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Problems, Knowledge, Solutions: Solving Complex Problems

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PROBLEMS, KNOWLEDGE, SOLUTIONS: SOLVING COMPLEX PROBLEMS

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Abstract

This paper examines complex problem solving using drugs and cyber crime as examples.

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1. THE PROBLEMS OF SOLVING PROBLEMS

Many of today's problems are new, complex, and very threatening. They are outside our day-to-day experience, there may be few experts available to give advice, and the consequences of not tackling them may be a major disaster. Some problems are so serious that, despite our lack of knowledge, we must make major efforts to remove or reduce them, even though the likelihood of success is poor.

Many very complex problems have similar characteristics. They are pervasive, spreading unhindered into regions, countries, and economic activities which seem powerless to resist the invasion. They are difficult, if not impossible, to control without major changes in human behavior and government priorities, and those which serve illegal consumer markets are very big money earners. These very difficult problems often arise from changes that are taking place in the social and economic environments in which we live and work. For example, the challenges of a new global market environment may place competitive pressures on companies that they are unable to handle; new products or processes may present novel and unanticipated health or environmental problems, and political, economic, or financial disturbances may suddenly change a viable market situation into a volatile and unstable one. Anticipating problems of this kind requires an ability to analyze the present and forecast the future, always a difficult and uncertain task.

Our hope is that by understanding and tackling problems that confront us we will achieve increased stability and regain a sense of control and well being. But a factor making success difficult is today's rate of change. Events are occurring at greater speed and with more impact than ever before. This influences the ease or difficulty with which solutions can be achieved. The philosopher Zygmunt Baumann suggests that one of today's great divides is that between order and chaos. The regular, predictable, controllable, and relatively problem free world that many of us cherish is increasingly becoming separate from a contingent, erratic, unpredictable, and hard to control world that we increasingly experience but dislike, even fear (Baumann 1993).

A critical question for all is "how can we make effective decisions in these kinds of situations and, once these decisions have been taken and implemented, how can we live with the results?" Taking decisions requires making choices and this always involves taking risks. We are never certain of the consequences of a particular decision because we never know what the future is going to contain. A solution that may seem logical and appropriate at one moment in time may turn out to have disastrous consequences when totally new sets of circumstances unfold.

We can never tackle all the problems that present themselves and judgments have to be made on which we address and which we postpone for future solution. This choice will require an assessment of the gravity of the problem—how serious are its consequences? And of its probability—how likely is it to happen? Both of these decisions require knowledge and sound judgment, attributes that may be in short supply. Many problems are not well defined and contained sets of events. They frequently consist of a series of actions and reactions with the final results, which may be a disaster, a product of the interaction of the different parts.

How we solve problems will depend to a large extent, but not entirely, on the nature of the problem. Factors that can exert a major influence are the environment containing the problem and the pressures and constraints exerted by this. Also exerting influence are the beliefs, values, and assumptions of the problem solver on what will produce a satisfactory solution. All of these will influence choice on whether solutions should be ethical or pragmatic, comprehensive or economical of effort, and short or long term.

Problem solving is never simple and, irrespective of whose problem it is or where it is located, uncertainty is always likely to be a factor in decision making. Great attention will have to be paid to what is acceptable, desirable, and achievable, with no guarantee that the right decision is being made. Problem solving is directed at changing situations and will always have intended and unintended consequences. If nothing changes, then the problem has not been solved. Successful problem solving is when a carefully planned and executed change achieves a desired result with a direct link between what is intended and what has happened.

2. TWO MAJOR PROBLEMS: DRUGS AND CYBER CRIME

There are many situations where the possibility, or need, for effective action coincides with an absence of precise rules or knowledge to help change the situation. This applies to the two problem areas chosen to provide specific examples in this paper. These are illegal drugs and cyber crime. They have been chosen for three reasons.

First, they are likely to be major problems for the foreseeable future. Neither show any signs of being diminished or controlled. If anything, the evidence suggests that both will increase in severity.

Second, we will all be affected by their continuance. The problem of drug misuse is a major one, with social, health, and economic consequences. Cyber crime, or fraud that is a product of illegal activity involving computers, is seen by industry as a very grave threat that is difficult, even impossible, to prevent.

The third argument for using these examples is that the two problems, although equally serious in their effects, take very different forms. Drug dealing requires complex networks of personal relationships. Like any entrepreneur, the drug dealer has to find a source for his product, has to arrange transport to his selected market, and has then to sell it, either direct to the public or to dealers who act as intermediaries. Well established drug dealers are likely to have permanent or semi permanent arrangements for doing these things. Their arrangements will be well organized and well protected. There must be contacts in a variety of countries who will share and coordinate a set of increasingly difficult and risky activities. There is usually a bent airport or customs official available to progress the product along its journey, providing the price is right.

Drug barons have learned to import their drugs using circuitous routes. They rarely bring drugs directly from a producing country, moving them first to a non-producer. They know that customs are always watching their movements. There are also informal rules that have to be kept. If a load is lost because it is intercepted by the authorities, then the shareholders in the deal lose their investment and accept liability for any costs. No one else is held responsible for the loss. If there is any kind of rip-off or double dealing, then the shareholders do not lose their investment. They get paid the agreed price and the person who ripped them off is held responsible for the loss. A member of the Mafia can escape responsibility if he kills the person who does the rip-off. And this person is usually not hard to identify. As the smuggling business grows and becomes more successful, it becomes increasingly complex and also of greater interest to government authorities such as European Customs and the American Drug Enforcement Agency (DEA).

While illegal drugs require complex organizational networks to enable them to travel across the world from their source to their eventual market, cyber crime can either be carried out by a single individual or a small group within a company or located many thousands of miles away. Distance is no problem to the cyber criminal because communication links are electronic and physical movement is not necessary. The only requirement is appropriate skill and knowledge and access to a computer network.

Illegal drug production and marketing is old, well understood, requires very little technology but continues to be difficult, if not impossible, to control. Cyber crime is new, little understood, technology-based and rapidly accelerating as electronic communication assists the movement of cash and sends information at lightning speed around the world. Each protection device that is installed to prevent crime is rapidly confronted by a technique for circumventing this. Overcoming security barriers provides an exciting and lucrative challenge for criminals who wish to access sensitive commercial data, damage competitors, or launder money. These are the cyber criminals of today and tomorrow. They regard the drug barons as "old fashioned" and out of date.

Cyber crime activities, like drugs, have consequences for all of us. Alvin Toffler, extrapolating from changes in industrial structures, sees conflict as moving from the traditional background of killing and war to the equally destabilizing battleground of bitter economic competition (Toffler 1990). Here the weaponry will be technology, particularly electronic communication and intelligence. He suggests that we are now in a period of what he calls "info-wars" in which industry fights industry throughout the globe. As in military wars, espionage will be a major factor and this will not be just a passive collection of intelligence. There will be "commercial covert action" in which attempts are made to destabilize rivals through feeding false information into their computer systems.

An interesting feature of both drugs and cyber crime is that they eventually both end up as part of the same process. This is money laundering. Both drug and cyber criminals need to turn their profits into a legal form of finance so that they can spend their ill-gotten gains. Without the availability of money laundering, this would be difficult, if not impossible.

The solving of complex problems will always be handicapped by difficulties and ambiguities, many of which have to be accepted as they cannot be removed. A number of questions have been raised by Professor West Churchman, a distinguished American academic (Churchman 1971). He asks (1) "How does the problem solver decide what problems and aspects of the problem should be given most attention? If a problem has many aspects, which is the most relevant to pursue?" (2) "The aim of the problem solver is to find a pathway from the problem to the solution, should any pathway be acceptable or should the easiest and quickest route be the one chosen, even if this means redefining the problem?" (3) "How can a problem solver tell if information is correct or distorted?" (4) "How do we know when a problem has been solved?" (5) "Can complex problems ever be seen as solved or is the problem solving process a continuing one? If it is continuous, how do we know when to stop?" (6) "Is the problem solver ever separate from the problem, or is he or she a part of it?" Many of these questions are unanswerable, but being aware of them will give those tackling problems an understanding of the difficulty of the task and perhaps a degree of humility.

Experts tell us today that we are living in a risk society (Beck 1992), that our environment has more negative than positive aspects, and that, instead of choosing between desirable futures, we are more likely to be faced with a proliferation of different risks. Complex problems have a considerable similarity to risks and can easily become risks. They often have a large subjective element, for what one person considers to be a problem or a risk, another will see as an opportunity. They can be threatening and some can be so threatening that they make people afraid. This fear may be realistic and related to something that is actually happening or it may be based on hypotheses and related to events that may or may not occur in the future.

3. SKILLS THAT AID PROBLEM SOLVING

Three important skills relevant to complex problem solving are the notions of *capability*, *competence*, and *coordination*. By *capability* is meant having the power, capacity, and knowledge to achieve desired objectives (Kay 1996). This concept can be applied to the problem solving needs of organizations and how they can provide necessary and appropriate support for their problem solvers. John Kay suggests that capabilities can be viewed as essential assets. It is important for them to be identified and their relationship to successful strategy formulation or problem solving recognized.   The problem solving ability of

individuals is called personal ***competence***. Competence has been defined by the philosopher Gilbert Ryle as "knowing how" (Ryle 1949). He argues that in ordinary life, we are much more concerned with people's competencies than with their intellectual brilliance or their beliefs. What people can do is usually more important than what they know, for knowledge is only useful if it is applied. Competence implies that a person presented with a problem can think things through logically and get results.

Coordination is the third important concept in complex problem solving. By this is meant the ability to collaborate creatively and productively with other groups. This attribute, sometimes called "networking," is seen by some management gurus as the one most related to organizational success in today's complex world (Castells 1996). National and local governments, companies, and security forces must coordinate their activities with many different community groups if they are to make an impact on the very difficult problems of drug misuse and computer fraud.

Capabilities related to the identification and control of illegal drugs and cyber crime will include the following:

*   **Knowledge capability**. The ability to learn from the experience of problem solving and, as a result, to continually improve problem solving techniques.
*   **Resource capability**. An understanding of the resources required to produce effective problem solving in the selected areas. This will include staff numbers and expertise and material resources such as transport and backup.
*   **Psychological capability**. An emphasis on the importance of leadership, team work, trust, and good social relationships within the problem solving team in order to create and maintain morale.
*   **Organizational capability**. An ability to plan and think strategically, to set objectives, to deploy resources effectively, to manage complex situations.
*   **Innovative capability**. An encouragement of creative thinking.
*   **Ethical capability**. An ability to create and sustain a set of ethical values regarding working practices and relations with other groups.

Kay maintains that an important success criteria is establishing a match between the challenges faced by the organization and its capabilities. This will also be true of crime prevention and solution. A particular challenge with problem solving in these areas is appreciating that criminal activity exists and is a problem waiting to be tackled.

These capabilities can also be translated into the individual competencies or problem solvers in the following way:

*   **Knowledge competence**. The ability of an individual to learn from the experience of problem solving and, as a result, to continually improve personal problem solving techniques.
*   **Resource competence**. An understanding of the personal resources required to produce effective problem solving in the selected areas. These will include time and skills.
*   **Psychological competence**. An ability to work with others, to maintain personal morale, to persevere with difficult problems.
*   **Organizational competence**. An ability to plan and think strategically about one's personal contribution and how this fits with the needs of the total situation.
*   **Innovative competence**. An ability to think creatively, to approach problems from different angles.
*   **Ethical competence**. An understanding of, and willingness to accept, organizational values if these do not contravene important personal values.

4. COORDINATION

Complex problems require good ***coordination*** with different groups working effectively together. These will range from governments to community and self-help groups. All will need to identify and agree on their areas of responsibility and to be clear where their task boundaries are located so that responsibilities do not overlap unduly. Good communication and the sharing of information on a fast and continuing basis will be essential an the development of networked information systems will be a valuable aid. Electronic information is no substitute for face-to-face contact, however, and meetings to discuss policy and

progress should be regular events. It is in this area of coordination that many problems in combating drugs have been experienced in the past. European countries have been reluctant to work with each other and to share information, while problem addressing groups such as police and customs have become rivals instead of collaborators. But increasingly, these problems are being solved by the development of cross-European information systems and by joint police and customs activities.

The problem solvers of today and tomorrow must be able to operate in complex and volatile environments which contain many other interested groups. They have to be good at facilitating cooperation. Strategies likely to be effective, whether problems are organizational or criminal, will require networks of partners and contacts. The wider and more diverse these networks, the richer the flow of new ideas. There are often many different groups with an interest in the same problem. With crime, these will include the police, community groups, the direct victims of the crime, and others who have suffered because the crime was committed. These will all have to develop relationships with each other and these relationships will, in turn, change over time with new expectations, demands, and solutions becoming of critical interest to each of the different parties. Because of this complexity, few problems will have a single, specific solution. Most of these will require a range of activities directed at achieving a number of different objectives. Many are likely to be seen as continuous and investigation will be halted only when resources such as money are no longer available.

With drugs and cyber crime, effective coordination is particularly important at the national level. The Director of the FBI told an International Computer Crime Conference in March, 1997, that law enforcement agencies throughout the world must cooperate with each other to fight on-line crime. He provided three recent examples: a Russian citizen with a laptop computer in St. Petersburg who tried to gain access to millions of dollars in Citibank; a convicted terrorist who used a laptop to create plans to blow up a dozen U.S. plants; and a Swedish teenager who hacked his way into a Florida computer system and shut down a 999 emergency response computer network for an hour. The FBI speaker described this last example as "a dress rehearsal for a national disaster."

Companies are not usually well organized to deal with these kinds of problems, but governments should be and are, in fact, making some progress. European officials are preparing to bring a raft of new laws to regulate the cyber economy. Brussels is about to press for the harmonization of anti-crime legislation throughout the Community and this was discussed at the 1997 Amsterdam Summit. A committee of the Council of Europe is also starting work on a convention to enable the police forces of Europe to fight cyberspace crime. It is hoped that this convention will be signed by the year 2000 and will form the basis for future EU legislation. It is forecast that by 2000, up tp $1,700 billion of financial transactions will be made across computer networks. But there are still many problems. There are no agencies to deal with cross-border crime in Europe. Different countries are bringing in different regulations. Some countries do not even have a legal definition of fraud and, at present, the European Commission has no direct powers to combat fraud. Lax controls by any one EU member directly affect the others. Luxembourg now acts as an entry point for pirated CDs, which are then distributed through Germany. And cross-border investigations are very difficult. For example, the Swedish tax authorities are not allowed to give police or prosecutors information they have received from abroad.

5. OTHER USEFUL ATTRIBUTES

Capabilities, competencies, and coordination are group and individual attributes related to increasing knowledge and improving relationships, but other characteristics are required for successful problem solving. ***Team work*** is also very important. With large, complex problems, good team work is necessary. Knowledge will need to be shared, strategies agreed, and individual competencies used effectively. Finally, ***motivation*** for both the group and the individual is essential. The problem solvers must actively want to understand and solve the problem, or make a contribution to its future solution.

All aspects of problem solving are dependent on knowledge. Success requires the ability to search for, analyze, and synthesize relevant information and to relate it to past, current, and future events. Knowledge should lead to considered action. With drugs and cyber crime, this is not easy. It will require fast thinking and an ability to work under stress.

Effective problem solving also requires *feedback*. Events must be monitored so that their impact is noted and understood. In volatile situations, effective feedback will provide the information to facilitate a constant adjustment of plans and actions. This adjustment will require creative responses in order to cope with new, unanticipated situations. If this does not take place, the problem solving process may break down and end in failure. Ideally, fast, effective problem solving requires a regular, orderly world situated in an environment that changes little. Today, this comfortable situation is very hard to find.

Problems, like risks, as they develop and change over time, often produce a fall-out of new and unanticipated problems. These require the problem solvers to be continually vigilant, entrepreneurial, and innovative, either to anticipate and prevent the occurrence of these new inputs or to solve them quickly when they appear. The need for cooperation with other groups can now be an advantage as this, in itself, can lead to innovative ideas. Problem solving always involves uncertainty. There is the possibility of solving or addressing the wrong problem, of missing important issues, factors, or variables, and of introducing new problems because of the strategies and methods that are being used.

6. PROBLEM SOLVING METHODS AND THEORIES

Problems can be solved in many different ways. Experienced investigators may prefer to decide on an approach after they have become familiar with the problem and will derive this from their own knowledge and experience. Others will have a well-tried method, often developed by experts and publicized through training courses and books, that they always adopt. A third group will mix and match ideas and procedures from a number of methods until they develop an approach that seems to fit their immediate problem.

Although formal methods may be regarded as unnecessary, even constraining by the experienced investigator, they do have a number of advantages, especially for the person who is new to problem solving. First, they can act as an aide memoire, providing a reminder of the different tasks that have to be completed as the investigation proceeds through the stages from problem identification to problem solution. Second, they can indicate what is important. For example, it is unlikely that a good solution will be achieved unless an accurate diagnosis has been made. Third, if a group has responsibility for handling the problem, then a method can provide a clear, agreed approach that all will follow.

The difficulty here is how to design or choose an appropriate method—one that is likely to provide a quick, accurate diagnosis and a feasible, easy to apply solution. There is always a danger that a method can act as a straightjacket, focusing attention on certain things while not addressing others that are equally important, but not covered by the selected approach. The complexity of many modern problems makes method selection particularly challenging and uncertainty. For example, tackling today's computer-assisted fraud will require a knowledge of how fraud can be carried out electronically as well as a knowledge of how data is captured and held on a computer. In addition, the investigator will need to take account of more traditional factors, such as motivation, relationships, security systems, and available markets if the product of the fraud can be sold to others. The problem solving process will now more resemble a complicated jig-saw puzzle than a neat, sequential set of enquiries.

As diagnosis proceeds, the problem solving group is likely to develop one or more theories on how and why the problem or crime has occurred and how it can be removed, reduced, or prevented. They will have ideas that can be described as theories, models, or hypotheses. Theories, if they are to have any validity, have to be built from experience and knowledge. Building a theory is like traveling on a journey, often a long one, where the route is not known. Having a theory is arriving at one's destination. Ryle (1973) has described Sherlock Holmes as an excellent theorist. Holmes uses his theories to apprehend and convict criminals, to thwart planned crimes, and to prove the innocence of wrongfully accused suspects. These theories are also used to teach his friend, Watson, effective problem solving techniques.

Here is another example of the value of theories. They can be passed on to others. A good theory will assist the recipient to act or react in new and improved ways. Building valid and helpful theories cannot be done overnight. They require experience, thought, and judgment. Theories will not come from reading a detective's or manager's reports. But they may come from talking to the detective or manager at length, through watching what he or she does, and from benefitting from years of

experience. This is why mature nurses may be much better at solving problems than junior doctors. Or why an experienced police officer on the beat and close to retirement can handle a volatile situation better than many of his superiors.

Once we have a theory that seems to provide a plausible explanation for the problem we are concerned with, we tend to pass it on to our colleagues and to other interested groups. This is how ideas spread and become current wisdom. Richard Dawkins argues that ideas behave like genes. They are capable of replicating themselves in order to maintain their own survival (Dawkins 1989). He argues that theories and ideas propagate themselves by leaping from brain to brain via a process of copying or imitation. If problem solvers find a good theory, they will pass it on to their colleagues. The survival of the idea is then related to its psychological appeal and its perceived usefulness. These will depend on the goals and interests of the reception group.

For those interested in theory, Ross Ashby's Law of Requisite Variety can provide some useful guidelines (Ashby 1956). Ashby argued that only variety can control variety. By this, he meant that if a situation was complex, with many variables, then the techniques for dealing with the situation would need to have the same amount and kind of variety. Ashby applied his theory to engineering but it is equally applicable to other kinds of problems. If Ashby's law is accepted, this means that the law enforcement groups trying to eliminate the drug barons must have the same kind and level of knowledge as the drug barons themselves. They must understand their objectives and strategies, their operational management techniques, and the problems they experience in moving drugs from source to customer. It is here that weak links may be found. Similarly, those trying to prevent children from experimenting with drugs must understand the children's world, the power of curiosity, and the urge to be like older role models. They must also have something to offer as an alternative attraction. Drug addicts will, in turn, require facilitators who can sympathize and understand their addiction and can help them move on to other ways of solving their problems, if they wish to do this. An important therapeutic need here will be contact with individuals or groups who can provide acceptable employment.

Ashby also points out that with most problems you can go so far and no further: continuing to take action will not lead to better results. This can also be applied to the social problem solver who should always be aware of what realistically can be achieved. Extravagant ideas of future progress should not be encouraged as further effort will be wasted energy. Ashby also provides some suggestions on how to deal with and regulate very complex environments. Here again he is addressing engineering issues but his idea can usefully be transferred to the problem areas with which this paper is concerned. For example, one way to get control and achieve results is to lower standards, so that easier goals are set. Ashby recognizes that this is not a desirable solution, but he argues that it should not be forgotten. Another approach is to increase the power of the regulator until it is able to deal with the complexity. This would mean increasing the size of the law enforcement agencies until they were able to overcome the drug barons. Ashby realizes that this is often impossible to achieve in engineering and when applied to drugs, it would mean governments spending vast amounts of money on the police, customs, and military.

Another way of dealing with excessive variety is to establish which variables are linked together and can be controlled as a single unit. Ashby calls these constraints but they could just as easily be called linkages. For example, if the police persuade a club owner to take pains to exclude drugs, they will be controlling the behavior of clients, of doormen who often manage the drug selling activity, and of dealers who will not be able to operate there. Three problems will be solved through a single initiative. The more linkages that are identified, the more a single or a small number of actions can control them. Ashby also assesses control over periods of a year using what he calls an assessment of the "Grand Disturbance." He argues that what matters is the long term picture. Translating this into problem solving success in the drug area mans that just counting the number of dealers caught is not enough. What matters is an assessment of the reduction in drug dealing over a 12 month period.

Ashby defines design as communication. He argues that the act of "designing" or "making" a machine is essentially a communication from "maker to made." Similarly, designing a problem solving program or strategy is communicating an ethical position, a set of values, and a series of practical operations designed to achieve a desired result. This communication stretches from those implementing the program to those benefitting from its results. He suggests proceeding in stages so that each part of a program can be tested out before the next is implemented. It can then be reversed if it has proved to be a mistake. He also believes in "amplification," describing an amplifier as a device that, if given a little of something, will emit a lot of it.

Once a theory is accepted, a course of action can be decided. The danger now is that if the theory is wrong, the course of action may be of little value. A recent theory that attracted international attention was business process reengineering, with its claim that business success came from radical reorganization. Only after large numbers of companies had tried this "clean sheet" approach and found it did not work was the theory abandoned. There are many theories at present about the beneficial effects of imprisonment for society and that retaining the illegality of drugs will reduce their use. These are influencing government strategy, but they too may turn out to be wrong.

The lesson here is that methods and theories are useful provided they are developed with care as a result of experience and evidence. Difficult problems, where information is limited, will require flexible methods and theory development. Both will need to be carefully assessed and tested before a decision on action is taken. There is always a danger that a theory will be arrived at too quickly, on the basis of too little knowledge, or even on the basis of prejudgment or prejudice. When selecting methods, developing theories and deciding on courses of action, it is important to predict their likely consequences or to try them out and discover what their consequences are. Should we decriminalize drugs as the Head of Interpol has suggested? We do not know what the consequences will be, but we could test them out by legalizing cannabis and seeing what happens.

Changing situations will require new methods, theories, and strategies for action. With illegal drug dealing and cyber crime, police, victims, and criminals will be trying to anticipate each other's behavior and take appropriate responsive action. Similarly, if management takes successful precautions to reduce large-scale theft or computer-related fraud, then those with an interest in breaking into the system for gain will respond with new approaches and new methods.

7. STAGES IN PROBLEM SOLVING

7.1 Seeing the Total Picture

The first requirement with any complex problem is to try and understand it as a totality. How has it arisen and why? Where is it going and what route is it taking? Is it changing its nature or structure as it develops? Will it eventually solve itself or destruct of its own volition or is action required to remove or reduce its effects?

These questions lead us into something very similar to reverse engineering, a process in which engineers take complex devices apart to discover how they work. It is also similar to the diagnostic processes used by doctors who practice holistic medicine. This group is not concerned only with a specific symptom or complaint; the members strive to understand how the whole person, including both the body and the brain, is being affected by a particular disease or dysfunction. The police too follow this "total picture" approach when they try to understand how a particular crime or social problem is affecting the community as a whole.

Reverse engineering only brings understanding if the investigating engineer knows why the machine or device was built and understands the problem it is designed to address or solve. The parts can only be understood in terms of the whole. Similarly, we can only understand the drug and cyber crime problems in all of their complexity if we know who buys drugs and who sells them, and the motivations and behavior of cyber criminals. We also have to discover and understand the organizational processes that enable illegal goods to be moved from the producers to the consumer and from criminals to markets. We also have to ask probing questions such as "why are drugs illegal?" and "why is electronic data of value?" Trying to answer these questions will bring us into the realms and interests of governments, politics, industry, and the security forces. Finally, and most challenging of all, we have to ask and answer the fundamental question of the problem solver: "If we want to change this situation, how do we go about it?" IT may then turn out that the problem is insoluble and our only course is to learn to live with it.

It must not be forgotten that criminals also have to be effective problem solvers. They have to manage and control their illegal activities and ensure that they work efficiently and responsively. The controls they use include both money and violence. Each Columbian drug cartel has a network of killers together with groups of armed personnel who police and terrorize the territories and areas of interest to the drug barons. They also have a responsibility to prevent competition and to act as protectors. If stability is to be maintained, the drug barons also require control over the political and institutional environment. This has to be corrupt at all points, including local and national authorities, judges, police, and customs. Those in positions of power are

often given a choice of receiving substantial sums of money or seeing their families terrorized. Cyber criminals are less associated with violence unless their objective is terrorism. But they still need effective strategies for concealing their activities.

7.2 Developing Strategies

Developing appropriate strategies is a critical stage in problem solving. Strategies are likely to be viewed as acceptable if they have three characteristics. If they "correspond" with known facts, if they are "coherent" and fit with accepted knowledge, and if they are "pragmatic" and there is evidence that they can achieve practical results. The most important capabilities and competencies required of problem solvers are those related to initiating action and getting results. Strategies have to be a combination of the ethical and the acceptable.

With drugs, the great dilemma is whether to legalize or decriminalize them. Few countries support legalization, yet the reality is that the drug threat is greatly increased through the control of the market by criminal barons. This, as we have argued elsewhere, has frightening spin-off consequences. The amount of illegal money in circulation from drugs is enormous and growing. It enables drug barons, if they wish to do so, to take control of legitimate industries.

Strategic planning will always be an important part of complex problem solving. This requires clear, structured thinking before problems can be addressed. Although most problems can be approached from a number of different angles, coherent strategies that fit logically together and provide operational guidance are essential. In volatile situations, such as drug dealing and cyber crime, where criminal behavior is both sophisticated and flexible, these strategies may have to be continually reviewed and adjusted. But strategic thinking should never be abandoned. Muddling through is not an option. It is important to point out that some problems may prove to be insoluble. Both drugs and cyber crime could be in this category. Despite strategic thinking and well thought out counter operations, the wars against the drug barons and cyber criminals are being lost rather than won.

7.3 Taking Action

This paper has stressed the importance of knowing the total picture and of commencing problem solving with some well thought out overall strategy. It is now time to consider how the individual facets of a complex problem can be addressed operationally. Most complex problems are too large and challenging to be addressed as a whole. They need to be broken down into sub-problems.

Once the totality of the problem is understood and an appropriate overall strategy agreed, problem solving groups are encouraged to start a project with a mission statement. This should provide a clear definition of the task they are about to undertake and a set of priority objectives. Next, there should be a number of carefully thought out plans aimed at achieving those objectives. The operational details of planning can be assisted by using Stafford Beer's viable system model. For example, the management task associated with problem solving can be described as a hierarchy of activities. These are:

1. Identifying the basic, often routine, tasks that have to be carried out in addressing the problem.
2. Thinking through and documenting the likely difficulties that may occur and inhibit the successful completion of these tasks.
3. Identifying the critical success factors that provide guidance on what aspects of the problem should be given priority or maximum attention.
4. Understanding the nature of the information that needs to be collected and disseminated as the problem solving process progresses.
5. Creating methods of evaluation—the monitoring checks and measures that can provide guidance on whether progress is being made and whether goals are being achieved.
6. Finally, there will be a need for a constant review of strategy to ensure that the results are in fact being achieved (Beer 1989).

The actions required to tackle drugs are similar to those of a good doctor. They will, ideally, be based on an approach in which the total picture has been established and an appropriate strategy for cure or improvement developed. Next, the many sub-

programs will have to be identified, understood, and managed with a recognition that each is likely to affect the others. Also, a number of groups will have to cooperate if progress to a solution is to be made.

The cyber crime problem, in contrast, is closer to the work of the scientist and lawyer. It requires recognizing that a crime has been committed and finding out exactly what has happened. In most situations, protective devices will have been breached and preventative measures will have failed. Somehow, an intruder has managed to break into the system. The investigator needs to discover what has happened, how it has happened, and why it has happened. What was the objective of the break in? All this can often be accomplished by one or a small group of security consultants.

Many companies will respond to attack by merely closing the hole that has occurred in the system and going no further. Others will want out carry out some systematic research to establish how the intruder was able to enter the system, where he or she was physically located, the nature of the electronic journey, the obstacles which had to be overcome, and the nature of the theft. Was it information or money? All this requires considerable knowledge and careful application.

Protection from cyber crime, in contrast to drugs, is primarily about prevention, and prevention in situations where the possibility of attack ranges from very possible to unlikely. While the drug problem is apparent to most people, although definitions of how and why it is a problem vary, the cyber crime problem is hidden and often unheeded. Many managers are quite unaware of it, and this is true at all levels in the company, from the board down. Those that do realize that fraud or illegal access to files is possible too frequently have an "it can't happen here" attitude. Nevertheless, when companies are aware and decide to take precautions, some useful problem solving lessons can be learned. One is that there are now available a considerable number of technical aids to protection. These will deter many criminals and especially those that are located within the company. They make fraud more difficult to carry out. Unfortunately, serious professional criminals will usually have the skills to get past these devices and this means they have to be continually upgraded.

A second valuable technique is the use of risk management techniques in assisting an accurate diagnosis of vulnerability to attack. Risk analysis and assessment can then lead to effective security strategies and plans, both to prevent attack, to know when it is happening, and to respond in a way that causes the least disturbance to the company.

8. CONCLUDING THOUGHTS

Problem solving is difficult yet too often it seems to be limited to a process of deciding to do something then following this with a series of actions which intuition suggests will achieve the desired result. This is similar to shooting in the dark. There is no way of knowing that the proposed actions will lead to a solution or even that the problem can be solved. The alternative is to create a well thought out, logical path to a solution.

Effective problem solving requires the control of "entropy." Entropy is a term used by physicists to describe energy which exists but is unavailable for productive use. When applied to problem solving, it can be described as energy which is not being used to good effect. It is wasted on inappropriate strategies and actions that make little contribution. Too much energy of this kind can lead to chaos. The problem becomes increasingly confused and insoluble and ideas on how to deal with it become more and more clouded.

Problem solving with difficult and complex problems also requires a recognition of the interaction that is taking place between psychological, economic, technical, cultural and political factors. Questions which need to be asked and answered are "who wants to solve this problem?" "Who will pay the costs of a solution?" "How can technology assist?" "What kinds of solutions will be culturally and politically acceptable?"

Most major problems are affected by the positive or negative answers that are given to these questions. In the United States, it is acceptable to describe the action against drugs as a "war" and to involve the military in the problem solving process. This approach is not favored in Europe, which prefers a softer approach. But European countries would not, at present, accept a strategy that involved legalizing or decriminalizing the use of drugs even though this would remove drug dealing from the control

of criminals. Again, all countries are finding it difficult to introduce effective strategies against money laundering, the process which enables the drug and cyber criminals to realize their profits. This is because illegally acquired money is now becoming irretrievably mixed with money associated with legitimate economic activities.

A second characteristic of complex problems is that parts of them may be very resistant to any solution. Drug dealers when attacked do not go away. They either change their criminal area of interest or are replaced by a new group who continue running the old business. Similarly, hackers are almost impossible to eliminate. As one group is caught, another replaces them. The problem situations then create and maintain their own futures. The opposite is also true. Complex problems always have their vulnerable areas where progress can be made if there is the political will to do so. The removal of money laundering facilities would immediately remove the profits from drugs and cyber crime and their criminal attraction would cease.

Another feature of complex problems is that they change over time. With drugs, youth fashion has a major influence on who takes drugs and what kinds of drugs are used. With cyber crime, developments in the business use of computers and in security technology affect the problems that have to be solved. Change here is more dynamic than with drugs because of the relationship between criminals and victims. There is a continual seesaw of competitive activity between the owners of the systems who are trying to protect them and the criminals who are trying to access them.

Most complex problem solving is a balancing act with problems being partially solved then returning in new forms, some of which may be as difficult or more difficult to solve than the original threat. Some solutions, which are politically attractive because they are cheap and acceptable to governments, can lead in the wrong direction. The early responses to mad cow disease provide many examples. Symptoms but not causes are being addressed. The answer here is understanding the social dynamics of the problem and identifying the pressure points where improvement can be secured.

Designing a problem solving program or strategy requires knowledge, especially a knowledge of the nature and extent of the problem. This knowledge will assist the development of an ethical position, a set of values, and a series of practical operations designed to achieve a desired result. All of these must be communicated by those implementing the program to those benefitting from its results.

It must never be forgotten that problem solving is a difficult process that can always be improved. Criticism of the ways problems have been solved in the past can lead to improvements in the future. A healthy sense of criticism is what gives problem solvers, designers, and inventors their edge. It is what drives progress and is an essential element in improving the world we live in (Petroski 1996).

References

Ashby, R. *An Introduction to Cybernetics*, Chapman & Hall, London, 1956.
Baumann, Z. *Post Modern Ethics*, Blackwell, London, 1993.
Beck, U. *The Risk Society*, Sage, London, 1992.
Beer, S. *Diagnosing the System for Organizations*, Wiley, New York, 1985.
Castells, M. *The Rise of the Network Society*, Blackwell, London, 1996.
Churchman, C. W. *The Design of Inquiring Systems*, Basic Books, New York, 1971.
Dawkins, R. *The Selfish Gene*, Oxford University Press, Oxford, England, 1989.
Kay, J. *The Business of Economics*, Oxford University Press, Oxford, England, 1996.
Petroski, H. *Invention by Design*, Harvard University Press, Boston, 1996.
Ryle, G. *The Concept of Mind*, Penguin, London, 1973.
Toffler, A. *Powershift*, Bantam Books, New York, 1990.