Sources Of Bias And Inaccuracy In The Development Of A Best Estimate

Richard Stein & Michael Stein

ABSTRACT

This paper aims to engender an awareness of the psychological, technological, and operational obstacles which confront actuaries throughout the reserving process, preventing them from developing appropriate best estimates.

Although reserving issues are a regular subject in actuarial literature, nowhere is the term "best estimate" defined. In response to this absence, the authors consider criteria for actuaries to target in developing a best estimate, settling on two ideals: precision and lack of bias.

This paper examines issues related to limits on human intelligence, performance, and judgment, and considers the impact of external constraints, business agendas, and methodological issues. The individual actuary's response to these issues -- in addition to any reaction to specific statistical patterns and sensitivity to the work environment -- all significantly impact the reserving process. In fact, each actuary may be viewed as a reserve estimator -- whose "parameters" have been set by a combination of ability, personality, and experience -- which produces best estimates in response to specific sets of data, reserving models, and business realities.

This paper also explores practical reserving considerations and concludes with several recommendations for reserving actuaries to implement in order to reduce the bias, and improve the precision, of their best estimates.

KEY WORDS

Actuary	Actuarial Judgment	Best Estimate Bias	
Client Relations	Decisionmaking	Estimation	Heuristics
Judgment	Loss Reserving	NAIC Issue Paper #55	
Social Psychology	Valuation	Working Conditions	

BIOGRAPHIES

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I. INTRODUCTION

The purpose of this paper is to explore the psychological and environmental issues which affect the value of the actuary's reserve estimates. Here, conformity to the Best Estimate requirement of NAIC Issue Paper #55 is used as the litmus test in judging the quality of the reserve estimate. This issue paper establishes statutory accounting principles for recording the liabilities associated with unpaid losses and loss adjustment expenses.

We first define the term "best estimate." Our attention then turns to identifying loss reserving processes which produce reserve estimates which are not in conformance to these requirements, in both letter and spirit. In addition, it is our belief that the actuary has a responsibility to investigate any issues which may bias or distort the reserve estimate.

As a result of these ideals, we can judge the following case: If, in developing a particular best estimate reserve value, an actuary has utilized poor data and statistically-biased loss reserving methods, and this professional's judgment is susceptible to a range of human cognitive errors and is overly sensitive to the client's business agenda, then we have the basis for determining that the resulting projection falls short of the specifications outlined in the Best Estimate requirement of NAIC Issue Paper #55.

In this paper, we first assess the criteria for an appropriate best estimate. We contrast the guiding principles of the natural sciences against the practice of actuarial science. Upon reviewing the ingredients, parameters, and steps associated with a reserve analysis, we focus on the importance of actuarial judgment to the process.

The second half of the paper emphasizes the performance associated with the use of human cognitive processes. The actuary's mind is the most important ingredient in loss reserving work since this process requires sophisticated technical skills, numerical proficiency, and practitioner judgment. Because there are elements to human decisionmaking which are likely to limit and bias the quality of actuarial analysis, they may interfere with the development of an objective best estimate value.

Finally, we focus on the technological and operational realities which confront the actuary throughout the reserving process and threaten the realization of the Best Estimate ideal. These obstacles may take the form of external constraints, business agendas, or methodological issues with which both consulting and in-house actuaries must contend.

The motivation for writing this paper is based on the belief that a best estimate developed from unsuitable ingredients does not comply with the best estimate definition. Unfortunately, many of the problematic inputs to the reserving process -- poor data, inadequate methods, cognitive errors, judgmental biases, business constraints, and undue sensitivity to the client's financial position -- are all too common. It is also the position of this paper that reserving practitioners are responsible for examining their own biases, work conditions, and methods in order to evaluate the quality of their best estimate selections.

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III. THE OBJECTIVE OF LOSS RESERVING

The purpose of loss reserving is to establish best estimates for the liabilities accrued by insurance companies for the costs of providing insurance coverage. The standards for setting these reserve values are established in a variety of statutory guidelines, for instance, by the NAIC in its Issue Paper No. 55. The current draft of this rule, which details the treatment for recording unpaid Loss and Loss Adjustment Expense liabilities, states:

> "For each line of business, management shall record its best estimate of its liability for unpaid claims, unpaid losses and loss/claim adjustment expenses. Because the ultimate settlement of claims . . . is subject to future events, no single loss or loss/claim adjustment expense reserve can be considered accurate with certainty. Management's analysis of the reasonableness of loss or loss/claim adjustment expense reserve estimates shall include an analysis of the amount of variability in the estimate . . . . In the rare instances when . . . . it is determined that no point within the range is a better estimate than any other point, the midpoint within the range shall be accrued."[1]

In addition to instruction regarding what should be included in a reserve review ("unpaid claims, unpaid losses and loss/claim adjustment expenses") and how to respond when a best estimate range has been established in which no point is superior to any other ("the midpoint within the range shall be accrued"), Issue Paper #55 suggests some ideas in reference to setting the best estimate. Among these issues are accuracy, certainty, reasonableness, analysis, and variability. There are a variety of challenges arising from these requirements: statistical assessment of variability, selection of reserving methodologies, establishment of reserves for each category of liabilities, and the role of management in analyzing and recording reserves.

Unfortunately, Rule #55 does not attempt to define either the term "best estimate" or its characteristics. While actuarial literature discusses loss reserving concepts, methods, and considerations, no definition has been developed for the best estimate. We take the liberty of establishing the requirements for a best estimate value as:

> *an unbiased, accurate, and financially meaningful estimate which is generated by a scientific, actuarial model which employs reasonable assumptions and in which the appropriate procedures have been applied dispassionately*.

Parameters

This definition suggests several requirements to achieve in the course of loss reserving in order to establish an appropriate best estimate:

1. Good estimator: The estimate produced by the estimation process is expected to include the true value of the population parameter of interest for a large fraction of repeated samples. It has a sampling distribution which is symmetrical and bell-shaped. A good estimator is robust enough to withstand failure of important assumptions, makes maximal use of the data, and has a very small bias.
2. Objectivity: Also known as freedom from Subjectivity. The ideal is an estimate produced in a process free of personal characteristics, reflections, feelings, habits, prejudice, or mental states. This is an impossible standard for any human practitioner to meet. On a practical level, it suggests that personal judgments should be limited and that practitioner independence should be maximized.
3. Freedom from Bias: The state in which the expected value of the estimate equals the true population parameter. Bias is related to consistent under- or over-estimation of the true

parameter and cannot be corrected by more sampling. Bias decreases with improvements in the design and implementation of the analysis.

4. Precision: It refers to the variance around the sampling distribution of the estimator and relates to the repeatability of a good result. Precision increases as the sample size increases and decreases when extra covariates are added to the model in an effort to reduce bias.
5. Accuracy: The actuary strives for exact conformance to reality and freedom from error. Because true accuracy is unattainable in sampling studies and statistical inference, the concept of precision is used instead. Accuracy can also be expressed as the combination of precision and bias.
6. Appropriateness: This is defined as the suitability of the analysis, which may be evaluated based on such issues as professional standards of practice, the scope of the project, and the use of proper methodologies. Some actuaries believe that it is more appropriate to use sound actuarial methodology in developing a best estimate value which proves to be incorrect than to obtain a more accurate number via inappropriate approaches.

Obviously, these statistical issues are meaningful in establishing a best estimate reserve value. These generally relate to the concept of credibility, the volume of data required to make projections, and the construction of a model which accurately captures the salient reserving issues. In addition, there are regulatory requirements and financial contexts associated with the development of a best estimate. However, this paper recognizes that these issues have been explored elsewhere and, instead, focuses on the issues of bias and precision. In particular, we concentrate on the hidden, more subtle elements of the reserving model -- the process of developing a best estimate. As a result, we seek to examine on the operational and cognitive obstacles which introduce bias and other inaccuracies to the reserving process and thereby prevent the best estimate ideal from being attained.

While the use of formulaic and mechanical methods may enable an actuary to avoid the risk of bias, such a step is hardly a step towards greater accuracy. Again, accuracy is composed of the elements of bias and precision. The main concern with formulaic methods is the way they are applied without regard for context. Adopting such a mechanical approach may lead to less bias; however, it opens up a raft of concerns regarding precision.

Actuarial Science as a Science

In view of such shared ideals as precision, bias, and objectivity, one issue worth assessing is the extent to which actuarial science may be considered a science. The goals of science are to describe, explain, and predict phenomena. Stated another way, science seeks to uncover universal truths and develop simple laws to explain the complexities of reality. The scientific method is an analytical system which utilizes hypotheses, experimentation, observation, and measurement according to predetermined rules of procedure. One of the ideals of science is objectivity, a standard which is pursued by employing standard methodologies, emphasizing the replicability and invariance of results, promoting self-awareness and recognition of the observer effect, and limiting personal judgment and agendas.

Unlike science, actuarial science gives heavy emphasis to the role of professional judgment.[2] However, there is at least one other field in the physical sciences which makes heavy use of practitioner judgment. Medical professionals constantly utilize judgment in making decisions regarding diagnoses, treatment decisions, and patient evaluations. Given the life-and-death nature of medicine, as well as its grounding in the natural sciences, it should be no surprise that practitioners stress the importance of the accuracy, replicability, and invariant nature of these

judgments. On the other hand, while actuarial science shares many of the same ideals, its application lacks the same sense of rigor, objectivity, and scope. This is reflected by its focus on developing projections for individual analyses instead of pursuing the discovery of universal truths. Rather than being a science, actuarial science is really an art in which judgment and craftsmanship are instrumental.

If actuarial science is not scientific, what are we left with? What standards should be upheld in the development of best estimates? What constitutes appropriate practice? If judgment pervades the process, how can bias be avoided?

In order to assess the role of actuarial judgment in the development of a best estimate, we have set out the steps associated with a typical loss reserving process model in Appendix A. Here we examine not only the steps involved in arriving at a best estimate, but also list the ingredients and parameters.

After considering the model in Appendix A and observing loss reserving practice, it is our conclusion is that raw data and information cannot, and should not, be transformed into a best estimate without the contributions of a variety of subjective and operational elements. In the following sections, this paper addresses how practitioner intelligence and judgment, the presence of client or employer agendas, and the process of selecting reserving models may substantially impact the quality of the best estimate reserve.

IV. HOW HUMANS MAKE DECISIONS AND JUDGMENTS

The human mind is the most important ingredient in the performance of loss reserving work. First of all, technical expertise and statistical skills are fundamental. More important, however, is the role of practitioner judgment which impacts the entire reserving process.

Judgment is a natural function for humans, utilizing our ability to compare and discriminate. As an activity, judgment requires evidence and insight. Evidence serves as a basis for knowledge while insight is the ability to look at a situation and comprehend its inner workings. Judgments are best when both the evidence and insight is of high caliber and at their poorest when both are lacking. What makes actuarial judgment so valuable? It is an actuary's insight (feel for the numbers and mathematical ability to detect patterns) and skill at working with evidence (data).

Actuaries are mature practitioners whose skills are applied after years of cognitive training. In evaluating the mental abilities of the actuary, it is instructive to consider the developmental stages adults pass through. The evolution illustrated by this maturation defines what an adult should be capable of with regard to thinking and making decisions. As infants, our minds start to develop mental habits and constructs, such as causality, categorization, and the recognition that something may exist even if it is not currently perceivable. As older children, we acquire fundamental skills in counting, reading, and reasoning. We also develop social skills, such as the ability to work in groups, assume specific roles and responsibilities, and how to negotiate and compromise. As teenagers, we investigate identity issues, integrate more of our skills, and develop a greater appreciation for context and situational agendas. Finally, as college students and actuarial test candidates, we refine our skills and test our commitment and knowledge through our coursework and actuarial exams. As adult practitioners, we focus on elements of our business relationships, such as client relations, ethics, professional standards, collaboration, and our contributions to company success.

Actuaries have a vested economic interest in the widespread recognition of the value of their practitioner judgment. It is the greatest defense against the incursion of computers and non-actuaries into the loss reserving role since statistical and actuarial methodologies may be easily copied by others. Restated on a more positive note, professional judgment encapsulates the value added by actuaries in the development of a best estimate.

Human Cognitive Limitations

The significant constraints on the mental capability of reserving practitioners belies the precision generally associated with loss reserves established through actuarial methods. These limitations are associated primarily with human intelligence and judgment, and affect the knowledge and performance of the actuary.

It goes without saying that humans are unable to peer into the future, nor are they omniscient regarding current conditions and historical events. Aside from these readily-acknowledged limitations, each individual's cognitive processes are hobbled by the organization of the brain. For instance, humans have trouble working with complex long-term models, are vulnerable to committing specific cognitive errors, and are unable to overcome their own subjectivity in applying their judgment to statistical and business problems. These issues conspire to bias and corrupt the quality of the actuary's reserving work.

Appendix B discusses how human cognition and mathematical ability are limited by physiological considerations.

Human Judgment

The human limits on intelligence, which are summarized above, serve to limit the quality and sophistication of the reserving work by reducing the complexity of the reserving models and the thoroughness of the analysis. In addition, there are several issues which may introduce bias to the analysis through the actuary's use of professional judgment.

Actuarial judgment has been established as the prerogative of the actuary to adjust formulaic results in order to develop a projection which is in concert with the intended application of the analysis. As noted earlier, opportunities for applying judgment occur throughout the reserving process: when selecting the model to use, evaluating historical patterns, adjusting raw data, identifying outliers, recognizing trends, considering the use of external statistics, etc. However, the actuary must recognize that, by employing judgment rather than utilizing a strictly formulaic approach to generate reserve estimates, the analysis becomes more of an art than a science. Of utmost concern is the possibility that the best estimate may be corrupted by judgmental biases regarding which the reserving practitioner is unaware.

This paper groups the sources of judgmental bias into three categories. **Artistic Feeling** addresses the emotional connection which actuaries establish with various types of numbers and data, the habits and expectations which develop from this psychic association, and how these tendencies affect the performance of the reserving work. **Inferential Errors** refers to the common mental mistakes which all humans (including mathematicians and scientists) are prone to making in assessing probabilities and developing forecasts. The **Business Systems** category considers the work environment in which actuaries operate, focusing on how working in groups or under certain expectations may bias, or otherwise affect, the quality of their reserving work. Please note that while the ensuing information comes from social psychology

research, the definitions associated with these three categories, and the names used for them, are the authors' invention.

JUDGMENTAL BIAS - ARTISTIC FEELING

Often what we believe to be objective approaches for solving problems are vulnerable to our own subjective issues. Actuaries do not operate as hyperobjective robots; instead, we have psychological incentives for reaching particular conclusions. These motivations should not be confused with those associated with wanting to keep clients happy nor with shortcuts taken in order to expedite the work. Instead, it is important to recognize that humans regularly project order and meaning onto their environments. These schemes correspond to a cognitive equilibrium or self-actualization towards which practitioners unconsciously strive in the course of their work. It may be expressed via artistic sensibilities or the craftsmanship through which actuaries may approach their work. These tendencies are very subjective and reflect the issues, habits, biases, and experiences connected to each individual. Insofar as reserving practitioners attempt to project meaning, establish order, and hunt for trends in the course of their reserving work, the objectivity, replicability, and accuracy of their analysis may be vulnerable.

Actuarial Characteristics

Since the projection of meaning is directly related to the practitioner's own issues, it make sense to ask: "What type of person becomes an actuary?" In other words, how homogeneous is the population of actuaries, and how might this homogeneity reduce the range of approaches utilized? How may the outcomes of actuarial work be thereby biased?

The vast majority of actuaries have college degrees, with many earning their masters degrees and doctorates. This indicates not only a certain skill set, but also a set of attitudes. There is a quantitative bent to actuaries, as well as a comfort with information systems and technology. In their articles, both Shrum and Patrick find actuaries to be intelligent, conservative, quantitative, reductionist, analytical, conscientious, self-disciplined, and studious. These are obviously appropriate qualities for performing reserving work, or any knowledge work for that matter. However, other attributes -- such as optimism, orientation towards the big-picture, or sensitivity to operational issues -- may also be appropriate in the course of reserving work.

In her discussion of the Strong Interest Inventory, Patrick finds that actuaries can generally be classified as Conventional and Investigative.[3] The Investigative ("Thinkers") category refers to people who possess strong math and science, analytical, and writing skills and have less well-defined verbal, interpersonal, and leadership abilities. The Conventional ("Organizers") profile suggests an aptitude for math and organizational skills, with weaknesses associated with creativity and verbal skills. It should be noted that Patrick's results were developed from a survey of members of the American Academy of Actuaries, so they probably apply to both life and casualty actuaries.

It would be of greater relevance to our discussion to determine general characteristics for those who establish property & casualty loss reserves. How do casualty actuaries compare to life actuaries, what type of actuary gravitates to loss reserving rather than to ratemaking, and which professionals are more likely to pursue consulting careers versus insurance company work? Unfortunately, no material concerning these issues appears to have been published.

Physiological Issues

Although most actuarial activity is cerebral, the distinction between mind and body is not absolute. Research indicates that physiological issues have some very real effects on how we learn, remember, and process the information used to make calculations and professional judgments. Human performance is constrained by the perceptional, psychological, and physiological composition of our minds.

External Stimuli

Mild shifts in our emotions have been found to influence our creativity, memory, problem-solving, risk-taking, and interpretation of ambiguous stimuli -- the building blocks of decisionmaking and judgment. Often, however, these emotions are not related to the task at hand and just result in impeding performance.

For instance, based on the context, external stimuli can evoke both physiological reactions and changes in our emotional states. An individual's recognition of physiological changes in the body can also trigger emotional responses. For instance, people who finds themselves yawning may conclude that they are tired and start to feel more drowsy. In addition, cognitive issues can also affect our emotions.

As professionals whose primary value-added contributions are associated with practitioner judgment and assessment, actuaries should be wary of the effect of external stimuli or emotional responses on the quality of their work.

Memory

Human performance is bound up in the utilization of our memory. In other words, what we know is bound up in what we can remember. Unfortunately, our memory is not a steady reservoir of objective information. Instead, its performance is subjective and inconsistent.

The brain stores each memory by breaking it up into fragments and scattering them throughout various regions of the mind. Accurately retrieving a particular memory requires collecting these -- and only these -- pieces. However, the purity of memory is not easy to keep intact. As a result, the process of reconstructing memory uses logical inferences to fill in missing details or associated memories. Extraneous material -- from other memories, dreams, conversations, experiences, the media -- may also become associated with the memory of specific events. This can occur because information regarding the origin of a memory deteriorates more quickly than its other aspects.

Research indicates that short-term memory can hold only 5-9 chunks of information, where a chunk is defined as any meaningful unit of cognition, such as digits, words, chess positions, or people's faces. In addition, memory is highly prone to suggestion, a fact which is used to cast doubt on repressed memory syndrome and witness testimony. These limitations have very real effects on actuaries who rely on their memory to integrate information gleaned from a variety of sources together with the knowledge and skills they have acquired over time.

Optical Illusions

Optical illusions are a familiar example of the role and limits of the human mind in capturing reality. They arise from the role the human mind plays in visual perception. Our retinal images, whether of a two-dimensional image or of three-dimensional objects, are flat representations on a curved surface. Because there is a many-to-many mapping between objects and retinal images, for any given retinal image, there are an infinite variety of possible three-dimensional structures that may apply.

However, humans are still able to perceive an accurate world of depth, surfaces, and objects. This is because both evolution and experience have readied the mind to project order in an effort to supplement our visual capabilities. What makes the visual system so interesting -- and so much like the decisionmaking and memory retrieval processes -- is that many different ways have evolved in order to resolve ambiguity and arrive at an interpretation of reality. Those few times when we settle on an incorrect visual interpretation, an optical illusion occurs. These illusions are a powerful tool for revealing the process by which our vision and perception are mediated.

Amount of Information

Although actuaries are invariably hungry for data, an abundance of information has been known to actually hinder decisionmaking rather than facilitating it.

"Anyone who has a lot of information, thinks a lot, and by thinking increases his understanding of a situation will have not less but more trouble coming to a clear decision. Once we gather a little information, however, we run into trouble. We realize how much we still don't know, and we feel a strong desire to learn more. And so we gather more information only to become more acutely aware of how little we know.... As we gather more and more information, our conviction that we have formed an accurate picture of the world gradually gives way to doubt and uncertainty. The more we know, the more clearly we realize what we don't know. This probably explains why we find so few scientists and scholars among politicians. It probably also explains why organizations tend to institutionalize the separation of their information-gathering and decisionmaking branches. Anyone who is fully informed will see much more than the bare outlines and will therefore find it extremely difficult to reach a clear decision." [Conge]

<u>Subjectivity</u>

Humans naturally have self-serving biases. For instance, the way we interpret events are driven by factors associated with our need to satisfy ourselves and maintain our emotional health. As a result, our self-awareness (and self-regulation) of all facets of our own skills and performance -- our levels of effort, precision, quality, bias, and knowledge -- are grounded in subjectivity. Memory also reflects this bias: information relevant to the self is easier to retrieve because the mind processes it more deeply and organizes it better than other forms of information. Other individual biases arise from the existence of personal tendencies and habits.

As individual practitioners, we develop close personal associations with particular methods, assumptions, or computer applications with which we have become familiar. These may be those that have worked for us in performing other projects, in the course of the prior year's review, or on which the actuary has received special training. Again, this is not a decision made based on productivity or laziness, but reflective of the identification of the actuarial craftsman with the available mental tools.

The self-fulfilling prophecy is a well-known bias in which a false attribution leads to a new behavior which itself causes the originally false conception to come true. Actuaries often work on projects on which they have developed expectations regarding the outcome of their analysis. This expectation may also include ideas about how the data should look, what constitutes an outlier, what the trends might be, how much variation is appropriate, what a believable explanation of a data anomaly may be, and what "just doesn't look right." Given the pervasive use of professional judgment in reserving, it is not difficult to see how a priori expectations may bias the conclusions of the analysis. In an effort to clarify the impact of this tendency towards subjectivity, it may be useful for the reserving practitioner to state what the expectations are before starting the analysis.

While independence may not be the most important consideration in developing an appropriate best estimate, the idea that an expectation developed before the completion of the analysis could have a material effect on the results makes us uncomfortable. In addition, the fact that the same models and industry data tend to be used by reserving actuaries begs the question: Is each reserve review really independent?

Numerical Preferences

Some of the issues associated with human subjectivity also affect how they work with numbers. Not only do humans project meaning in the course of their work, they also identify with their results. At times, they internally "cheer" for, and gain satisfaction from, particular outcomes. These responses are independent of the rigor or precision of the analysis. For instance, we have been told by individual actuaries that, all business issues aside, they feel more comfortable (and even get enjoyment out of) developing relatively high reserve estimates. It is obvious how this psychic involvement may bias the selection of the best estimate.

Associated with this issue is the fact that humans have personal responses to specific types or sets of numbers. For instance, we prefer to work with integers, "round" numbers or factors, and those ending in 0 or 5. Whether this is due to the ease of using these types of numbers or in order to achieve some internal equilibrium, these preferences do affect the way reserving actuaries work with their data. Reserving actuaries often adjust for data with which they are less comfortable, such as negative numbers or factors less than unity. These adjustments can always be explained away rationally; however, the tendency to regularly make adjustments in only certain situations is indicative of a bias.

This discomfort with particular categories of numbers has a historical precedent in the reaction of the Pythagorean school to the discovery of irrational numbers. Pythagoreans held that positive integers had a fundamental, mystical significance which embodied an eternal truth. They believed that numbers had a physical existence, from which the universe was constructed, perceivable only to the soul and not to the senses. Their arithmetic regarded numbers as sums of units and that all magnitudes could be expressed in terms of integers or ratios of integers. Their philosophy of numbers was bound up in an ascetic lifestyle whose foundations were threatened by the discovery of irrational numbers, then known as an "incommensurable magnitude." Ironically, the discovery of the irrationals followed the application of the Pythagorean theorem to an isosceles right-triangle with sides equal to one. The meaning attributed by the Pythagoreans to this issue, and the role played by mathematical constructs in their lifestyle, illustrates how humans may ascribe meaning to the supposedly objective science of mathematics.

Similarly, through his study of his patients' dreams, psychology pioneer Carl Jung came to believe that the smaller natural numbers are symbols in the same sense that the people and events of our dreams are symbols of character traits and behavioral situations. He speculated that numbers represented the most primitive archetype of order, the building blocks of psyche and matter. Jung posited that integers correspond to progressive stages of psychological development. The number One corresponds to a non-differentiated psyche (lacking self-awareness), Two reflected differentiation or polarity (reactiveness), Three suggests movement towards resolution (similar to Hegel's thesis-antithesis-synthesis model), and Four indicates stability and wholeness.

Presently, there are some actuaries who consider themselves conservative, while some others who call themselves "optimistic." Classifying themselves as such suggests a belief that acting upon one's tendency results in a nontrivial difference in the reserving work. Despite acknowledging these predispositions, all of these actuaries consider their work to be appropriate and accurate.

In addition to these numeric preferences, reserving practitioners often have expectations regarding the nature of their conclusions, well before all the analysis has been completed. It is important to consider how we arrive at an expectation. At times it is based on reserve work completed previously, or based on work performed on other companies or clients. When we are satisfied that our result falls within some pre-established range of acceptable outcomes, how is our work affected? To what extent are we motivated to act (by disregarding results, excluding some data, changing the model, etc.) when our initial analysis falls outside of the expected range? Even when actuaries assume that they are proceeding logically, it is important that they understand the nature of self-fulfilling prophecies and how their internal tendencies and agendas may be driving them subconsciously towards a pre-determined result.

It is difficult to ascertain to what extent the reserving process will be flawed due to these issues. Rather than trying to quantify these very personal mental processes, the primary purpose in identifying them is to create a self-awareness of the psychological stake we have in the results. It is important to recognize that individual biases such as these distort the use of even the most objective and scientific methods.

JUDGMENTAL BIAS - INFERENTIAL ERRORS

The earlier exploration of optical illusions gives us insight into the terrain of the human mind. Just as our minds are fooled by optical illusions, our minds are vulnerable to biases which are hard-wired into our cognitive processes and which cause us to make logical errors.

Heuristic Biases

Extensive research has been conducted in the fields of organizational psychology, philosophy, and statistical decision theory directed towards examining and measuring human cognitive tendencies. Research in these fields has led to the discovery of mental short-cuts, called "heuristics," which humans use for quick assessment and decisionmaking. Thus, it appears that humans do not make decisions based solely on a rational assessment. These researchers have also determined that these heuristics are vulnerable to a variety of common biases. The emphasis of the study of heuristics is not to prove that humans are often irrational; rather, the interesting conclusion is that, even when we try to be logical, we make decisions which are sub-optimal and often inconsistent with the laws of probability.

The errors in judgment associated with these biases are not attributable to wishful thinking nor any kind of incentives. In fact, sometimes the research participants were encouraged to utilize more accurate thought processes. Despite these efforts, humans proved to be consistently vulnerable to these heuristic biases which apparently result from the short-cuts taken by the mind in evaluating complicated odds and complex situations. The consistency and predictability of these biases suggest that any human decisionmaking process, including the use of professional judgment, may be fraught with errors.

Most of the experiments used to define these biases were performed on lay people. However, researchers have discovered that scientists, research psychologists, and mathematicians are as vulnerable as laymen in committing these specific intuitive missteps. In this paper, we are less interested in biases associated with statistical ignorance, but with human reactions to less easily quantifiable situations. It is these obstacles with which actuaries must contend.

Heuristics play an important role in cognition by allowing decisions to be made without the meticulous exploration and analysis of all combinations of variables and conditions. It may be necessary to use these heuristics in order to simplify complicated problems or to expedite the decisionmaking process. However, it is imperative that practitioners recognize the implications of the biases associated with use of these heuristics.

The Fundamental Heuristics

There are several heuristic biases with which humans make judgments and predictions. The three fundamental biases are Representativeness, Availability, and Anchoring and Adjustment.

Representativeness

People evaluate the probability of how likely something is to occur based on how representative it is of how we imagine particular events to be. As a result, we believe scenarios described with greater detail more than scenarios with less detail. This often leads to a situation in which the cojoint probability of two events occurring is considered more likely than the probability of each occurring independently, which is of course impossible.[4]

For example, when reading a description of a tall man who has great dexterity, a competitive nature, and can jump very high, people will tend to attribute a lower probability to the chance that this individual is a male nurse than to the probability that he is a male nurse who plays basketball twice a week. Humans are susceptible to this mistake because of their effort to develop a composite picture of reality based on all available information.

People often do not account for varying reliablities of different sized samples. In addition, they often assume variances in chance within identical experiments, due to differences in how the problem is presented. For instance, when flipping a coin ten times, a result of all heads might be considered less likely than a specific, seemingly random, ordered set of several heads commingled with several tails; in actuality, the probabilities are equal.

In addition, they are likely to ignore underlying statistical evidence or implications in favor of a strong, but relatively baseless, feelings about a less statistically satisfying answer. Though a decision-maker may understand all of the underlying data, there may be a susceptibility to an ego bias -- in which the actuary puts more stock in a possible result which is more attractive or which better fits the expectation. Ultimately, the professional may be tempted to forego results which have been most strongly supported.

Actuaries do not seem to be vulnerable to biases involving Representativeness since they know to consider a variety of factors in determining probabilities, such as prior Bayesian probabilities, sample size, and the nature of chance. However, this bias does affect which outcomes they attribute to chance (random variation) and which they decide have projective meaning. Another issue to consider is that if humans make Representative errors on well-defined sampling processes, odds are that reserving practitioners may commit the same type of errors in hypothesizing about complex business systems.

Availability

The availability heuristic recognizes the human proclivity to estimate the probability of a particular occurrence based on the ease with which it can be brought to mind. Bias results anytime the ease of recall associated with an event is not related to its probability. Earlier discussions indicated how inconsistent memory retrieval could be. The mental availability of an event may be affected by a variety of irrelevant issues: its recency, topicality, concreteness, or emotionally impact. The decision-maker should endeavor to preclude subjective biases in deference to correct statistical interpretation.

The availability heuristic may introduce bias into reserving work if actuaries have difficulty recalling certain outcomes as easily as others, have either experienced or remember only a limited number of episodes, and base their ideas of relative probabilities more on their perceptions or feelings rather than on substantiated statistical results. In particular, biases associated with the retrievability of similar examples may affect the level of conservatism in reserving. It may be applicable in describing the range of possible outcomes/processes which appear in the data, relative to the appropriate frequency of such instances. It may also be applicable in assessing the memory/knowledge of the actuary.

Anchoring and Adjustment

When estimating or making judgments, people are overly sensitive to any point of reference (anchors) which had been established in a prior period. Even when people dissent from this initial starting point, and believe that this anchor was arbitrarily set, they are unable to ignore it; as a result, the magnitude of their adjustment from the anchor is inappropriately low.

For instance, a retailer might greatly mark-up an item, and then announce a sale on it. Since the public's anchor is the marked-up price, they believe that they are getting a good deal when they sees it on sale, despite the fact that the original value of the piece may be less that the sale price. Another example is the power of stereotypes and prior expectations. In addition, research on auditors has revealed that their work and decisions are inappropriately anchored to unaudited values. This heuristic bias also has considerable application to actuarial practice.

Actuaries work with values, factors, or ratios derived from formulas. Often the actuary decides that these numbers should be adjusted to reflect prospective conditions. When the reserving practitioner relies on judgment to make these corrections, the Anchoring and Adjustment heuristic may affect the adequacy of the adjustment. The main issue is insufficient adjustment from the last value, or average of all values, or the prior estimates in selecting the prospective value. As a result, the projected value may be overly close to historical numbers.

One important example to consider is the use of reported claim data to project unreported claim amounts, paid claim data to project unpaid claim amounts, and older exposure periods to project claim activity to take place in future periods. All of these "anchors" require adjustment; the amount of this adjustment is invariably an actuarial judgment.

Specific Judgmental Biases

Behaviorists argue that ultimately accurate analysis is likely to be impeded by the representative, availability, and anchoring heuristics. Perhaps in some fields, it is acceptable to allow for individual preference and relatively baseless perception and emotion. However, in order to reach accurate conclusions in the actuarial sciences, the professional must limit both emotional biases and mathematical shortsightedness. Therefore, it is important to recognize that these three fundamental heuristic biases give rise to a variety of specific behavioral and cognitive effects which themselves impede judgment.

Insensitivity to the Prior Probability of Outcomes

When given basic information regarding the frequency of particular outcomes in a certain population -- for instance, the percentage of accountants in the workforce or percentage of registered nurses who are male -- people generally have no problem developing expectations of the outcomes of random samples which are consistent with the laws of probability. For instance, if told that 5% of the people at a particular party are professional actors, most people understand that there is a 5% chance that a randomly selected party-goer is an actor. However, when collateral information is made available about the sample, humans have a tendency to ignore the prior probabilities, and make judgments by focusing on this new information, particularly when it conforms to their intuitive theories. Assuming the other 95% of the attendees at the aforementioned party are accountants, if people are told that an individual party-goer with a flamboyant personality has been randomly selected, respondents are prone to attribute a higher probability to the selection of an actor than of an accountant.[6]

This willingness to ignore base rate information stems from the availability heuristic and occurs even when the additional information is irrelevant. While we do not believe that actuaries are particularly sensitive to this bias when data is available, they should be aware of other judgments they make regarding more qualitative issues. In addition, it is rare for actuaries to specifically identify the prior probabilities of outcomes.

Context Dependence & Framing Effects

Judgments are sensitive not only to the merit of the alternatives, but also to the context in which they appear. The way an argument is framed often affects the decision-maker's response to it, primarily because this framing plays the role of an anchor. For instance, the evaluation of an option is dependent on how it compares to other options presented, in what order they are all presented, feelings about external issues which may be related, and how the description of the issue is phrased. Similarly, research shows that 25-30% of survey responses reflect pseudo-opinions which have been evoked by issues such as these. Context dependence may affect the actuary's selection of reserving methods, explanations of anomalies in the data, and choices regarding with whom to work.

Phrasing an issue in terms of a loss or a gain has also been shown to have a significant effect on people's responses due to risk adversity and utility values. For instance, problems framed as a loss induce people to risk absorbing a greater expected loss in exchange for the possibility of avoiding any loss at all.[5] We believe that the judgment of actuaries, who have a more sophisticated mathematical background and who are comfortable with manipulating and transforming numbers, are less sensitive to this particular type framing. Because the non-actuarial professionals with whom they work and to whom they present conclusions may be more reactive to these issues, actuaries should be careful of the way they characterize issues of risk and variance in their work and the phrasing they use in discussing their results.

The Law of Small Numbers
The belief that the characteristics of an entire process or population will not only be represented globally in the entire sequence, but also locally in each of its parts, to a much greater extent than probability theory would suggest. Stated another way, by examining a small sample, people overestimate their ability to draw conclusions about the entire population. Unfortunately, many traditional reserving methods are premised on reading too much into small amounts of data.

Reserving actuaries typically behave as if a small random sample is highly representative of the population's principal characteristics, thereby expecting that another small sample will exhibit essentially the same traits. To avoid this law of small numbers bias, actuaries may choose to incorporate a more rigorous hypothesis-testing approach to their work. They would thereby calculate and consider the significance level, power, and confidence intervals associated with their work and estimates.

Regression to the Mean
One application of the law of small numbers occurs when people believe that the available information has perfect predictive accuracy and do not consider the possibility that this may represent an exceptional outcome. In any series of random events, an extraordinary event is most likely to be followed, just by luck of the draw, by a more ordinary event. When dealing with a result which differs greatly from the mean, it is important to realize that when the experiment is done again, the resulting answer should more approach the mean.

Researchers studying heuristics dealt with fighter pilot trainers who used negative reinforcement with students who had just had a particularly poor flight. These instructors thought their methods were helpful since their trainees would almost always fly better in the next run. However, the researchers realized that, due to random chance, the pilots were more likely to fly better regardless of the reinforcement. In the world of sports, regression to the mean has been used to debunk the "hot hand" and "sophomore jinx" myths.

This heuristic should give actuaries pause before they identify trends in the data. They should be vigilant in identifying, and determining what they should read into, outliers.

Sunk Costs
When people invest significant time and effort in working toward a particular outcome, they lose their ability to objectively assess its value. Sometimes, the rationale for a project dissipates or is surpassed by another alternative. Even when this occurs, it is common for people to give undue consideration to the investment that was already incurred, although, in reality, these investments are *fait accompli* and should not affect the utility calculations or strategy associated with choosing the optimal approach.

Similarly, an actuary who has mastered a particular reserving approach -- for instance, the use of a particular method or software product -- is likely to utilize it in subsequent reserve reviews, even if superior methodologies have emerged.

Hindsight Bias
Another mental bias results from the presence of a posteriori knowledge of an event's outcome. This hindsight bias has a significant effect on judgment and our sense of our own knowledge and cognitive processes. Humans are unaware that outcome knowledge has an effect on their

perceptions; even when they are made aware, they are unable to ignore or rescind the effect of that knowledge. Often, they also fail to accurately remember what their a priori predictions were, which gives new meaning to "I told you so." The end result has been called "creeping determinism," the tendency to perceive reported outcomes as having been inevitable. This inability to reconstruct judgments may be associated with the anchoring, representativeness, availability, and law of small numbers biases.

Hindsight bias has a significant contribution to make in terms of interpreting best estimates. Loss development is a function of time and our inability to precisely predict the future is what makes the precision and biases associated with a loss reserve so important. Actuaries utilize the concept of a valuation date to define the liabilities under review (particularly with respect to on-going business). In addition, the valuation date reflects the loss development which the liabilities have undergone, as well as the knowledge of that development which is available to the actuary. Sometimes actuaries develop reserves for a set of liabilities well after the valuation date of the study. In this case, it is not unreasonable to believe that the actuary may employ knowledge of subsequent loss development in setting a best estimate, consciously or subconsciously. The hindsight bias suggests that an actuary cannot undo the effect of this knowledge -- and we are not convinced that, in the interest of accuracy, this is worthwhile to attempt. Perhaps it makes sense to recommend that a best estimate be described not only by the associated valuation date, but also by a "knowledge date."

Overconfidence

Researchers report that the majority of people rate themselves as better than average (i.e., above the median) in any of a wide variety of tasks, including knowledge of trivia, driving ability, and hearing acuity. Even experts are appallingly overconfident within their areas of expertise.

It has unfortunately been our experience that sometimes actuaries exhibit overconfidence -- with regard to the faith they have in their projections and the sophistication of their methods, and how they rank their knowledge and professionalism against that of non-actuarial insurance professionals. Overconfidence blinds people to the need to reduce risk, act with forethought, seek feedback, and constantly review one's own performance and accuracy. Perhaps actuaries would be wise to develop external mechanisms for evaluating the quality of their work.

Illusory Correlation

Correlation is a measure of the strength of the association between events. When the association is based not on a rigorous, statistical study but is instead determined judgmentally, the risk of illusory correlation is very real. Apparently, the availability and representative biases lead humans to perceive correlation where it does not exist.

Reserve practitioners are susceptible to inappropriately identifying correlations in their analysis of loss data. The challenge is for them to use the statistical tools and know-how which is at their disposal in order to avoid such mistakes.

Confirmation Bias

When trying to explain the occurrence of an event, humans have a tendency to seize upon any evidence which may constitute an explanation. We believe that the subjective and judgmental elements of reserving practice lead actuaries to be are particularly vulnerable of this. Often they encounter an unexpected result for which it may not be easy to determine the cause -- why numbers do not balance, why the best estimate changed so much, why loss ratios have increased -- and proceed to brainstorm possible explanations. Humans are often satisfied with

the first idea which explains the direction of the anomaly, without regard for its feasibility. Sometimes, actuaries will seize on a justification, and a few minutes later realize that the explanation actually indicates the opposite; the explanation then gets rejected and the search continues for another reason. Meanwhile, the existence of the first idea should represent even greater concern. The confirmation bias is not only inaccurate, but also intellectually dishonest.

Another interesting bias is summarized in Sholom Feldblum's article, in which he points out that while appointed actuaries sign (unqualified) statements of actuarial opinion indicating that their company's reserves make a reasonable provision for its liabilities, these same actuaries, when surveyed, report a belief that the insurance industry as a whole is significantly under-reserved. "How can each company's reserves be adequate and the industry's deficient?" [p. 6] This hints at another type of cognitive bias which perhaps reflects either overconfidence, a "not my kid" blindspot, or a lack of agreement of what constitutes an appropriate best estimate.

Other Biases

Humans also have the tendency to overestimate the likelihood of an event that is familiar or dramatic, that is under one's control, or that is beneficial, while underestimating the probability of negative events. Other judgmental biases include:

- Association Bias, in which an individual tries to repeat past success by choosing strategies more related to the past situation than to the current set of circumstances.
- Escalation Phenomena, in which an individual finds it difficult to abandon a course of action and ignores feedback that the process is failing.
- Self-serving Bias, in which individuals take credit for successes which occur, but deny responsibilities for failures by blaming external issues or circumstances out of their control.

Several of the biases discussed may exist in the same analysis, and may serve to contradict each other. For example, the law of small numbers and availability may serve to overemphasize recent and rare events, while the anchoring and adjustment heuristic may suppress the amount of the deviation which is attributed to the probability of these particular events.

Why do these biases exist? Despite experiencing the reality of these heuristic issues throughout their lives, humans do not interpret their experience in a way that allows it to be coded as a lesson in probability principles or in the accuracy rate of their judgments. Clearly, there are important cognitive efficiencies or psychological benefits associated with these mental shortcuts. Unfortunately, these mental habits are likely to interfere with the cognitive sharpness required for the development of accurate and unbiased best estimates.

JUDGMENTAL BIAS - BUSINESS SYSTEMS

There are a variety of issues which arise in the business environment which affect how the actuary performs at work. Actuaries fulfill a specific financial and organizational role which determines the type of projects they work on, impacts how clients or other employees relate to them, and affects their own self-image. This positioning affects the nature of the judgment and selections which the actuary employs in the course of the reserving work. An actuary must contend with both subtle and obvious incentives for producing biased reserve estimates. For example, an actuary may strive to keep the client happy and thereby maintain consistency with

the results of prior reviews. Since these biases are contextual and self-defensive, they differ from the artistic biases discussed above.

Roles Played By Actuaries

Self-Image Issues

The reserving professional's self-image has an effect on the way the work is performed, expressions of suggestions or direction, and the level of conservatism in the analysis. For instance, actuaries are more likely to adhere to a straight-forward, formulaic approach to reserving if they view themselves as: scientific truth-tellers, lacking an agenda or bias, and the last bulwark against insolvency and inaccurate financial statements. Such a practitioner may interpret any contact with business managers or clients as representing inappropriate pressure. On the other hand, an actuary who identifies primarily as a business manager -- and is less focused on the mathematical knowledge which non-actuaries lack -- is more likely to entertain input from business managers. Perhaps a financially-oriented actuary would exhibit a greater concern for the impact of changes in the best estimate on the annual statement, the collectability of ceded reinsurance, and calendar year payout projections.

What perspective would an actuary who identifies more as a ratemaking practitioner bring to the reserving analysis? If the self-perception of analysts also impacts how they perform their work, how do their reserving practices change when they become credentialed? Does their role affect their comfort level in saying "I don't know"?

We believe that it is appropriate to expect that the caliber of the reserve analysis and the selection of the best estimate will vary based on the role the actuary has been assigned in the reserving process. For instance, the actuary may serve as an employee, a consultant, or a peer reviewer, asked to give a second opinion or sign the Statement of Actuarial Opinion, or selected by regulatory authorities. Who we are and how we approach our work changes from project to project, based on our roles, constraints, and motivations.

Partisanship

In setting IBNR reserves in support of an offer to commute a reinsurance contract with a (re)insurance company, is a best estimate required? How partisan (i.e., biased) can an actuary be on the company's behalf (gross ethical or legal violations aside)? In his article, Sholom Feldblum points out that reserving actuaries play two roles -- as a professional expert who assesses reserve adequacy for state regulators (and for the public good) and as a business manager acting on behalf of company management (for the benefit of shareholders). While the AAA's Code of Professional Conduct appears to allow partisan analysis, it is still important to ask: given this duality of agendas and responsibilities, how can an actuary avoid bias?

Bias & Client Relations

If given a choice, actuaries would universally choose to select a best estimate which is exactly accurate. However, given the uncertainty involved with projecting future events, actuaries may consciously bias their selection in recognition of their working relationship with their client or employer. Sometimes this bias will be on the low side which is generally what the risk-retaining entity prefers. At other times, the actuary will select a best estimate value which is artificially high, with the knowledge that it is relatively easier to lower the estimate over time, but raising it is more politically difficult.

In the performance of reserving work, there are many opportunities to be conservative since selections and assumptions are made throughout the process. For instance, decisions must be

made in terms of evaluating link ratios, recognizing trends, selecting methods, picking discount factors or payment patterns, and identifying and treating outlying data points. The level of conservatism built into the best estimate will vary based on which (combination of) reserving activities are performed conservatively and to what extent.

Similarly, when actuaries want to be conservative, they may find themselves compromising and being more moderate or liberal in some assumptions. This happens when the actuary has been so conservative in the first few decisions that were made that there is a tendency to let up eventually or finally relent in the face of complaints or issues raised by client. The problem is that nobody is keeping score in terms of the magnitude of the conservatism associated with each of these decisions, and how the best estimate will ultimately be affected.

Whether conservative or optimistic, the actuary will have to eventually adjust the ultimate loss estimates in light of how the losses have developed. The timing and severity of this reserve adjustment are other issues to consider.

Of course, actuaries may be put into a position in which they are pressured to override their best judgment. This may be more likely to be the case when the client account is considered too valuable to lose, or when company profitability and officer bonuses will be affected. Actuaries may be exposed to arguments by high-level individuals that IBNR is not real, that development will take place into the distant future, or that the use of nominal reserve estimates rather than discounted dollars is a distortion. Organizationally reporting directly to non-actuarial business leaders or account managers may offer the actuary insufficient political cover. In the face of this pressure, some actuaries may be inclined to incorporate the client's explanations for recent results (even if these arguments are self-serving and not always substantiable), disregard their professional intuition, or otherwise adjust their selections.

Other issues related to bias and client relations are identified in Appendix C (External Consultant Turnover).

<u>Group Performance</u>

It often makes sense for reserving professionals to work in groups. The inclusion of a variety of people suggests many benefits: the sharing of knowledge and information, a larger constituency and support for group decisions, and greater efficiency and coordination. Despite this expectation, however, the creative and analytical performance of individuals in group settings is often sub-optimal. Poor group performance hinders communication and quality control, and sidetracks attention towards tangential and harmful issues. When these group dynamics take place in the course of a loss reserving analysis, the accuracy and objectivity of the best estimate is threatened.

Personal Differences In Style

The individual personalities of decision-makers and group participants affects the quality of their judgment. The Myers-Briggs Type Inventory has identified four different personality dimensions.

1. Introversion / Extroversion - Extent to which one understands the world through acting and reacting to it or through careful contemplation.
2. Sensing / Intuition - Reliance on careful detailed observation of hard information or the intuitive perception of patterns and relationships by reading between the lines.
3. Thinking / Feeling - Extent to which logical analysis or personal values affect decisions.

4. Judgment / Perception - Preference for structure and planning versus flexibility and spontaneity.

These types are simply preferences held to a greater or lesser extent by everyone. Their existence indicates that decisionmaking is a complicated and highly personal process. While practitioners gravitate toward particular traits and habits, they may find that, in given situations, they may choose (or be encouraged) to operate against our preferred type.

Other personal factors which practitioners possess to varying degrees and which influence decisionmaking include:

- thoroughness (willingness to analyze all the costs and benefits)
- hesitancy (tendency to start on one action then change course)
- social resistance (unwillingness to take advice)
- control (enjoyment of decision making and feeling of being in control)
- instinctiveness (making decisions on gut feeling)
- idealism (valuing principles over practicalities)
- perfectionism (searching for better optimal solutions rather than just satisfactory ones)

Group Dynamics

Subpar performance by groups is generally driven by "group-think" dynamics. Group-think occurs when a group's need for total agreement overwhelms its need to make the wisest decisions, and when the members' needs to be liked and accepted overwhelm their ability to disagree with poor decisions.

Group-think occurs most often in groups which are composed of homogeneous membership, lack impartial leadership, are unable to call upon methodological standards, and are insulated from other organizational constituencies. To exacerbate these structural flaws, group processes seem to facilitate intellectually dishonest and shallow discussions. Researchers report that it is typical for participants in these groups to overestimate their collective ability, shield themselves from adverse information, develop mass-rationalizations, stereotype external opponents, and pressure each other towards uniformity. As a result, these groups tend to fall short in accurately assessing their objectives, information resources, possible alternatives, and the risks associated with their decisions.

Decisions made by groups are sometimes more risky or cautious than its individual members' decisions would be. This phenomenon occurs due to a process known as group polarization. The process initially starts when the members of a group express perspectives on which there is a difference of opinion. The difference of opinion becomes more polarized as participants are forced to substantiate their convictions and develop new supporting arguments. Meanwhile, moderate or undecided group members take sides, leading to the polarization. Finally, the proponents argue so vehemently and identify so much with their stances that when the deadlock is broken, only an extreme decision sounds reasonable.

Group Roles

Groups are often dominated by one person, whether selected or self-appointed. These leaders play a key role in the effectiveness of the group, particularly with respect to staying on track, working through conflict, and the need for consensus. Even when leaders have little official power of enforcement, group members may feel compelled to follow commands from an authority figure.

In addition to leadership roles, group participants may adopt other roles, some of which may correspond to highly charged family dynamics. When participants "act out" -- whether as a father figure, a favorite child, a consensus-building middle child -- the positions people take and the alliances they build correspond to hidden, unrecognized, inarticulated agendas. The deep emotional components of these roles distort the participants' investment in a successful completion of the project.

In those situations in which these "family dynamics" are able to avoided, the participation of group members may not be based strictly on their merits. Clearly the risk of stereotyping the abilities of, or limiting the participation of, people with different racial or ethnic backgrounds is not an infrequent occurrence. Even when participation is not limited due to such base biases, group members may be inappropriately engaged, simply based on their credentials, seniority, or reputation. In addition, studies have established that humans have a tendency towards attributing positive characteristics to physically attractive people. It is clear that no matter what an individual looks like or has experienced, the emphasis on anything other than the merit of any and all participant's ideas will result in the sub-optimal processes produced in a group-think environment.

Group Communication

Groups can improve their prospects for success by focusing on the basics of communication. First of all, the need for well-defined objectives and expectations, intragroup trust and focus, and precise language and terminology, cannot be overestimated. There are also less obvious issues which affect the level of constructive communication: the size of the group, the size and layout of the meeting room, the shape of the conference table, and the positioning of people around the table.

One way that groups reach consensus is through the use of persuasion. While we would like to believe that the exchange and acceptance of ideas is based solely on merit, our moods and temperament affect our openness to the ideas of others. Group dynamics and the roles we adopt also impact our willingness to listen to others.

The use of poor analytical skills -- through polemics such as: appeals to authority, character assassination of dissenters or opponents, refusal to concede any compromises or weaknesses associated with beliefs, harping on trivial flaws of opponent's argument, the use of anecdotes and post hoc observations as proof, changing the guidelines or application of the analysis to fit the conclusions -- will result in inferior conclusions, decisions, and recommendations.

While these group-think dynamics may sound alien to the reader, research has confirmed them as a common occurrence which affect not only work groups and task forces, but also organizations as a whole. The poor performance of individual members of these dysfunctional teams is grounded in the transforming power of social pressures that are implicit with all groups. Research indicates that if these issues can be avoided, groups can deliver better decisions than individuals with respect to problems requiring quantitative and logical skills, and a wider range of knowledge.

Changing A Decision

Once a judgment or decision has been made, there is still an opportunity to change it. While regret, peer review, or reevaluation of the work may suggest that a new decision be made,

humans are often unreceptive to the idea of changing their judgments. These psychological defenses include:

1. Selective Exposure, whereby individuals focus primarily on the positive features of their decisions and forget about other options.
2. Rationalization, through which humans develop reasons a posteriori for the decision even though these specific arguments had not been used to motivate the decision originally.
3. Commitment. Faith in the decision grows as the individual psychically invests in it. This defense reflects their identification with the decision as a personal issue, not based on its merits.

Cognitive dissonance exists when a person simultaneously holds two inconsistent beliefs or behaves in a way which is at odds with personal beliefs. People tend to change their beliefs (at least temporarily) in order to re-establish consistency with their behaviors, often using the three psychological defenses listed above. For instance, if an actuary sets out to perform an extensive reserving analysis and runs out of time before accomplishing all of these tasks, this individual is nonetheless likely to develop a best estimate, express confidence in the work which was completed, and downplay the importance of the unexamined issues. Another example is when the results of the reserving analysis differs noticeably from what was expected, the practitioner is prone to justify the latest results by grasping at any plausible explanation.

In general, people are reluctant to give up a course of action which they have contributed to and invested in. The mental activities which reinforce their comfort with their decisions play an important mental health role in reducing anxiety, perhaps at the expense of best estimate precision.

As numbers-driven as actuaries may be, we are susceptible to the same emotional needs, judgmental flaws, and myopic self-satisfaction. As mathematics historian Morris Kline wrote, "Mathematicians, let it be known are often no less illogical, no less closed-minded, and no less predatory than most men. Like other closed minds they shield their obtuseness behind the curtain of established ways of thinking while they hurl charges of madness against the men who would tear apart the fabric." [McNeill, p. 60]

Summary Of Cognitive Issues

In association with the general limits on human intelligence and the cognitive forecast errors to which we are all vulnerable, the individual actuary's internal agenda, reaction to specific statistical patterns, and sensitivity to the work environment all have a significant impact on the reserving process. In the performance of each reserve valuation, these considerations culminate in a unique best estimate value. In fact, each actuary may be viewed as a reserve estimator -- whose "parameters" have been set by a combination of genetics, education, and experience -- which produces estimates in response to specific sets of data, reserving models, and business realities.

In the following section, the role which business constraints and model selection play in developing the reserve estimates is analyzed. These issues provide the context in which many of the cognitive considerations discussed above are acted out. Compared to the issues outlined already, the discussion that follows focuses on items that are less general and pervasive. Rather, significant variation exists with respect to business considerations and model selection. These issues are more self-evident, malleable, and may already receive

attention from actuaries. Because of these considerations, the following sections of this paper are shorter.

V. PRACTICAL ISSUES

In addition to the sources of human bias and imprecision which are discussed above, there are issues which are more specific to the reserving actuary. Other obstacles to the development of a precise Best Estimate may be found in the constraints associated with the work environment and in the selection and use of actuarial methods. However, because work and methodological issues reflect local conditions and processes, it is difficult to quantify any inherent biases or inaccuracy which may exist.

The Work Environment

In addition to the limits associated with human intelligence, judgment, and social psychology, there are other significant contributions to the imprecision and bias of the best reserve estimate which arise from constraints in the work environment. Unlike the subconscious decisionmaking issues discussed earlier, the work environment is under the control of human practitioners. An examination of the resource constraints actuaries tend to face may shed light on how they may be able to improve their best estimates through improvements to their work environment.

The goal of the reserving process is to evaluate the liabilities likely to develop in the future by carefully considering a wide variety of relevant issues.[7] This process requires the ingredients and parameters listed in the loss reserving model of Appendix A, such as time, data, technology, knowledge, effort, and quality. The availability of these resources is generally restricted by a budget or other institutionalized limitations. This budget is usually implicit; however, for consultants, some aspects of it may be explicit. Constraints on these ingredients and resources leads to the idea of bounded rationality.

The bounded rationality model recognizes that decision-makers face limitations which constrain rationality in the decision process. When decision-makers are forced to operate with limits, their analysis results in sub-optimal decisions. How severe are the constraints and sacrifices with which actuaries must contend? How might the precision and bias associated with a best estimate be affected?

SPECIFIC CONSTRAINTS

Time

Time is one of the most fundamental resources available to the actuary. Our conversations with actuarial students indicate that they tend to rate the resource of time as more important than do credentialed actuaries. This difference may be due to the fact that students are more likely to be responsible for the performance of the analysis while credentialed actuaries are more likely to supervise the work.

Social psychologists report that people tend to underestimate the amount of time it takes to accomplish work. Actuaries who are vulnerable to this are likely to be blindsided by changes in deadlines and project specifications, forcing them to rush the work at the end, at the expense of quality and comprehensiveness.

Issues arising from constraints on time should be addressed early in the reserving process. How much time is needed to complete the reserve analysis and settle on a best estimate? Has

time been spent on evaluating all salient issues? Are time constraints associated with financial and regulatory deadlines, the need to work on other projects, or a limited budget? How has the selection of actuarial techniques been affected by the time constraints? Which issues have not received the attention they warrant as a result of these constraints?

Knowledge

Knowledge as a loss reserving resource includes information related to insurance, the company, and the industry; the use of company information systems and software; the application of statistical techniques and actuarial methods. In addition, a modicum of work skills are required, such as those related to time and project management, communication, and teamwork.

The CAS's Statement of Principles Regarding Property & Casualty Loss & Loss Adjustment Expense Reserves requires that the actuary be familiar with the organizational structure, data sources, claims processes, and underlying exposures of the liabilities being evaluated. It is our belief that reserving practitioners at all levels considered these issues important to the development of accurate and unbiased best estimates.

In practice, actuaries must ask themselves how much they know about the specifics of the underlying liabilities, exposures, and coverages, besides what can generally be attributed to the line of business. Issues may include changes in underwriting, amount of coverage, claims adjusting, and case reserve adequacy. The means of acquiring this information requires knowing which questions to ask, with whom to be in contact, and how to recognize when something does not seem right. While this is a function of actuarial experience, it is also reflects prior experience with the particular liabilities in question. This is often problematic when either employee turnover or actuarial rotation programs result in the reassignment of projects. For consulting actuaries, dealing with the loss of clients and the engagement of new ones present similar issues. Appendix C (Consultant Turnover) addresses some of these issues.

A company's actuarial rotation program, hiring policy, and other human resource issues may affect the knowledge and experience of the employees who perform the reserving work. Insurance companies are more likely to utilize analysts for reserving while consulting firms may only employ credentialed actuaries. In some work environments, non-actuarial employees are active in the reserving process and actually perform the spreadsheet analysis. One might presume that the craftsmanship of the work, the models used, and the ability to cope with project constraints vary among these populations.

Even the most skilled actuarial practitioners can identify a variety of reserving issues which are difficult to analyze and regarding which they would like to see additions to the actuarial literature and the development of new methods. Among these are the use of poor data, volatile development patterns, the credibility of loss data for reserving, and reserving for asbestos, environmental, and mass tort exposures.

Another aspect of knowledge is associated to earning one's actuarial credentials by passing actuarial exams. We believe that there is a disparity in attitudes regarding the value of credentials between lettered actuaries and students. Many students have a dimmer view of the benefits of credentials in the reserving process and may believe that little separates the performance of experienced students and lettered actuaries.

Data

In its "Guidance Regarding Management Data and Information" and "White Paper on Data Quality," the CAS Committee on Management Data and Information recognizes the fundamental role data plays in actuarial work, specifically with respect to the accuracy and quality of projections. The first of these articles states, "Data needs to be managed as a critical resource. Information...is best when it is timely, accurate, easily obtainable [and]...should be consistently defined and shareable." [p. 135] This paper goes on to define quality control efforts and the type of information required for various actuarial activities.

The white paper describes the actuary's responsibilities in using data and information and defines data quality terms. Actuarial Standard of Practice #23 (Data Quality) guides the selection and evaluation of data and requires the actuary to comment on the quality of any data supplied by others. If substantive defects are identified, the actuary is to review the control procedures and quantify material biases which arise due to imperfect data.

In order to promote precision and avoid bias in the development of the best estimate, the actuary must consider and balance several data issues, including data quality and integrity, homogeneity and consistency, sufficiency and credibility, and the identification and use of external data. To the extent that the data is incomplete or flawed, the reserving practitioner must consider how to judgmentally redirect the results in order to obtain a best estimate which minimizes bias and imprecision.

Among the behaviors which social scientists attribute to the bounded rationality model is the fact that because humans can never have complete information, not all alternatives or approaches can be identified for consideration. Limitations associated with data availability and quality similarly constrain the methodologies and judgments which actuaries can employ.

Technology

Reserving practitioners tend to have a wide variety of technology available for evaluating more information, utilizing more sophisticated techniques, and completing tasks quicker. These tools include spreadsheets, simulation programs and random number generators, database applications, programming languages, statistical software, and applications developed just for the purpose of loss reserving. It goes without saying that these tools differ in their strengths and weaknesses, sophistication, sensitivity, ease-of-use, complexity, flexibility, and comprehensiveness.

The use of technological tools introduces a range of problems also. These include security issues, the threat of viruses, and system crashes. More important is the extent to which these tools dominate the reserving process, eclipsing practitioner knowledge and judgment, and promoting a black box mentality. In addition, quality becomes much more difficult to guarantee with the complexity inherent in these tools. All of these issues affect the determination of the best estimate.

Quality

Clearly, the biases and constraints addressed above are cause for concern. Quality problems may also result from all of the processes an actuary performs in developing a best estimate.

A significant source of practitioner error arises from the use of spreadsheets. Consultants estimate that 20% to 40% of all user-developed spreadsheets contain errors; other studies indicate that one in a hundred cells contains an error. [Panko] This high frequency has been attributed to the informal nature of spreadsheet creation, the large number of interrelated cells

in spreadsheets, and few quality control processes. Errors arise from all tasks associated with the development and use of spreadsheets -- design activities, data entry, range changes, macros, multiple spreadsheets and links, and even the performance of code inspections.

In addition, those who develop spreadsheet applications have identified several errors and difficulties which arise from "display-based problems." Among those are problems associated with relative-absolute cell references. Reserving practitioners who have tried to update the calculation of link ratios after adding another diagonal to loss development triangles can sympathize with this problem. Another issue arises when, given verbal problems to model, spreadsheet users have difficulty transforming the spoken word into spreadsheet formulas without first using mental images and writing notes on paper. The issue is that often these mental images involve manipulation of whole regions of the spreadsheet, not just individual cells. Another problem concerns working with dimensions. The spreadsheet is two-dimensional, workbooks are three-dimensional, and linked workbooks allow for four-dimensional modeling. As dimensions are added, the user's coordination of the system gets more difficult and is susceptible to error. Other quality concerns arise from the use of the pen-based numeric entry technology associated with Personal Digital Assistants. Researchers have found that, despite the serious nature of these problems, experienced spreadsheet developers tend to be overconfident regarding the quality of their work.

Anecdotal situations indicate that simple spreadsheet mistakes may have a significant financial impact. Spreadsheets created by reserving practitioners are used to develop projections which contribute to many important financial issues -- mergers & acquisitions work, cash flow models, agreements to commute reinsurance treaties, in addition to the development of best estimates. We have personally witnessed an event in which a very simple spreadsheet error led to a misstated case reserve total which resulted in the calculation of a significant reserve deficiency and the subsequent involvement of the Department of Insurance.

Management has a responsibility for creating the departmental systems which ensure quality and accuracy. Such an environment would feature the precise communication of project specifications, wide-spread documentation, and a variety of process measurements. Actuaries with whom we have worked utilize a variety of practices to ensure the quality of their work, such as checking all numbers, reconciling all totals, performing reasonability tests, reviewing changes in ultimate losses over time, arranging peer reviews, making comparisons to industry benchmarks, checking the internal consistency of all assumptions, and employing IBNR recasts and survival ratios.

One theory addresses the topic of human error by pointing out that humans are fast and flexible and are able to juggle multiple tasks and constraints. Unfortunately, the cognitive processes allowing us to operate this way invariably result in occasional errors; in fact, errors follow the same underlying cognitive process as does correct performance. Given the creative, exploratory, and ad hoc nature of reserving work -- in addition to complications arising from communication issues, financial pressures, and a variety of constraints -- actuaries are at particular risk of producing flawed work.

PRACTITIONER RESPONSES TO CONSTRAINTS

The confluence of constraints on the reserving actuary's resources is stressful. Any anxious reaction is likely to exacerbate the bias and inaccuracy of the best estimate. Stress affects people emotionally (heightened anxiety and frustration, more easily discouraged), socially (isolation, loneliness, lashing out), and mentally (forgetfulness, poor concentration, low

productivity, less creativity). As a result, stress causes practitioner performance to fall off. Decision-makers typically respond to stress by narrowing the search pattern, reverting to habitual modes of operation, erratically switching between options, and failing to act once judgment has been rendered.

Few reserve analyses are performed under an absence of constraints and an abundance of resources. As a result, they are unlikely to constitute an exhaustive review of all issues. Perhaps another source of bias in the best estimate value is attributable to issues which have not been evaluated. After all, it would be highly coincidental if the best estimate value would neither increase nor decrease after all additional issues were explored.

The bounded rationality model recognizes that decision-makers often respond to their constraints by selecting sub-optimal alternatives or methods. One approach which decision-makers take in the face of overwhelming complexity -- "sub-optimizing" -- involves ignoring some parts of the problem and making the effort to develop an optimal solution for the remaining considerations. Unfortunately, this procedure may lead to overlooking the global best solution. Sub-optimizing also occurs when a decision is made based on the agenda of a particular group or department, but which does not attempt to find the best solution for the entire organization. Reserving actuaries sub-optimize when they focus strictly on financial issues rather than claims processing or other operational issues, develop best estimates but not a reserve range, and ignore credibility issues related to the data.

A "satisficing"[8] strategy is used when a problem is considered solved not when the global best estimate has been identified, but when the result is deemed to be "good enough." Satisficing may be used when the number of alternatives is too large (or expensive) to investigate, the solution's accuracy does not require optimization, or the environment is so dynamic that the optimal solution changes rapidly and unpredictably. Actuaries reflect this "good enough" behavior in their utilization of very simple models, use of a limited number of methods, and lack of a procedure for identifying and evaluating a wide variety of methods for a given reserve analysis.

Researchers have found that the use of sub-optimizing and satisficing strategies has a negative effect on intracompany communication and practitioner morale, in addition to the precision involved with a best estimate. The quality of the reserving process requires the dedication, craftsmanship, effort, and professionalism which is often associated with highly motivated practitioners. In general, these personnel performance issues are management's responsibilities. In addition to project oversight, management must develop a departmental infrastructure which ensures appropriate levels of motivation, skill, and communication. Systems can also be devised to facilitate quality, coordinate the sharing of knowledge, inspire creativity, and foster insight.

Methodological Issues

The reserving practitioner is modeling a complex, fluid, and dynamic insurance system. Typically, there are thousands of company transactions executed in response to a variety of random processes which may each have social and economic parameters. The statistical tools and methods which are traditionally used for reserving are simplistic. As Richard Derrig has claimed, the loss reserving techniques used by actuaries "have not yet been formulated into a precise science." In addition, the model selected and resulting fit are no better than the care

with which they are applied. As a result, the best estimate values are vulnerable to biases and imprecision which arise from the selection and use of loss reserving techniques

SELECTING THE RESERVING MODEL

By using models, we attempt to create a substitute for reality which captures its essential elements. The advantage of models lies in the fact that they are simplifications which exclude all the factors which we believe to be less relevant to our analysis. From a reserving perspective, models are essential because they provide a structure with which we can make forecasts. Other advantages are that the modeling enhances our understanding of loss development and liability issues, enable us to test several solutions, and allow us to express the wide range of insurance operations through currency amounts.

The disadvantages of using models is that the practitioner can lose sight of reality and that the composition of the model may reinforce our incorrect beliefs.[9] In attempting to select a fairly simple model, how do we know what is appropriate to exclude from our analysis? Because models are indispensable to the reserving process, it is essential that the actuary take the appropriate steps to understand the risks of poor model selection and usage.

Simplicity Considerations in Model Selection

How much freedom does the actuary have in selecting a loss reserving model to use? One consideration is associated with the business incentives and workplace constraints which point to the use of simple, quick, and easy-to-use models.

The reserving models which are generally utilized employ historical loss and exposure data, coverage and reinsurance information, and a raft of assumptions regarding trend, loss development, and operational issues. The simplest models compromise on the complications of reality by positing a set of convenient assumptions.

Taking the simple loss development triangle model as an example, the actuary assumes that the relative development occurring in each development period will be consistent over all accident years, an assumption which allows for the selection of one link ratio selection per period. The use of this model overlooks how changes occurring in the following areas may differ by policy year, accident year, calendar year, or development period: communications and financial technology, claims department staffing levels, exposure and coverage issues, regulatory and tort issues, case reserve adequacy, claim adjusting philosophy, and identification of environmental or mass tort issues. By choosing to ignore the impact of these issues, the actuary is free to project historical averages into the future.

In general, the level of detail in the data used for ratemaking work is usually greater than what is used for reserving. For instance, pricing actuaries utilize a wide variety of exposure, loss layer, and underwriting information. Since these issues are important enough to consider for determining the appropriate rate to be charged, it may be appropriate to capture these factors in the process of establishing a best reserve estimate. Are there biases and inaccuracies that accompany the changes in business, markets, contract language, underwriting, and coverages which are not captured in reserving data and which would improve the analysis?

Another issue concerns the extent to which the actuary has the freedom to deviate from the traditional model, if so indicated. Can the “system” -- the limits and expectations associated with personnel, computer system, time, data resources, client expectations -- accommodate such a change? Often the selection of the model is made out of respect for the existing

infrastructure, resulting in a bias towards methods or software which are easily available and cheap to use, require little training time, were developed in-house, or which promote business agendas (such as productivity and cross charges), in addition to precision.

Of course, unless actuaries keep up with actuarial literature, journals on forecasting and statistics, new econometric models, and emerging technologies and applications, they will be unable to make informed decisions about which model to use. To what extent do actuaries learn from their own successes and failures? Cummins and Derrig point out that the process actuaries typically follow in selecting their models lacks a formal feedback loop through which the performance of the selected models may be assessed.

Finally, reserving practitioners should consider the fact that all models are ultimately false.[10] They should be aware of the vulnerabilities of each model and honestly assess if the model under consideration is a good fit for the body of liabilities to be evaluated. Documentation and controls should include clear statements about the assumptions underlying the model and the range of values for important variables for which the model works best.

Problems with linear models

Linear models are often selected for loss reserving analyses. These models typically require the practitioner to develop and apply numeric factors as a surrogate for loss development. The resulting functions are either linear or they may be transformed into linear models. Loss triangle and frequency-severity methods are common linear reserving models.

One cause of bias in the best estimate arises from the inappropriate selection of linear models for use in reserving work. This bias occurs anytime linear models are misapplied, either because the data reflects a nonlinear relationship or if a relevant variable has been excluded. Although commonly ignored, one precept of least squares line-fitting is that it is only appropriate to use the regression line over the range of independent variables over which it was fit.

In addition, the R^2 statistic -- which is easy to calculate as a measure of the goodness-of-fit for linear models -- is commonly used improperly. First of all, the actuary should expect artificially high R^2 values for fits involving data which has been scrubbed, which is particularly easy to do with reserving software or through the exclusion of the lowest and highest historical link ratios. In addition, unless the adjusted statistic is used, the R^2 statistic can only improve with the addition of more independent variables. Of course, it is easier to generate high R^2 values for lines with greater slope. Consideration should also be given a priori towards whether the fitted line should have an intercept at the origin, rather than assuming that maximizing the R^2 statistic is the sole concern.

Finally, the recognition and exploration of dynamic nonlinear systems suggest that linear models may be inappropriate to use since they ignore fundamental systemic consistency. Nonlinear systems exhibit complex effects which would never be anticipated by a modeler accustomed to only linear techniques. For instance, complicated interactions and correlations are important to model. For instance, if frequency is projected to change significantly, it would be naive to imagine that claim severity will continue to hold constant. Nonlinear systems should not be considered a special case since they are so common. As noted mathematician Stanislaw Ulam pointed out: most of nature is nonlinear in the same sense that most of zoology is non-elephant zoology.

Software

Another important resource available to actuaries is loss reserving software. These tools are the most useful when data is limited, a variety of roll-ups and summaries are required, and the software is compatible with other applications. Much of the value is associated with the extent to which the software is easy to use, accelerates number-crunching, and generates results which are easy to interpret.

Some actuaries are more cynical about the use of this software, viewing these tools as inflexible black-boxes which generate dubious results when questionable data was utilized. Some critics point out the arbitrary nature of some of the parameter values the practitioner is expected to input and are concerned that some practitioners would unquestionably accept the results. Others focus on how difficult it is to master the software, with the fear that anything less than mastery could result in severe misapplication. In addition, peer review is made more difficult by the closed system nature of some of these applications. There is also the fear that loss reserving software may lead non-actuaries to think that they can do actuarial work. It is important to remember that software is not required for good reserving practice.

A fundamental issue to consider with respect to loss reserving software is that they are models unto themselves. As a self-contained system, each has its own specific logic, flow, structure, and output. The human user of these systems will find themselves adopting a mentality which enables them to use the tool efficiently, but which may blind them to other issues which the software does not address as well. There is the "hammer" analogy which is used to describe how a child reacts when given a toy hammer -- all of a sudden, everything in the house needs hammering. Similarly, if a particular software allows a user to easily deselect specific historical link ratios in order to adjust the development period averages, but is difficult to manipulate with regard to replacing outliers via a cubic splining method, the actuary is likely to adopt a perspective in which historical data is either kept or excluded, but never adjusted.

Detail in Data

When a model is being chosen, the level of detail in the data should be considered. To what extent has the data been established and organized to specifically meet, and optimize the results of, the actuary's reserving needs? Does the level of data detail allow for rigorous use of statistical tools and mathematical models which are covered in the CAS's exam material: cubic splining, linear programming, ANOVA, regression, time series analysis?

The actuary has decisions to make regarding the organization of the data which will facilitate the effort to develop an accurate and unbiased best estimate. For instance, consideration should be given to the width of the development periods (12 months, 6 months, 3 months), the use of data organized by accident year or policy year (or both), the use of claim count information and calculation of severity statistics which reflect changes in each claim's status as it ages (unreported, unrecorded, pure IBNR, reopens, case development[11]), and the availability of ratemaking variables in establishing homogeneity in the data.

We have seen many reserve studies which produce estimates to whole dollars. These best estimates reflected a greater number of significant digits than indicated by the development and trend assumptions from which they were generated. Is there a need to generate more accurate factors? How frequently should reserving research be conducted in order to examine various loss development issues, such as the measurement of report lags, quality of case reserves, inflationary trends, and LAE loads? How will the results feed the decision to reconsider the reserving model under use?

IMPLEMENTATION

Another issue affecting the precision of the best estimate is the self-awareness, sophistication, and precision with which the actuaries employ their mathematical techniques and models. Assuming that the reserving practitioner's toolbox is more than adequate to set a reserve for any set of liabilities, is it employed accurately? How often do individual actuaries make it a practice to rigorously assess their estimation statistics and formulas? For example, do they assess their use of linear models? their independence assumptions? their use of the mean as a measure of central tendency? Do they examine the distribution of the errors or residuals? Do they inappropriately use regression fits to project values outside the range of the data set?

It is not our contention that actuaries lack the understanding, training, or sophistication required to accurately utilize these procedures, but that human factors and systems constraints often interfere with the proper technique.

Correlation

We should expect that there are some correlations which may be identified in the model. These may occur between the magnitude of data or ratios associated with consecutive development periods, accident years, calendar years, seasons, or with competitor/industry data. Identifying correlations should improve the reserving analysis by helping the actuary understand internal relationships which should affect the judgments and selections. Of course, ideally, we want a model that captures causality, but we must be careful of confusing correlation and causation.

In fact, actuaries should be careful in identifying correlation. First of all, they must avoid illusory correlation by using statistical analysis rather than judgment in identifying correlations. Of course, the important concern is the risk that the apparent correlation between two variables will not continue in future periods. This may result when correlations between two variables are driven by their relationships with a third variable or by the presence of a particular set of circumstances. The credibility of the data must also be considered. Before accepting the validity of the apparent correlation, it is advisable to conduct a more formal, rigorous study.

Outliers

An important area of concern is the treatment of extreme, outlying data points. Some practitioners choose to ignore these outliers and exclude them from the calculation of historical averages, others attempt to mitigate their impact. Of course, eliminating them removes anything you could learn from them. One issue to consider is: can the use of historical data ever be biased, or just inappropriate?

How typical are these outliers? Are there operational processes or historical events to which they may be tied? What can they tell us? If we do not want to exclude them, should they be approached as catastrophe losses are modeled by ratemaking actuaries? It is also important that the actuary be aware of the heuristic biases -- such as availability, anchoring and adjustment, or the law of large numbers -- which may affect the interpretation and treatment of these outliers.

It is worth noting that Cheng-sheng Peter Wu's paper indicates that the use of link ratio averages which exclude the highest and lowest historical values results in a downward bias in best reserve estimates. Also, Daniel Gogol points out that both the simple average development factor method and the weighted average development factor method are both biased upwards.

Interpretation of Data

The purpose of using models for reserving is to generate results that may be interpreted by the actuary. The challenge is to determine why historical data has unfolded as it has, to establish consistency with real life trends and insurance operations, and to consider how accurate the model's results may be in forecasting the future.

The reserving professional must determine which historical numbers to evaluate. Are they all from the same population (with respect to exposure type, claims adjusting, and technological processing) or from different loss development regimes? If from the same process, can the same system be expected to continue in the future and thereby affect the company's liabilities for unpaid claims? Can a trend be identified? If so, what is the magnitude and direction of these changes? When does a shift in the historical averages over time indicate the same underlying business conditions, a one-time change, or a trend?

Actuaries are vulnerable to making detailed forecasts based on data with limited predictive value or questionable validity. This is especially the case when the data or methods is highly redundant; for instance, when data from both company and industry sources has experienced the same general exposure and claim processes, or when different methods arise at similar results since the same data source, exposure period, and assumptions are utilized for all methods.

The reserving practitioner should avoid falling back on the facile use of historical averages alone in making projections. The law of small numbers, regression to the mean, recency framing effects, and interplay of other biases and cognitive processes should prompt the actuary to evaluate the credibility of, and interpretation of, the data. It may make sense to try a sensitivity analysis regarding decisions regarding factors, assumptions, and models.

Of course, judgment will be used in determining the application of methods and interpretation of data, no matter how scientific the process has been. It is important to remember that the future is not a function of the past, nor is it necessarily correlated to the past. The actuary's real responsibility is to assess the predictive value of historical patterns, quantitatively, systematically, and philosophically.

Use of Judgmental Forecasts

Researchers recognize two types of forecasts: quantitative and judgmental. Quantitative forecasts include statistical or formula-driven projections developed mechanically from the data. Judgmental forecasts arise from human participation. Examples include the use of qualitative data in the absence of hard data, forecasts developed through consensus-building techniques such as the Delphi method, and upper management's decision to adjust a quantitative forecast before granting approval.

Actuarial reserving practice consists of developing individual projections (of link ratios, ultimate losses, claim size distributions, and payment patterns) through the use of quantitative methods infused with practitioner judgment in selecting the best estimate. Rather than being either "touchy-feely" and unscientific or the result of sacrosanct actuarial revelation, judgment can play an important role in forecasting.

Research indicates that judgmental and quantitative forecasts are equally accurate, particularly in projecting time series and eye-fitting linear regression lines. When extra qualitative data is

available, judgmental forecasts were found to be superior to statistical ones. That is not to say that judgmental approaches have no shortcomings. For example, judgmental forecasts tend to underestimate growth, particularly exponential growth. In addition, some research suggests that the way information is presented (i.e., via graphs or tables) affects the quality of the projections. Also, the width of confidence intervals set judgmentally is usually unrealistically narrow. These issues may be associated with the human cognitive limitations and heuristic biases discussed earlier.

The reason why judgmental estimates compare so well to statistical models is that the latter are usually very simple, utilizing few variables, employing the mechanical identification and projection of historical patterns, and omitting qualitative information and fuzzy data. By ignoring the dynamic forces which drive economic, financial, and operational results, quantitative methods suffer from their own set of limitations.

Development of Composite Forecasts

If judgmental forecasts have merit and statistical approaches are limited, which method should be used to generate accurate and unbiased projections? Until now, we have discussed considerations for identifying the "best" model. Cummins and Derrig suggest that it would be more appropriate to focus on how to guarantee the selection of a best forecast. They point out that no single method can be expected to always generate the most accurate forecast.

An important finding is that accuracy increases and variability in accuracy decreases as forecasts are combined. This is particularly true for methods that have high errors associated with them. The forecast errors of quantitative forecasting techniques have been shown to be more highly correlated with each other than with judgmental forecasts. In the case of reserving, this finding makes sense if the same basic assumptions are used for all loss development triangle methods. Another explanation may be that different (and contradictory) heuristic biases (anchoring and adjustment, availability, the law of small numbers) may figure in the development of judgmental forecasts from quantitative ones.

The use of a variety of projection methods, both qualitative and judgmental, requires that they somehow be combined into one final forecast. Research indicates that simple averaging techniques are very effective for developing composite forecasts. Not only is judgment ineffective to use in determining how to combine forecasts, it is also much more time-consuming. [Lawrence, et al, (1986)] Other researchers point to using statistical methods, fuzzy logic, and neural networks for the optimal combination of forecasts.

Perhaps here we've come full-circle in discussing how to meet the rigorous requirements of a best estimate. First, we started with an assessment of actuarial science's similarities and differences with science, continued with the centrality of actuarial judgment in loss reserving work, went on to survey the limitations which affect human knowledge and judgment, and ended by considering ways to scientifically combine judgmental forecasts and statistical projections, thereby bridging the gap between judgment and statistics, and between ad hoc approaches and a formal scientific method.

VI. DISCUSSION

"The probability that there is a secret mental trick that at one stroke will enable the human mind to solve complex problems better is practically zero. It is equally unlikely that our brains have some great cache of unused potential. If such things existed, we would be using them. Nowhere in nature does a creature run around on three legs and drag along a fourth, perfectly functional unused leg. Our brains function the way they function and not otherwise. We must make the best of that; there is no magic wand or hidden treasure that will instantly make us deep and powerful thinkers.

"Real improvement can be achieved, however, if we understand the demands that problem-solving places on us and the errors that we are prone to make when we attempt to meet them. Our brains are not fundamentally flawed; we have simply developed bad habits. When we fail to solve a problem, we fail because we tend to make a small mistake here, a small mistake there, and these mistakes add up. Here we have forgotten to make our goal specific enough. There we have over-generalized. Here we have planned too elaborately, there too sketchily.

"Failure does not strike like a bolt from the blue; it develops gradually according to its own logic. As we watch individuals attempt to solve problems, we will see that complicated situations seem to elicit habits of thought that set failure in motion from the beginning. From that point, the continuing complexity of the task and the growing apprehension of failure encourage methods of decisionmaking that make failure even more likely and then inevitable." [Dorner]

Strategies

The purpose of this paper is not to belittle the reserving work of actuaries or despair of their ever reaching the Best Estimate ideal set in NAIC Issue Paper #55. Instead, the goal is to sensitize actuaries to many of the issues which affect the quality and precision of their work. With the identification of these business constraints and human limitations, perhaps reserving practitioners can gain a self-awareness which will enable them to make the necessary corrections or allowances to their methods in order to select best estimates with greater confidence.

Below are some ideas for overcoming some of the performance obstacles discussed in this paper.

1. Individual actuaries should be encouraged to examine (and measure) individual biases and agendas, as well as those associated with the general reserving methodologies practiced in their work environments.
2. Before performing a particular reserve analysis, the actuary should identify and list the primary obstacles to developing unbiased and accurate best estimates, and consider how to adjust for these considerations.
3. Establish metrics for evaluating reserve adequacy across all reserving work. Look for systematic biases, by client type, line of business, by accident year, and by calendar year. Which type of projections are either invariably redundant or inadequate? For particular categories, how do the redundancy amounts compare to the inadequacy totals?
4. Insulate judgments against heuristic biases. Pay attention to base rates, consider regression to the mean, and focus more on the merit of information than issues associated with how it is presented. Do not be misled by highly detailed scenarios.
5. Develop and implement formal guidelines for spreadsheet development. These should include well-organized layout (group development, separate sections for input and output, modular design, preplanning and upfront design), use of helpful spreadsheet options (range

names, sheet and cell protection, cellnotes), and quality control efforts (spot checking inputs, use of crossfooting, use of test data, inspection teams, detailed feedback), in addition to other issues (formal training, extensive documentation).

6. Prevent group-think biases by examining group processes. Encourage certain participants to be impartial or even contrary; allow time for the expression of residual doubts or objections; make a special effort to consider improbable or unpopular ideas and perspectives. Fight overconfidence by challenging people to stop and consider reasons that their judgment might be wrong. Improve group decisionmaking performance by introducing brainstorming, Delphi group processes, or nominal group techniques which emphasize equal participation by all group members.
7. Actuaries should consider the impact of work environment constraints on the results of their analysis and explore the possibility that the expected variability associated with their best estimates is directly related to the severity of these constraints.
8. Maintain detailed notes regarding the sources of information and bases of decisions made throughout the reserving process in order to reduce hindsight bias and reconstructed memory.
9. Develop an independent peer-review process which is designed to add value to the reserve study and through which business, systematic, and group-think issues may be avoided. The reviewer should be free to play devil's advocate and question assumptions, processes, and conclusions.
10. Once the initial stages of their reserving work is complete, actuaries should redirect their attention from their technical models and numerical factors. Instead they should be encouraged to express their results in general business terms, explaining their findings with respect to business processes, operational events, and loss development and exposure assumptions.
11. Perform post-mortum analyses on the assumptions and methodologies associated with the reserving work. These reviews should be performed with respect to the reserving process after the work is complete, and with respect to both the assumptions and the model as subsequent data becomes available.

VII. ENDNOTES

[1] Paragraphs 9 and 10 of NAIC Issue Paper #55.

[2] Practitioner judgment is the basis of the value added by actuaries. Annotation 1-1 of the Code of Professional Conduct of the American Academy of Actuaries states that "an actuary fulfills the profession's responsibility to the public ... by offering actuarial advice, recommendations, and opinions that are the *product of the actuary's exercise of professional judgment*." (italics added)

3 In addition to Conventional and Investigative, the other four classifications of the Strong Interest Inventory are: Realistic ("Doers"), Enterprising ("Persuaders"), Social ("Helpers"), and Artistic ("Creators").

[4] P(A) >= P(A and B)

[5] This is an inappropriate conclusion, unless respondents believe that actors are more than 19 times more likely to be flamboyant than are accountants.

[6] Options A and B exist with the following losses, probabilities, and expected values:

Option A	100% chance of $200 loss	Expected loss = $200
Option B	80% chance of $275 loss; 20% chance of no loss	Expected loss = $220

Research shows that people will choose B despite its higher expected loss because of the chance to avoid any loss at all.

[7] Many of these are covered in the CAS's Statement of Principles Regarding Property & Casualty Loss & Loss Adjustment Expense Reserves.

[8] **SATISFICING** = **SATIS**FYING + SACRI**FICING**

[9] These drawbacks are consistent with some of the cognitive and judgment issues discussed earlier in the paper, such as overconfidence, group-think, and availability.

[10] Any model simple enough to be articulated or developed by humans must be lacking the recognition of some level of realism. As Einstein said, "As far as the laws of mathematics refer to reality, they are not certain, and as far as they are certain, they do not refer to reality." [McNeill, p. 29]

[11] In using claim counts for severity analysis, it is important to remember that classifying them is a categorical process. Claims are either unreported, open, or closed; meanwhile the loss amounts grow smoothly. This leads to something of a mismatch in the calculation of severity figures.

VIII. REFERENCES

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IX. APPENDICES

Appendix A
A Loss Reserving Process Model

Most of the methodologies used by actuaries for developing a best reserve estimate rely on a set of general ingredients and follow a particular order of steps. There are several inputs which reserving practitioners may choose to utilize in their work, whether for their company or a client. There are also parameters established by the practitioner and the client for governing the conduct of the work. These may be categorized as follows:

INGREDIENTS		PARAMETERS
Information	Models	Statutory requirements
Loss/Claims data	Reserving methods	Client's business agenda
Exposure data	Formulae	Client expectations
Business information	Reserving software	Actuarial practice standards
External information	Statistical software	Precision
Prior reserving analyses		Reasonability
	Practitioner Issues	Quality
Processes/Resources	Actuarial knowledge	Business Ethics
Work procedures	Business knowledge	Deadlines
Human resources	Process knowledge	Budget
Technology	Professionalism	
Client communication	Experience	
Time	Judgment	
Efficiency	Effort	

Several steps are required in performing a comprehensive reserve analysis. Within these eleven steps, the components listed above tend to be employed as follows:

1. Determine the purpose of the reserve analysis and how the results will be used
   Ingredients: Business knowledge, Actuarial knowledge, Business information, Client relationships, Experience
   Parameters: Client's business agenda, Statutory requirements, Client expectations
2. Define the resources, requirements, and other expectations for the work
   Ingredients: Process knowledge, Business relationships, Experience
   Parameters: Client's business agenda, Deadlines, Budget, Quality, Client expectations
3. Assign the resources required to perform the work
   Ingredients: Process knowledge, Information, Business relationships, Experience
   Parameters: Deadlines, Budget, Quality, Accuracy
4. Decide on the general model to utilize -- select the level of detail for both inputs and results
   Ingredients: Actuarial Knowledge, Data and Information, Prior analyses, Experience, Judgment
   Parameters: Precision, Reasonability, Client's business agenda

5. Review and adjust the data -- identify trends and outliers, assess data quality issues, consider the use of external data
   Ingredients: Actuarial knowledge, Data and Information, Prior analyses, Experience, Software, Judgment
   Parameters: Quality, Reasonability, Client's business agenda
6. Select specific model(s) to utilize for generating projections
   Ingredients: Actuarial Knowledge, Process knowledge, Data and Information, Prior analyses, Experience, Judgment
   Parameters: Deadlines, Budget, Quality, Reasonability
7. Work with (each individual) model -- select parameters, make assumptions, determine use of additional data, etc.
   Ingredients: Actuarial Knowledge, Data and Information, Prior analyses, Experience, Judgment
   Parameters: Client Expectation, Reasonability
8. Calculate initial numbers or historic (link) ratios
   Ingredients: Actuarial Knowledge, Data and Information, Human resources, Technology and Software, Time, Work procedures
   Parameters: Precision, Reasonability
9. Review the results and make adjustments to numbers, assumptions, and selections for consistency and reasonability
   Ingredients: Actuarial Knowledge, Prior analyses, Experience, Judgment
   Parameters: Quality, Precision, Reasonability
10. Recalculate results arising from (each) model
    Ingredients: Actuarial Knowledge, Data and Information, Human resources, Technology and Software, Time, Work procedures
    Parameters: Quality, Precision, Reasonability
11. Select a specific reserve value to use as the best estimate
    Ingredients: Actuarial Knowledge, Prior analyses, Experience, Judgment
    Parameters: Quality, Precision, Reasonability

Usually the ingredients and parameters associated with reserving work are taken for granted and not specifically identified. However, the steps detailed above underscore their importance and indicate that decisions must constantly be made regarding their usage. It is also obvious that practitioner experience and judgment are employed throughout the reserving process and have an overarching effect on the details, and outcome, of the work process. In fact, the reserving process may be viewed as a series of practitioner judgments applied to statistical stimuli.

IX. APPENDICES

Appendix B
Physiological Issues Associated with Limits on Human Intelligence

Human Intelligence

The human brain is composed of neurons which communicate with each other through synapses. There are over 10 trillion synapses in the brain and about 100 billion neurons, each having about 10,000 contacts with other neurons. The neurons of the human cerebral cortex would reach over 250,000 miles if placed end to end. The resulting complexity of this organ is enormous. In a lifetime, a human being can learn up to 15 *trillion* items of information.

Despite this impressive hardware, the cognitive performance of humans is limited in terms of our ability to absorb information, overcome our own personal biases. In addition, we have constraints on our memory, concentration, and attention. We have difficulty comprehending complex and nonlinear systems, identifying long-term effects and side effects, and working with conditional probability. Research also indicates that there are clear limits to the accuracy with which we can differentiate between various grades of a sensory stimulus. In addition, stress and fatigue contribute to diminished human cognitive performance.

The use of the part of our minds which house our logical capabilities -- the "attentional system" -- is "limited, sequential, slow, effortful, and difficult to sustain for more than brief periods." [Reason, p.50] Because the attentional system is responsible for a wide variety of activities -- logical processing, planning for future actions, and dealing with the unexpected -- its resources are often stretched, generally at the expense of our memory, logic, and ability to deal with complex problems.

Dorner explores the origins of the cognitive limitations which human face:

> "This seeming failure of our capacity to think [in systems, on problems which don't have linear solutions, or which involve side effects and long-term repercussions] has prompted sweeping criticism of the human intellect, if not for the existence of our problems, then at least for our inability to solve them. The theories advanced are grandiose and run the gamut from genetic to evolutionary to culturally determined.
>
> "Some suggest that, very early on, human beings developed a tendency to deal with problems on an ad hoc basis. The task at hand was to gather firewood, to drive a herd of horses into a canyon, or to build a trap for a mammoth. All these were problems of the moment and usually had no significance beyond themselves. The amount of firewood the members of a Stone Age tribe needed was no more a threat to the forest than their hunting activity was a threat to wildlife populations. Although certain animal species seem to have been over-hunted and eradicated in prehistoric times, on the whole our prehistoric ancestors did not have to think beyond the situation itself. The need to see a problem embedded in the context of other problems rarely arose. For us, however, this is the rule, not the exception. Do our habits of thought measure up to the demands of thinking in systems? What errors are we prone to when we have to take side effects and long-term repercussions into account? These questions are especially pertinent when we address such problems as environmental degradation, nuclear-weapons build-up, terrorism, and overpopulation.

> "Some analysts complain that all our difficulties stem from the fact that we have been turned loose in the industrial age equipped with the brain of prehistoric times. They see our tendency to think in simple chains of cause and effect as genetically preprogrammed and locate our inability to solve our problems in this genetic programming. Others note the conditions that evolution has placed on the development of the human cognitive apparatus. The claim is that we have a strong tendency to visualize when we form hypotheses about the world and that our minds therefore have great difficulty grasping problems that cannot be visualized. Still others have located the source of the trouble in male domination of society. They distinguish between the "serial" male thinking and "parallel" female thinking and identify the latter as more appropriate for dealing with complex problems. Indeed, the entire tradition of Western "analytical" thinking is often blamed for all our woes."

Working with Numbers

As reserving practitioners, we identify with our mathematical skills. It is thus worthwhile to investigate how the human mind works with numbers.

Any manipulation of numbers -- even comparing their magnitudes -- is a brain-intensive task. There are a series of complicated steps required to perceive external representations of numbers (i.e., digits, the names of numbers, lines on a graph) on a document or computer screen, comprehend them mentally, arrange them for the purposes of calculation, and project them back as an external representation (via speech, data input, etc.). Scientists are only now examining how humans perform these activities, but are starting to recognize similarities in the way the brain performs musical, lingual, and numeric tasks.

One issue of concern with respect to actuaries' use of numbers is the role of "lay theories." These are oversimplified cognitive schemata on which people rely when they deal with complicated technical areas. Even after people receive advanced training in specific technical areas, they often revert back to the more basic lay theories which they had employed for years earlier. Unfortunately, these lay theories are oversimplifications (similar to "old wives' tales") and the use of them is likely to result in errors.

Similarly, but on even a more basic level, research indicates that the ability to assess the comparative size of individual numbers is a fundamental brain activity, one that infants, crows, rats, insects, pigeons, and chimpanzees are all capable of at some level. Because the recognition of numeric patterns does not require the ability to count, the human grasp of numbers is independent of an understanding of mathematical functions.

Both the easy availability of lay theories and our primordial understanding of numbers suggest that, when making numeric judgments, humans may more typically use their intuitive facility with numbers, rather than an analytic approach. We are concerned that while actuaries are expected to utilize an expansive knowledge of mathematics and statistics in setting reserves, perhaps they do not necessarily call upon their highest quantitative skills in deciding which historical link ratios to use or in peer-reviewing another actuary's loss development selections.

It is important that the reserving practitioner makes every effort to employ a sophisticated knowledge of higher mathematics, as well as an understanding of the business, processing, and claim issues which affect historical statistics, in analyzing loss data and making reserve selections. An actuary who is not careful in recognizing the role of intuition may not develop an appropriate best estimate.

IX. APPENDICES

Appendix C
Insights from Auditors and Accountants

The American Academy of Actuaries' Code of Professional Conduct focuses on the actuary's responsibilities towards principals, actuarial organizations, and the public. In touching upon themes such as professional integrity, confidentiality, standards of practice, and conflicts of interest, the Code introduces important concepts into the professional life of the actuary. However, this reference does not elaborate on some of the issues which may give rise to the concerns of this paper: bias and imprecision. Fortunately, we can turn to non-actuarial sources for additional insight.

Sources of bias which impact the quality of a reserve estimate have been identified by those who study the work of accountants and auditors. Not only are their roles similar to those of reserving actuaries, these professionals have a strong reputation for their independence, avoidance of impropriety, and lack of bias. Perhaps, actuaries can learn from these standards of practice.

Independence
In their Standards of Professional Practice, the Institute of Internal Auditors emphasize that internal auditors should be independent of the activities they audit in order to permit them to render unbiased judgment and perform their work freely and objectively. Independence is a function of organizational status and objectivity, while objectivity is somewhat circularly defined as arising from an independent mental attitude. In order to achieve objectivity, audit professionals should perform audits in such a way that they have an honest belief in their work product and that no significant quality compromises were made.

In addition, auditors are instructed not to subordinate their judgment on audit matters to others', are told that performance of non-audit activities is presumed to impair audit objectivity, and are reminded to be vigilant about potential biases and conflicts of interest. Although it does not specifically refer to independence, the CAS White Paper on Data Quality is of similar mind in directing actuaries to investigate quality problems in data supplied by others.

Internal Consulting
One area of concern is that internal auditors jeopardize their independence when they perform in a consulting role for their companies. This is particularly true when the consulting activities pertain to accounting systems or financial issues. However, there is less risk when they are involved in activities not considered accounting-related. These concerns have led to the development of precise delineations of consulting activities and audit activities. Several risks were identified with participation in consulting activities, such as: failure of individual projects could foster negative perceptions of the internal audit department, the emergence of conflicts of interest, management may shift internal auditors towards more consulting activities at the expense of auditing activities, resources available to auditors for their audit activities may be drained by cost overruns on consulting projects, and auditors may be exposed to political pressure and be asked by management to legitimize unpopular or controversial decisions.

Similarly, in-house reserving actuaries may be utilized for a variety of projects, such as: mergers & acquisitions work, commutations, claims department evaluations, wide-ranging

analysis of asbestos and environmental issues, financial and legal issues regarding the annual statement, and information system development. Any failures, missteps, or "Monday morning quarterbacking" could jeopardize corporate esteem for actuaries and their models.

External Consultant Turnover
Evaluations of independent auditor performance during the Savings & Loan crisis concluded that the riskier S&Ls were more likely to change auditors frequently. In our experience, the same phenomenon is true for consulting actuaries.

There exist unsophisticated or financially weak insurance companies which appear to be "shopping" for a reserve opinion to their liking. Despite the best efforts of consulting actuaries -- who we assume maintain high levels of integrity and independence in their work -- the client's appointment of new actuaries reduces the precision and increases the bias attributable to the best estimate. The accuracy is compromised since each new actuary has little time to develop sufficient knowledge of the client's organization, processes, exposures, and data. If the insurer actively shops for a favorable reserve opinion and will settle on an actuary whose particular methodology happens to result in a low best estimate when applied to the client's situation, there is obviously a bias in the system, despite the fact that the actuary's approach is in conformance to actuarial standards of practice.

If the nature of the insurer is fairly obvious, the actuary may choose not to invest a lot of time or resources into the development of a best estimate (even at the cost of accuracy), figuring that this is unlikely to be a long-term engagement through which the initial investment may be recouped. Unfortunately, there may practitioners who will cater to their client's agenda and actively but subtly bias their results in order to retain account.