ocean tugs, but was not a big shipyard such as Bethlehem Steel, and did not use the same construction standards and practices as the "major" shipyards. Although it had information about Halter's normal practices because of prior negotiations, Amerada Hess later denied that Halter had provided such information.

The First Contract: Halter Agrees To Build Two Catugs

After extensive negotiations, the parties in January 1979 entered into contracts for the construction of two ITB's. As preparation of the working drawings and construction

of the tugs moved forward, Halter began encountering problems with what it considered to be errors and omissions in the contract plans and specifications. In addition, scheduling difficulties arose because J.J. Henry often did not approve Halter's working drawings within the time period required by the contract. Disputes, perhaps predictably, also arose about what was required to conform with the specification requirements in areas involving construction standards and procedures. Amerada Hess representatives told Halter that they wanted the vessel built "their way" and that Halter was to follow their instructions subject to negotiation of price increases at the time when the first vessel was ready for delivery. This was not an unusual way for Halter--or others in the oil patch--to do business. In fact, the company, during its 20-odd-year history, often had started large construction projects on the basis of a handshake.

According to an interview with Leon Hess published after the settlement of the Catug litigation, this apparently was not an uncommon way for him to do business, either:

> *Hess can be a formidable--and notoriously stubborn--competitor. Often, though, his style with peers is strictly old-fashioned oil patch. Jock D. Ritchie, who ran Royal Dutch/Shell Group's U.S. marketing arm in the 1960's, recalls making the biggest supply deal of his career one day over lunch with Leon at Manhattan's La Caravelle. On the backs of four small cards, Hess scribbled the terms of a contract to buy 125,000 bbl. a day at $2 a bbl. The formal contract wasn't signed until more that a year and $110,000 million worth of business later. "You don't need everything in writing," says Hess. "If your fiercest competitor had a fire or a catastrophe, you'd pick up the phone and start loading oil for them--never ask about money. We're still that way."*
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> *"In a day when integrity is in short supply, his word is his bond," notes John J. McCabe of Dorsett McCabe Capital Management Inc. and a former oil analyst with Bankers Trust Co. When Mobil went drilling for oil and gas offshore in New England on the Georges Bank, Hess committed himself for 10%, or $40 million, over the phone--and upped that to $100 million when other partners dropped out. Only dry holes were found. Says Hess: "When you're a big boy, you live with it."*
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> James R. Norman, "Leon Hess: Can the Bottom-of-the-Barrel Oil Baron Get Back on Top?", Business Week, June 29, 1987, pp. 50-54.

The Second Contract: Halter Agrees to Build Four More Catugs

In August 1979, Amerada Hess wanted to order four more Catug units, but Halter was reluctant to proceed, partly because of the problems encountered on the first two units. On his own initiative, Leon Hess flew to New Orleans and met with Harold Halter and other members of Halter's senior management. Halter alleged in its complaint that Mr. Hess, urging Mr. Halter to go forward with the second contract, said that Mr. Hess would ***"not let Halter get hurt"*** and that Amerada Hess would ***"keep Halter whole on the job."*** Furthermore, according to Halter's complaint, Mr. Hess told Mr. Halter to call other businessmen to confirm that Mr. Hess was a ***"man of his word"*** and that Mr. Hess's ***"word was his bond."*** On the basis of these and other assurances, and contact with the reference suggested by Mr. Hess, Halter entered the second contract in October 1979 and continued to follow owner instructions in instances of unresolved disputes about the construction. Amerada Hess later denied that these assurances had been made.

Moving Toward Litigation

The magnitude of changes in the scope of work caused by owner demands could not be reasonably anticipated at first. However, these changes were quite substantial and ultimately had serious effects on the project. They rendered Halter's original production planning and scheduling obsolete, and they caused a significant decrease in overall productivity on the project. When Amerada Hess and J.J. Henry voiced concern about the status of Halter's planning, Halter management likened efforts to predict the total scope of the project to "shooting at a moving target."

A major problem that arose during the project--and which led to the commencement of litigation--involved the "seaworthiness" of the tug portion of the Catug unattached to the barge. The contracts required Bethlehem Steel to build the barge portion of the ITB's in its yard at Sparrows Point, Maryland and Halter to build the tugs at Chickasaw, Alabama. Halter's subcontract with Bethlehem Steel required Halter to "transport" the completed tugs from Chickasaw to Sparrows Point for joining to their respective barges and delivery to the owner. This trip required an ocean voyage around Florida, northward in the Atlantic off Cape Hatteras, and into Chesapeake Bay.

In May 1980, Bethlehem Steel raised the question of whether the tug, unattached to the barge, was seaworthy for the ocean trip from Alabama to Maryland. Model tests conducted at the Stevens Institute at Halter's expense suggested a substantial risk of injury to the crew and damage to the tug if head seas were encountered during the voyage. When Halter communicated the test results, Amerada Hess claimed that Halter was fabricating the deliverability problems as a means of "blackmailing" the owners into paying more money for disputed items of work. Halter responded that the deliverability issue was separate from its claims for additional compensation.

In the spring of 1981, the first Catug was finished, and its behavior during sea trials in the Gulf of Mexico confirmed to Halter the Stevens Institute model findings. Halter concluded that the problems with the tug's ability to navigate safely created an unreasonable risk to the lives of the crew and the physical safety of the tug. After receiving legal counsel about the potential criminal implications of proceeding with delivery under these circumstances, Halter decided that it was commercially impracticable to transport the tug to Sparrows Point. As a result, Halter tendered the first tug for delivery at Chickasaw, Alabama, in May 1981.

Halter urged Amerada Hess and Bethlehem Steel to tow the first completed barge to Alabama and to join the two units there. They refused.

The Lawsuit

In July 1981, Halter filed a lawsuit seeking damages then estimated at $60 million and a declaratory judgement that it had no obligation to attempt a delivery voyage. In short, Halter contended that the man-hour overruns and the delays were caused by owner-imposed changes, regulatory body reinterpretations, rework resulting from defects in the plans furnished by J.J. Henry, and the owner's failure to perform other obligations required by the contract plans and specifications.

Amerada Hess, denying these allegations, took the position that Halter's problems resulted from its own incompetency, poor management, bad planning and scheduling, and generally "getting in over its head" in a major construction project for which it was

not adequately equipped. Amerada Hess counterclaimed for damages in excess of those claimed by Halter. The stage was set for a major--and expensive--legal confrontation.

Halter's Difficulty In Quantifying the Catug-Related Damages

Halter management began the task of more accurately quantifying the impacts on the Catug project of owner-imposed changes and other events and conditions that were the subject of their claim. They quickly realized that tracking these impacts on an item-by-item basis would be difficult, if not impossible.

This difficulty resulted in part from Halter's internal accounting procedures. Halter had a computerized system that tracked expenditures of labor and materials against a series of line items representing the various elements involved in building a vessel, for example, "Steering System," "Bilge, Ballast, and Firemain System," and "Hull Module No. 1." These line items corresponded to the categories used for estimating construction costs. For several reasons, the accounting system did not segregate the exact man-hours and materials caused by individual owner actions during the course of the Catug project:

1. Halter's accounting system was designed to accumulate information for managing current and future projects, not for documenting a legal claim. Its emphasis was on supporting the shipbuilding process, not tracking subgroups of expenditures that later might become legally relevant.

2. In many situations the extra work was a matter of degree. For example, it was difficult for foremen charging time to decide how much weld smoothing was a basic contract requirement and how much was extra work.

3. The sheer volume of owner-imposed changes overwhelmed the system. Halter used a special series of charge numbers to track expenditures for easily identifiable changes, but the supply of available numbers quickly was exhausted. Halter then made the decision to charge all work on a particular element of the project, regardless of its causes, to the original line item number.

Halter also began to recognize an even more fundamental obstacle to quantifying the full impacts of the various events and conditions which disturbed the Catug project. The immediate, direct impacts were like the tip of an iceberg. Beneath the surface, there seemed to be far larger, indirect, impacts. Those indirect impacts resulted from changes, delays, etc. rippling through the project, producing inefficiencies and rework that were ***"separated in time and space"*** from their original causes. Halter management sensed that there was substantial ***"delay and disruption"*** on the Catug project. But they were having great difficulty pinning it down.

Halter's Use of System Dynamics Modeling

Against this backdrop, a Halter vice president, who previously had worked at the Ingalls Shipbuilding Division of Litton Industries, recommended that Halter's attorneys consult with Pugh-Roberts Associates about the potential use of System Dynamics modeling to estimate the indirect impacts attributable to the owner's conduct. In the late 1970's, Pugh-Roberts had quite successfully assisted Ingalls with a similar, but far larger claim.[Cooper 1980]

The lawyers knew that any expert testimony based on computer-generated results must meet the demanding standards imposed by the Federal Rules of Evidence, i.e., the results must be authentic and reliable. Consequently, they entered the relationship with Pugh-Roberts armed with considerable skepticism. In fact, they privately feared that Pugh-Roberts ultimately would offer no more than subjective judgements cloaked in computer technology.

Pugh-Roberts built a computer model of the Catug project based on data obtained from Halter, interviews with Halter managers (including their quantifications of how they typically responded to the needs and conditions of projects), and relationships derived from their many previous shipbuilding models. As Pugh-Roberts moved forward with the process of gathering information and developing a computer model, Halter's lawyers became convinced that their fears were unfounded. By the time the model was finished, they had learned enough about the methodology to respect and trust the integrity of System Dynamics and its practitioners at Pugh-Roberts. They were won over by several aspects of Pugh-Roberts' approach:

1. Given a set of conditions at the start of the Catug project, the model walked through time from the project's starting point to its conclusion without being adjusted, manipulated, or told any additional information.

2. The model reported the results of simulations in terms normally tracked by shipyard management, such as number of people hired, man-hours worked, drawings completed, construction work accomplished, and rework discovered. These results were compared statistically to what actually happened in the course of the project.

3. The output of the model tracked the actual performance of the shipyard during the course of the project in terms of these measurable and objective data. A statistical analysis showed a remarkable degree of consistency between what the model simulated and what actually occurred.

4. The lawyers could imagine that a simulation expert intent on manipulating the analysis could cause a biased (and therefore incorrect) model to track some of the measurable variables with a degree of accuracy. However, the model developed for Halter accurately simulated a large number of such variables on not one, but six different ships built sequentially.

Halter's attorneys concluded that there was only one plausible explanation for this result: System Dynamics modeling, properly applied, is a useful, accurate, and legally credible tool for the analysis of shipbuilding and other design and construction projects. The methodology's uncannily accurate performance, without midcourse corrections, in simulating a series of complicated and interrelated phenomena convinced them of its validity.

The "Base Simulation" of the model correctly and accurately recreated the actual history of the Catug project. Pugh-Roberts then altered the inputs to the model to create a simulation of ***what would have occurred*** but for the changes, delays, and other owner action cited in Halter's claim. The only differences between this "Would Have" simulation and the Base Case were the specific inputs describing Amerada Hess's actions; ***in every other respect, the model and inputs were the same.*** The Would Have simulation was compared to the Base Simulation in terms of such factors as man-hours expended and vessel completion dates. These differences were the impacts of the owner-responsible events and conditions. The differences computed from the two simulations

were "dollarized" and formed the basis of the claim against Amerada Hess submitted by Halter to the Court.

The Litigation Process

The litigation continued for five years. All aspects of Halter's claim--including the model developed by Pugh-Roberts--were subjected to strenuous examination during the pretrial process. The Court's pretrial order required Pugh-Roberts to submit a written report describing its opinions about the causes and amounts of owner-responsible "delay and disruption" on the Catug project. After receipt of this report, the order permitted the defendants to submit their own expert reports concerning this subject. The order also provided that all expert witnesses could be deposed (questioned orally under oath) by the opposing party's attorneys.

Halter's lawyers were acutely aware that the model had to be authentic, reliable, and relevant to the questions presented by the litigation. They also knew that computer simulation modeling was not the traditional method for estimating damages. Concluding that a primary purpose of the report should be to "educate" Halter's opponents about the methodology, the attorneys decided that Pugh-Roberts should make as full a disclosure as possible. Toward that end, the report included a detailed explanation of the model and the process by which it was built, refined, and validated.

The defendants responded in two ways to the Pugh-Roberts report. They hired a firm that used one of the more traditional methods to estimate damages, and they also hired a consultant with a "specialty in System Dynamics." Both concluded in their respective reports that the Pugh-Roberts analysis was seriously flawed. To get somewhat ahead of the story, none of this criticism stood up.

The "traditional" firm dismissed Pugh-Roberts' findings for three principal reasons. According to their analysis, Halter's scheduling efforts were deficient. They contended that Halter's own inefficiencies and mismanagement were the major causes of delayed deliveries. And they stated that the conclusions reached by Pugh-Roberts were not supported (and sometimes contradicted) by the "project records." Dismissing System Dynamics in general as a methodology built on "vague, sociological theories," this firm concluded that there were ***no*** owner-responsible delays.

The System Dynamics "specialist" also rejected Pugh-Roberts' conclusions. According to him, the model did not accurately reflect either Halter's management decision making or the construction activity at the shipyard. Nor, he contended, did the results generated by the model accurately reflect the direct impact on the shipyard of the events and conditions cited in Halter's claim. He accused Pugh-Roberts of changing the equations and inputs to the model to force the model to reach the desired results. And, in his opinion, the model omitted other causes of delay and disruption, e.g., management turnover, effects of other construction programs on the availability of labor.

Continuing the strategy of full disclosure, Pugh-Roberts was permitted to communicate directly with the Amerada Hess experts without attorney supervision or intervention. This technical interaction allowed Pugh-Roberts to answer many questions about the model. It also served as an effective prelude to the deposition of Kenneth G. Cooper, the senior Pugh-Roberts manager who had led the modeling effort.

Mr. Cooper was deposed on three different occasions. During that multi-day process, he was asked detailed questions about the nature of delay and disruption, the

System Dynamics methodology, and each phase of model development and use. Needless to say, these questions were not asked out of academic interest. They were not pursued according to the etiquette of scientific enquiry. The questioning was extremely aggressive, hostile, and manipulative. The opposing attorneys went to great lengths in attempting to discredit both the witness and his conclusions.

Although many of the questions might be considered unfair, they provided the opportunity for Mr. Cooper to explain how a System Dynamics simulation model can accurately portray what had happened in this situation and explain why it happened. He effectively answered all of the criticisms thrown at the Pugh-Roberts work by Amerada Hess's experts. The more Mr. Cooper explained, the more credible the modeling became. The opposing lawyers realized that this work could not be brushed aside but, rather, had to be taken very seriously. The credibility of the Amerada Hess experts was further damaged in their depositions.

Halter's lawyers felt that the groundwork had been laid to argue at trial that the model should be viewed as the ***"objective source of correct information."*** In other words, the model could be used as more than a way to estimate damages. It could be used to show how ***"something happened"*** which resulted in a situation far different than expected at the outset by the parties.

And in a subtle but significant way, the tide had turned. All of the parties increasingly were using the vocabulary and concepts of the Pugh-Roberts model to express their views. This included the Judge and his influential clerk. While the defendants would not admit in so many words that the model had influenced them, it definitely was there, on the stage, affecting the drama.

The Settlement

After 275,000 pages of deposition testimony, the production of over 2 million documents, and total legal expenses in the neighborhood of $20 million, the parties in July 1989 began the final pretrial conference. Prior to that time, the best settlement offer received by Halter was Amerada Hess's proposal to "call it even." Considering the extent of Halter's losses, this proposal was totally unacceptable. For example, Halter estimated that the six Catugs would take 1,500,000 man-hours to build, but they actually took 3,200,000; their engineering effort, estimated at 25,000 man-hours, grew to 66,000. Halter sustained an audited cash loss on the project of almost $48,000,000.

Earlier in 1986, the Judge had requested each party's attorneys to submit a confidential letter in which they evaluated the various positions taken by their clients. These letters, along with extensive pretrial submissions also required by the Court, became the basis for a series of discussions at the final pretrial conference.

Those round-robin discussions led to the settlement of the dispute. The Judge, meeting separately and confidentially with the attorneys for each party, effectively assumed the position of a mediator. For example, during the meetings with Halter's lawyers, the Judge discussed on a specific, detailed basis the various components of their claim. In fact, the Judge commented on what he saw as the relative strengths and weaknesses of the claim. Concepts and conclusions from the model significantly influenced these discussions. And there can be little doubt that Amerada Hess's total lack of success in discrediting the model, and the prospect of the model-generated results figuring prominently in the trial, strongly influenced their attitude toward negotiation and settlement.

Halter received a highly favorable settlement on the eve of trial. Although the terms were "sealed" as confidential by the Court, the damages as estimated by the System Dynamics model played a major role in bringing about this favorable settlement.

IV. PRACTICAL RESULTS OBTAINED

The Halter litigation is typical of how System Dynamics has been used in connection with formal legal disputes. To date, System Dynamics has entered the dispute on one side, i.e., as a tool selected by one of the adversaries or their attorneys, not in a mediation role. Hence, in the first instance, the introduction of System Dynamics into disputes may be viewed by the "other side" as an escalation of the hostilities.

As in the Halter case, the process of disclosure, explanation, challenge, and defense of the modeling work has a substantial effect on the dispute resolution process. The model gains credibility and stature, and must be taken seriously. It therefore becomes increasingly clear that the model results will have an important influence on the conclusions by a Judge, jury, or arbitration panel regarding "who did what to whom" and what damages were incurred. At this point, the results from the model take on much greater significance. They suggest the range of likely outcomes from pursuing a long, expensive, bitter, legal battle. Inevitably, both sides (often strongly encouraged and guided by a Judge or arbitrator) begin to think: "Why go through all that pain when the outcome can be seen; why not get down to business and negotiate a settlement?"

As also illustrated by the Halter case, the process of introducing the modeling work into the dispute resolution process affects the way in which all of the parties think about the substantive issues. Concepts from the model become accepted: there really can be indirect, "ripple effects" of various events and conditions; these can become manifest after substantial delays; they can be much larger than the obvious direct effects; they can spill over to impact other concurrent work; the impacts of disturbances to a project can cumulate in a highly non-linear fashion; reasonable and customary management practices may not cope very well with severe delay and disruption. While major disagreements always remain about the extent to which these things happened, who is responsible, and what damages were incurred, the intellectual "common ground" established by the model facilitates negotiation and settlement.

Since 1976, Pugh-Roberts has applied System Dynamics to over twenty legal disputes with a total of more than $5 billion at stake. Twelve of these cases have been resolved thus far. While many of the disputes were the subject of litigation or arbitration, the strength of the System Dynamics approach led to ***negotiated settlements in all twelve cases.*** Pugh-Roberts' clients recovered on average 50% more than would have been typical using traditional approaches for quantifying and explaining damages. These cases were settled faster, with less long-term damage to relationships between the disputing parties.

In many instances, the disputes were among parties who had very substantial on-going relationships, e.g., defense contractors and their major customers. A quicker, more equitable, less acrimonious, and more defendable settlement allows such parties to "normalize" their relationship once more and get on with their common business. Lessons learned from the modeling work may show ways of mitigating the costs of the

dispute at hand, and perhaps most valuable, ways of ***avoiding comparable disputes*** in the future.

Lawyers and the legal system increasingly are turning to alternative ways to resolve disputes. System Dynamics modeling can play a key role in that process. But as Nyhart observed, "*...Use of models offers no instant remedy for the tough work and disappointment that are often part of negotiation.*" [Nyhart 1988; p. 14]

REFERENCES

Antrim, L.N. 1984. "Computer Models as an Aid to Negotiation: The Experience in the Law of the Sea Conference," MIT Sea Grant Symposium on Conflict Resolution in the Outer Continental Shelf and Economic Zone, November 1984. In Nyhart, J.D., ed., 1985. Coastal Zone and Continental Shelf Conflict Resolution. Cambridge: MIT Sea Grant Publication 85-28.

Cooper, K.G. 1980. "Naval Ship Production: A Claim Settled and a Framework Built," Interfaces, Vol. 10, No. 6, December 1980, pp. 20-36.

Nyhart, J.D. and D.K. Samarasan 1989. "The Elements of Negotiation Management: Using Computers to Help Resolve Conflict," Negotiation Journal, Vol. 5, No. 1, January 1989, pp. 43-62.

Nyhart, J.D. 1988. "Computer Modeling in Dispute Resolution -- An Overview," Dispute Resolution Forum, April 1988, pp. 3-14.

Pugh, A.L. and A. Makowski 1979. "A Systems Analysis of Railroad Track Maintenance," Proceedings of the 1979 Summer Computer Simulation Conference. Montvale, NJ: AFIPS Press, July 1979.

Pugh-Roberts Associates, Inc. 1981. Ocean Shipping System Dynamics. Washington, DC: U.S. Department of Commerce, Maritime Administration, Office of Advanced Ship Operations.

Pugh-Roberts Associates, Inc. 1975. The Future of Thoroughbred Racing in the United States. New York: The Jockey Club.

Weil, H.B. 1990. "Strategic Learning -- Preparing Senior Managers for the Future," Vers une Ecole Européenne du Management Stratégique. Paris: AFCET/AFPLANE.

Weil, H.B. and K.P. Veit 1989. "Corporate Strategic Thinking: The Role of System Dynamics," in P. M. Milling and E.O.K. Zahn, eds. Computer-Based Management of Complex Systems. Berlin: Springer-Verlag.