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THE RANKING TECHNIQUE AS AN AID TO DECISION MAKING

JOHN CHARLES CHICKEN

A THESIS SUBMITTED FOR THE DEGREE OF MASTER OF ARTS  
OF DURHAM UNIVERSITY

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10 MAY 1994

## ABSTRACT

This thesis examines the capability of the Risk Ranking Technique as an aid to decision making. First the nature of the Risk Ranking Technique is described and its capability demonstrated by applying it in a post hoc way to the Channel Tunnel decision. Then to provide a basis for comparison the methods banks use to assess the acceptability of financial risk they are exposed to are examined. This is followed by examination of the problems of assessing technical, economic and socio-political aspects of risk. Then the adequacy of the theoretical basis of the Risk Ranking Technique is analysed. This is followed by examination of the range of possible alternatives to the Risk Ranking Technique. The efficacy of these alternatives is then compared with the Risk Ranking Technique by applying them to three major decisions. Finally a comparison is made of the Risk Ranking Technique with the methods used by the banks and insurance companies to assess the acceptability of risk.

The main conclusions from the study are:-

- 1) Of the techniques examined the Risk Ranking Technique is the only one that is based on comprehensive assessment of technical, economic and socio-political factors involved in a decision.
- 2) The Risk Ranking Technique is transparent to the proposer and the lay public.
- 3) There is a logical structure to the Risk Ranking Technique.
- 4) With the Risk Ranking Technique and the other techniques considered their efficacy as aids to decision making is enhanced if the criteria they use are tailored to suit particular families of decisions.
- 5) The comparison of the Ranking Technique with the methods used by the Banking and Insurance industries shows something of the range of criteria that may be required for particular applications.

**KEY WORDS: RISK RANKING, BANKING, INSURANCE, TECHNICAL, ECONOMIC, SOCIO-POLITICAL ISSUES**



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## CHAPTER 1

### Introduction

Nothing is more difficult, and therefore more precious, than to be able to decide.

Napoleon 1  
Maxims (1804-15)

The aim of the research described in this thesis was to assess to what extent the Comprehensive Risk Ranking Technique could be used for comprehensive assessment of the acceptability of the risks inherent in major project decisions. The Technique was originally developed by Chicken to fill a gap in the repertoire of techniques decision makers used for assessing the acceptability of hazardous projects. At that time the techniques in the repertoire were mainly aimed at assessment of the technical aspects of risk. The Comprehensive Risk Ranking Technique provided a way of integrating assessment of the technical, economic and socio-political issues involved. The comprehensive technique was found to have the potential to help decision makers assess a broader spectrum of project decision making situations and it is that aspect of the Technique's capability that is at the centre of the study.

The start of the development by Chicken of the Comprehensive Risk Ranking Technique was work he did in 1973/74 on Hazard Control Policy in Britain, the work was reported in reference (1). The work was discussed with Lord Ashby and was recognised in his own work on the acceptability of risk (2). In the following years the concept of Comprehensive Risk Ranking was developed further by Chicken and the developments reported in references (3)(4)(5)(6)(7)(8) and (9). Some of this development was funded by the Commission of the European Communities and the results of that part of the work was published as reference (10) in 1986. In reference (10) the Comprehensive Risk Ranking Technique is presented in terms that could be described as the embryo from which grew the Comprehensive Risk Ranking Technique discussed in this thesis. The next

developments were mainly concerned with the acceptability of risk in terms of the technical risk to the public and these developments were reported in Reference 11. Development of the Technique continued with the aim of making it useful as an aid to assessing the acceptability of a wide range of projects. The efficacy of the Technique was then tested on five projects which were: Canvey Island, Moss Moran, Rijnmond, The Channel Tunnel and Energy Options. This work was reported in reference (12). These tests showed that there was scope for improving the Technique in three areas. The areas were: refining the scoring of acceptability, incorporating allowance for the experience and capability of the proposer and determining the extent to which the economic acceptability of a project should be related to the methods financial institutions like banks and insurance companies use. In this thesis the possibilities for refining the three areas of the Technique are explored.

The Risk Ranking Technique was designed to present the decision maker with a comprehensive non-dimensional assessment of the technical, economic and socio-political factors associated with a decision; in a way that does not conflict with the best traditions of statistical analysis. In some ways the design of the technique was influenced by systems thinking. The extent of the influence is that the Ranking Technique aims to unify the influence of various factors into a coherent whole. (13) The Technique has also been influenced by Lindley's approach to scoring, uncertainty and blending numerate ideas with less formal approaches (14). Encouragement that there may be need for yet another method of assessing decision options has been taken from Hogarth's view that:- many of the existing aids to decision making lack the flexibility necessary to capture the essence of the problems inherent in major decisions (15).

An important consideration in developing the Risk Ranking Technique was to provide decision makers with a coherent, transparent and defensible way of arriving at decisions, which could be used to justify decisions to the lay public. The specification of a coherent and transparent assessment implies that the method must be logical and relatively simple. These practical requirements mean that use of some

elegant statistical methods has had to be avoided; at the same time it is recognised that such methods may have a role in the preparation of the evidence on which Ranking has to be based. The importance attached to being able to justify complex decisions to the lay public is recognition of the fact that often every aspect of decision making related to major projects, and to expenditure of public funds, has to be defended in public against searching examination by official organizations and by the media. Unless the basis for a decision can be explained and defended in clear terms, easily understood by the general public, there is a distinct possibility that the arguments will be misunderstood and perhaps even unintentionally generate opposition. The need for comprehensive justification of decisions is illustrated by: the range of topics examined in Public Inquiries like the Sizewell 'B' Public Inquiry, (16) the way in which international companies like Ford and Nissan decide where to build their plants, and the way international financial institutions like Banks assess the credit worthiness of countries. Such decisions have to take account of a combination of many factors, but not always the same combination of factors. The specific combinations of factors and the criteria used for assessing acceptability are often not clearly stated in advance, nor is any indication given of the weight attributed to each factor in arriving at an overall view about acceptability. The Ranking Technique is seen as one way of overcoming this problem by providing a consistent way of assessing each factor and providing a predictable way of weighting and combining each factor to give a consistent overall assessment.

In building up this thesis use has been made of the earlier work published by Chicken, particularly reference (12). The new material introduced with the aim of refining the Risk Ranking Technique falls mainly in six areas, which are:- financial institutions' methods of assessing the acceptability of risk, refining the scoring technique, modification of the way technical factors are assessed, modification of the way economic factors are assessed, discussion of theoretical considerations and the discussion of possible alternatives. The assessment of socio-political factors remains essentially unchanged from

earlier work (12). The thesis also makes use of the assessment of the Channel Tunnel which Chicken made for clients of his consultancy and which was reported in reference 12.

So that the argument that follows can be more easily understood the nature of the Risk Ranking Technique is first explained. Essentially the Technique consists of an assessment of the significance of all the factors associated with the acceptability of the risks inherent in each option that has to be considered. In this thesis the term risk is used to denote the measure of uncertainty about acceptability associated with any estimate of the significance of a factor. For assessment purposes the factors are considered under three broad headings, which are:- technical, economic and socio-political. These three groups of factors are intended to cover every aspect of acceptability and taken together they provide a realistic basis for Ranking the overall acceptability of a proposal. One possible composition of the factors is shown in Table 1. To rate the acceptability of each group of factors they are scored on a numerical scale against specific criteria. The higher the score the lower the factor's acceptability. The overall Ranking of the acceptability of a project being calculated by integrating the scores of the individual factors. The integrated score determining which of four Ranks of acceptability the proposal as a whole belongs to. How the overall risk Ranks are defined and the Ranks related to the Ranking scores of the individual factors is shown in Table 2. The scoring scheme being arranged so that the highest score, that is the least desirable score, of any factor will dominate the overall Ranking of acceptability. This is an important change from the linear scoring scheme used in earlier versions of the Ranking Technique such as the scheme described in reference (12).

Ranks 2 and 3 are both Rankings of proposals that can be made universally acceptable by modifying the proposal. The changes required to make a Rank 2 proposal acceptable being much more extensive than required to make a Rank 3 proposal acceptable.

To some extent the success of the Ranking Technique depends

**TABLE 1 Composition of the Main Groups of Ranking Factors**

FACTOR	NATURE OF RISK	POSSIBLE COMPOSITION OF FACTORS
TECHNICAL	Plant would not perform as required.	Plant performance. Plant reliability. Harm to the public.
ECONOMIC	Less than optimum benefit from financial commitment.	Supply and demand. Magnitude of possible financial loss. Payoff. Index of harm/benefit. Cost/benefit analysis. Through life cost.
SOCIO-POLITICAL	Not politically acceptable.	Public acceptability. Results of Public Inquiries. Political climate. Views on current quality of life.

on having available a relevant reliable analysis of each factor. Ideally the analysis should be quantitative with the degree of uncertainty clearly defined. But the Technique is also useful when, as is often the case in decision making, there is little or no reliable data available as in such cases the Technique provides a logical structure to the assessment.

Application of the Ranking Technique requires six basic steps. The steps are:- 1) Define decision. 2) Specify the criteria that have to be used to judge the acceptability of the parameters associated with each factor. 3) Identify the options available. 4) Identify the data available about each factor associated with each option. 5) With the data

**TABLE 2 Construction of Risk Ranks**

RISK RANK	ACCEPTABILITY	POSSIBLE ACTION TO MAKE RANKING MORE ACCEPTABLE	SCORE FOR ANY FACTOR IN THIS RANK	TOTAL SCORE RANGE
1	Unlikely	Unlikely any possible	14	16-42
2	Only if risk can be reduced	Greater investment or organizational and major technical changes	5	7-15
3	Subject to certain action	organizational changes or minor technical changes	2	4-6
4	Without restriction	None required	1	3

available assess the Ranking justified for each option. 6) Using the Rankings obtained determine which decision option is the most comprehensively acceptable. In reality each step involves a considerable amount of analysis, but before delving into the detail of the technique a simple illustration of the application of the technique is given.

To illustrate the application of the Ranking Technique an assessment is presented of the decision to build the Channel Tunnel, the assessment is derived from that presented by Chicken and Hayns in reference 12. The assessment was based mainly on the information in the official case presented to Parliament (17). It was on the basis of the official case that the government decided to approve the construction of the Channel Tunnel. It is stressed that the criteria used to judge acceptability in this case represent initial thinking on criteria and in the later chapters the problems of specifying criteria are critically assessed.

In arriving at the decision to build a Channel Tunnel the government had five options to consider. The options were known as:- Eurobridge, Euroroute, Channel Tunnel, Channel Express and No Fixed Link. The essential features of each option are summarized in Table 3. As with any application of the Ranking Technique criteria had to be postulated for assessing the Ranking of the acceptability of the risk associated with the technical, economic and socio-political factors of each option. Simple subjective qualitative criteria were adopted, these criteria are summarized in Table 4. It is stressed that the criteria are for demonstration only. In a real case more quantitative criteria may be used, which would require the uncertainties associated with estimates of parameters to be identified. In later chapters the question of how uncertainty in the data can be allowed for is discussed, particular attention being given to novel projects for which there is no relevant quantified data base.

One reason for using simplified criteria was that in the evidence, presented to Parliament, no attempt was made to quantify the probability associated with the various predictions. The evidence used did not draw attention to such facts as: the real experience with the material proposed for the suspension-bridge cables was only about one seventh of the life proposed for the material and no justification was given for the acceptability of the explosion risk in long tunnels. Nor for every option was there discussion of the possible variation in construction costs. In this context it is important to remember the variation in novel construction jobs can be considerable. For example, quite unrelated projects like the Sydney Opera House and Concorde escalated to about ten times the original estimate. (18) The Thames barrier was originally estimated to cost £23 million and actually cost £461 million. (19)

The Ranking scores considered to be justified for each factor of each of the options are shown in Table 5. The overall Ranking justified by integrating the scores of each option are shown in Table 6. The conclusion that the Ranking exercise appears to endorse, on the basis of the evidence in reference 17, is that overall the Channel

**TABLE 3 Summary of the Essential features of Channel Crossing Proposals\***

PROPOSAL (Proposers)	ESSENTIAL CONSTRUCTION FEATURES	TECHNICAL PROBLEMS
EUROBRIDGE (17) (Laing, Brown & Root and ICI)	Suspension bridge of seven 5km spans plus 6m diameter rail tunnel. Traffic lanes enclosed in a Superferrolo tube. The suspension cables 1.4m diameter Parafil.	Suspension tower to withstand impact of a 250,000 ton ship. Oscillation of spans. Ventilation of traffic tube. Explosions on the bridge. Driver fatigue. Life of components.
EUROROUTE (17) (Trafalgar House, British Steel and Banks)	For road transport two bridges from each coast to artificial islands. Islands linked by tunnel on the sea bed. Also a rail tunnel on sea bed coast to coast.	Ventilation of the tunnels. Earth movement. Resistance of the 34 protective caissons to damage by shipping. Explosions in the tunnel. Life of components.
CHANNEL TUNNEL (17) (5 UK and 3 French construction companies and banks)	A 3-tunnel system, two railway and one service tunnels. Terminals for loading and unloading road vehicles on and off trains.	Ventilation. Earth movements. Life of components. Explosions in the tunnels.
CHANNEL EXPRESSWAY (17) (British Ferries)	A twin tunnel system, each tunnel taking both road and rail traffic. Would be the largest drive through tunnel in the world.	Ventilation. Earth movement. Life of components. Driver fatigue.
NO FIXED LINK OPTION	Revision of Ferry Regulatory requirements	Redevelopment of ports and congestion in ports and sea lanes.

\*Developed from Table 23 ref. 12

**TABLE 4            Ranking Criteria Assumed for Illustration**

FACTOR	RANKING SCORE	CRITERIA
TECHNICAL	1	No technical problem
	2	Minor changes required to overcome technical problems
	5	Major changes required to overcome technical problems
	14	Technical problems unlikely to be solved.
ECONOMIC	1	Capital required easily raised. Return on investment above average.
	2	Capital can be raised. Return on investment at least average.
	5	Capital can only be raised with difficulty. Return lower than average.
	14	Negative return on investment. Unlikely capital can be raised
SOCIO-POLITICAL	1	Acceptable by the public
	2	Minor objections by the public
	5	To satisfy objections by the public major changes have to be made
	14	Unacceptable to the public

Tunnel is the most acceptable option and the No Fixed Link Option the least acceptable. In other words, on the basis of evidence used, the decision to build the Channel Tunnel was justified. In 1989 it appeared the Channel Tunnel would cost 40% more than the original estimate, so perhaps the favourable view taken of the contingency allowance in the original figures was not warranted (20).

**TABLE 5**                      **Justification of the Channel Crossing Options' Ranking Scores\***

PROPOSAL	TECHNICAL	ECONOMIC	SOCIO-POLITICAL
EUROBRIDGE	Limited life data about some materials it was proposed to use <u>Score 5</u>	Cost estimate £5.9bn possible variation not discussed Return 21-22% <u>Score 2</u>	No structured survey of opinion made. No serious objection reported <u>Score 1</u>
EUROROUTE	Although not all technical issues examined technical justification adequate <u>Score 2</u>	Estimated costs might reach £10.7bn Return 17%  <u>Score 5</u>	No structured survey of opinion made. No serious objection reported  <u>Score 1</u>
CHANNEL TUNNEL	Although not all technical issues examined technical justification adequate <u>Score 2</u>	Maximum debt allowing for contingency estimated to be £4.75bn Return 19%  <u>Score 1</u>	No structured survey of opinion made. No serious objection reported (21)  <u>Score 1</u>
CHANNEL EXPRESS WAY	Although not all technical issues examined technical justification adequate <u>Score 2</u>	Cost estimated to be £2.5bn No discussion of possible variation Return 27%  <u>Score 2</u>	No structured survey of opinion made. No serious objection reported  <u>Score 1</u>
NO FIXED LINK	Requirement not known No designs presented  <u>Score 5</u>	No costs given but financial risks assumed to be similar to present pattern <u>Score 2</u>	Present crossing service considered inadequate  <u>Score 2</u>

\*Derived from Tables 26, 27 and 28 ref.12

**TABLE 6 Overall Ranking of the Acceptability of Channel Crossing Proposals\***

PROPOSAL	TOTAL SCORE	RANK
EUROBRIDGE	8	2
EUROROUTE	8	2
CHANNEL TUNNEL	4	3
CHANNEL EXPRESSWAY	5	2
NO FIXED LINK OPTION	9	2

\*Modified form of Table 29 Ref.12

Ranking has been used in various ways including describing the acceptability of potentially hazardous plant and equipment, but such uses have tended to be limited to making assessments simply on a technical basis. Although the Commission of the European Community has encouraged the development of comprehensive assessment of the acceptability of proposals involving potentially major hazards such methods have not yet been adopted as a mandatory part of the regulatory procedure. However, at a CEC seminar in Nice in September 1988 (22) the representative of the Netherlands Ministry of Housing Physical Planning and Environment announced that the Dutch government was considering adopting, as part of its regulatory procedure, a comprehensive form of Ranking the acceptability of risks that takes into account technical, economic and socio-political factors. The approach is similar in concept to the procedure just described, but details of the procedure have not yet been made public.

As the aim of this thesis is to critically examine how the Risk Ranking Technique can be refined to increase its potential as an aid to decision making for major projects, the potential of the Technique was compared with the techniques used by banks. This comparison was considered to be important as banks are at the heart of many business decisions. Recently banks have been underpressure to

improve the way they assess credit worthiness of applicants for loans. This is partly a consequence of the dramatic increase, since 1979, of the amount of international debt rescheduling. It has been suggested, by Channon, that the primary cause of the need to reschedule debt interest payments and debt repayment was the disturbance to the balance of world capital flows caused by changes in the price of oil in 1974. (23)

In the examination of the risk assessment methods used by financial institutions particular attention is given to the procedures the Swiss Bank Corporation developed for assessing the credit worthiness of various countries. The process they use was introduced in the early 1980's and has, over the years, been refined to take account of experience. The technique they use incorporates an assessment of the country's domestic economy, external economy, debt, the political risk involved and the per capita growth in the gross domestic product. The criteria that the Swiss Bank Corporation use for judging acceptability have some similarities with the criteria for Ranking of the Channel Crossing options described above.

In the following first an assessment is made of the techniques financial institutions use in evaluating the risks they consider accepting. Then an assessment is made of the problems of evaluating the various factors that have to be considered in assessing the acceptability of using the Risk Ranking Technique, this includes assessment of the theoretical considerations and the possible alternatives. Then a view is postulated about what is considered to be the optimum way of assessing decision options. Finally a number of conclusions are drawn about the general efficacy of the refined form of the Risk Ranking Technique. The analysis is built up in ten steps. The steps are:-

- 1) Describe the approach of financial institutions to the assessment of risks.
- 2) Assess the theoretical considerations underlying the Ranking Technique.
- 3) Evaluate the problems of assessing the technical aspects of risk.

- 4) Evaluate the problems of assessing the economic aspects of risk.
- 5) Evaluate the problems of assessing the socio-political aspects of risk. (This is virtually the same as given in ref. 12)
- 6) Review possible alternatives to the Ranking Technique and the financial institutions' approach to assessing risk.
- 7) Comparison of efficacy of alternatives.
- 8) Compare the efficacy of the Comprehensive Risk Ranking Technique with the methods used by financial institutions.
- 9) Postulation of the optimum method of assessing decision options.
- 10) From the analysis, a number of general conclusions are drawn about the potential capability of the refined version of the Risk Ranking Technique as an aid to decision makers dealing with a broad spectrum of project decisions.

## CHAPTER 2

### Approach of Financial Institutions to Risk Assessment

In this chapter the ways financial institutions assess the risks, associated with their lending procedures, they are exposed to are examined to determine what features their practices have in common with other aids to decision making. Banks' views on risk management were put into perspective by Aloys Schwietert, Vice President and Chief Economist of the Swiss Bank Corporation, when he introduced a paper on the Swiss Bank Corporation's approach to Country Risk Assessment. He then described the role of a banker in the following terms:- (24)

"The banker's job is to manage risk rather than merely avoid it. The recent stock market crash reminded the world at large that risk management is increasingly important in the area of international finance. One major aspect of risk management is the assessment of the risk: Before you can try to manage your risks - by diversifying, hedging or at least bracing yourself for what lies ahead - you have to identify them and put them in perspective. This is true whether we're talking about conventional credit risks or the 'country' attached to loans to foreign borrowers.

Not all banks are equally willing to take on risk exposure. There is a broad spectrum of lending policies ranging from extremely cautious to highly aggressive. Each bank follows its own course and develops its own parameters for the risk/reward targets governing its operations.

At the same time, the banks draw on a long tradition of shared experience and professional procedures in developing the information base from which risk assessments can be derived. Country risk assessment is a case in point."

Schwietert also mentioned that the Country Risk Assessment procedure his Bank used had proved to be a useful aid to

monitoring the economic stability of developing nations and industrialised countries. He also recognized that the general subject of Country Risk Assessment is still evolving as a discipline. This leaves open the question of how the problem is dealt with by other corporations or government agencies.

Banks like other financial institutions are subject to both internal and external control over the amount of risk they can accept. The external controls are those imposed by government regulatory authorities and in the case of countries in the European Economic Communities imposed by directives of the Council of the European Communities. In the case of Britain the Bank of England is the regulatory authority and the body that advises British banks on the way European Economic Communities directives must be implemented. The two directives that are particularly relevant to the amount of risk a financial institution can accept in general are the directives on: Credit Institutions' own Funds (25) and a Solvency Ratio for Credit Institutions.(26) These directives were implemented by the Bank of England in two notices they issued to Institutions authorised under the Banking Act 1987. One notice dealt with implementation in the United Kingdom of the Directive on credit institutions own funds (27) and the other dealt with implementation in the United Kingdom of the solvency ratio directive.(28)

The importance of these directives and the way they have been implemented is their implication for risk acceptance. Although the directive uses the term "solvency ratio" the Bank of England in their notices prefer to use the term "risk asset ratio", which makes the concern about risk clearer. The risk asset ratio is the ratio of a bank's capital to the risk-adjusted values of assets and off-balance sheet items. Both the directive and the Bank of England notice say the ratio should not be less than 8%. Various asset items included in the calculations are risk weighted according to type and location. Although the directive specifies risk weightings it also states that:"competent authorities may fix higher weightings". In Appendix 1 the Bank of England's risk weightings are given. Perhaps the most important implication of the directives is that they represent an external influence on banks, which

attempts to harmonize the magnitude of financial risk in their portfolio of risks in relation to their assets.

The internal controls banks use to manage their portfolios of risks take several forms, each bank tending to develop its own methods. There are however important common features. All the criteria used are to a certain extent variable. The criteria being adjusted to reflect the current economic climate and developments in what are considered to be important parameters in assessing the acceptability of risk. For example in Britain in the early nineteen nineties it is much more difficult for a company to borrow money from a bank than it was in the mid-nineteen eighties. Because the recession had resulted in banks having to make extensive provision for bad debts they were more demanding about the quality of the loans they got involved in.

The methods banks use to assess the acceptability of risks in the loans they make vary, not only between banks, but also according to the size of the loan. The assessment of a small business man's application for a ten thousand pound loan is somewhat simpler than the assessment made of a country's application for a five hundred million pound loan. This does not mean that the more detailed assessment is necessarily more accurate. A fair judgement on the methods used would be that they give the experienced Loans Officer a qualitative indication of the magnitude of the risks associated with a particular loan.

At the heart of any decision about the acceptability of a loan will be an assessment of the five basic characteristics that determine the acceptability of a loan proposal. The characteristics are, in order of importance:- 1. Ability of borrower to repay, 2. Willingness of lender to make loan, 3. Wealth of borrower, 4. Security against loan, 5. The economic environment. The risk may be categorised on a seven point scale of the type shown in Table 7. Every organisation may have its own special classification system but the general concept is the same.

At the level of a personal loan a bank simply assesses a person's income, outgoings, employment record, age and

**TABLE 7 Generalised Loan Risk Classification**

<b>RISK CLASS</b>	<b>RISK CODE</b>	<b>INTEREST CHARGED</b>
1. Nominal or No risk	A+ to A-	Standard
2. Minimal risk	B+ to B-	Standard
3. Reasonable risk	C+ to C-	Standard + 10%
4. More than normal risk	C- to D+	Standard + 25%
5. Cash basis loan only	D	Standard + 40%
6. High risk	D- to F+	Standard + 50% to 100%
7. Unacceptable	F	No loan possible

marital record. For slightly larger loans their account may be reviewed, a security or guarantee called for and a general check made on their creditworthiness. A small business seeking a loan would be expected to show three years accounts to prove that it was trading profitably. In addition a cash flow forecast certified by an accountant may be called for. In assessing a company's financial report the figures would be assessed under five main groups, which are:- Activity Ratios, Selling Expense Ratios, Leverage Ratios, Liquidity Ratios and Profitability Ratios. The composition of these five groups is shown in Table 8. Just one year's figures can often give a misleading impression and a better feeling can be developed by looking at trends over three or more years. The acceptable ratios will not be the same for all industries, for example the fluctuations in the fashion trade may be seasonal and in an engineering consultancy there may be a three year cycle.

Some analysts have recently been using fifteen cause and effect ratios. Some of these ratios are very similar to the financial statement ratios just mentioned. The fifteen ratios are shown in Table 9. Taken together the ratios just described give a good indication of the past performance of a company. It is stressed that they only indicate the past performance. Because the ratios are calculated from financial statements they tend to be out of date. Past performance is no measure of current or future

**TABLE 8      Composition of Financial Report Assessment Ratio Groups**

RATIO GROUP	COMPONENT RATIOS
Activity Ratios	Inventory Turnover = $\frac{\text{Sales}}{\text{Inventory}}$
	Fixed Asset Turnover = $\frac{\text{Sales}}{\text{Net Fixed Assets}}$
	Total Asset Turnover = $\frac{\text{Sales}}{\text{Total Assets}}$
Cost Structure Ratios	Gross Profit Margin = $\frac{\text{Sales less Cost of Sales}}{\text{Sales}}$
	Selling Expense Ratio = $\frac{\text{Selling Expense}}{\text{Sales}}$
	General Cost Ratio = $\frac{\text{General and Admin. Costs}}{\text{Sales}}$
	Depreciation plus Lease and Rental Costs Ratio = $\frac{\text{Depreciation plus Lease and Rental Costs}}{\text{Sales}}$
Leverage Ratios	Leverage Ratio = $\frac{\text{Total Debt}}{\text{Total Assets}}$
	Fixed Charge coverage ratio = $\frac{\text{Income available for meeting Fixed Charges}}{\text{Fixed Charges}}$
	Before Tax Income Required for Sinking Final Payment = $\frac{\text{Sinking Final Payment}}{1.0 - \text{Tax Rate}}$
Liquidity Ratios	Current Ratio = $\frac{\text{Current Assets}}{\text{Current Liabilities}}$
	Working Capital = Current Assets - Current Liabilities
	Quick Ratio = $\frac{\text{Current Assets - Inventories}}{\text{Current Liabilities}}$
Profitability Ratios	Profit Margin on Gross Revenue = $\frac{\text{Net Income}}{\text{Gross Revenue}}$
	Return on Investment = $\frac{\text{Net Income + Interest}}{\text{Total Assets}}$
	Return on Net Worth = $\frac{\text{Net Income}}{\text{Net Worth}}$

**TABLE 9 Cause and Effect Ratios**

RATIO GROUP	COMPONENT RATIOS
Causal Ratio	Inventory Turnover = $\frac{\text{Net Sales}}{\text{Inventory}}$
	Profit Objective = $\frac{\text{Net Profit}}{\text{Net Sales}}$
	Recurables Analysis = $\frac{\text{Current Accounts Recurable}}{\text{Longest Credit Terms}}$
	Use of Capital = $\frac{\text{Fixed Assets}}{\text{Net Worth}}$
	Trading Ratio = $\frac{\text{Net Sales}}{\text{Net Worth}}$
	Evaluation of Asset Classification = $\frac{\text{Miscellaneous Assets}}{\text{Net Worth}}$
Effect Ratio	Current Ratio = $\frac{\text{Current Assets}}{\text{Current Liabilities}}$
	Current Liability Ratio = $\frac{\text{Current Liabilities}}{\text{Net Worth}}$
	Total Liability Ratio = $\frac{\text{Total Liabilities}}{\text{Net Worth}}$
	Inventory Ratio = $\frac{\text{Inventory}}{\text{Working Capital}}$
	Receivable Ratio = $\frac{\text{Trade Receivable}}{\text{Working Capital}}$
	Long Term Liabilities Ratio = $\frac{\text{Long Term Liabilities}}{\text{Working Capital}}$
	Net Profit Ratio = $\frac{\text{Net Profit}}{\text{Net Worth}}$
	Net Sales Ratio 1 = $\frac{\text{Net Sales}}{\text{Fixed Assets}}$
	Net Sales Ratio 2 = $\frac{\text{Net Sales}}{\text{Working Capital}}$

performance. One factor that is claimed by Dun and Bradstreet to give quite a good indication of the viability of a company is the length of time they take to pay their bills.(29) Gradually extending the time they take to pay bills is taken as a sure sign that a company is heading for financial difficulties perhaps even bankruptcy.

Another method that is claimed to be 90% accurate in predicting financial problems is the so called Z-Score model. (30) The general form of the Z-Score model is:-

$$Z = 1.2X_1 + 1.4X_2 + 3.3X_3 + 0.6X_4 + X_5$$

$$\text{Where } X_1 = \frac{(\text{Current Assets} - \text{Current Liabilities})}{\text{Total Assets}}$$

$$X_2 = \frac{\text{Retained Earnings}}{\text{Total Assets}}$$

$$X_3 = \frac{\text{Earnings Before Interest and Taxes}}{\text{Total Assets}}$$

$$X_4 = \frac{\text{Market Value of Preferred and Common Equity}}{\text{Total Debits}}$$

$$X_5 = \frac{\text{Sales}}{\text{Total Assets}}$$

A firm with a Z-Score below 1.8 is considered to be heading for bankruptcy. While the method has much to commend it for assessing the financial status of a company that has been operating for some years it does not help with assessing the financial stability of a new company. Nor does the method make any allowance for the general economic environment. It may be that different weighting factors can be accepted in a time of deep recession and that there could be some flexibility in the 1.8 score.

For a new company without any trading record a detailed business plan would be called for and the proprietor's experience, capability and background investigated. In both the case of a new small company and an existing small company a bank is likely to call for some kind of security or guarantee for any loan it makes. The security may be:

deposit of shares, a life insurance policy or call on the proprietor's property. Also the bank will expect to be kept informed about the company's trading performance. The loan contract will generally be such that if the company starts to perform in an unsatisfactory way the bank may call in the loan. It is easy to envisage that in some cases calling in a loan may force a company into liquidation. The problem for a bank is that it may not be in close enough contact with a company to know exactly when it is approaching a crisis in its financial affairs. As already hinted credit rating systems may not tell the whole story, as they may not be adjusted to the circumstances of the particular company or proposer.

With large companies, that is companies who employ more than 500 people or have a turnover of more than £20 million the risk problems are more complex. In the case of lending to governments the risk problems are even more complex. Large companies tend to have assets they can offer as security for loans. Governments justify their credit worthiness by being backed by the wealth of the nation. But as is shown in a moment confidence in the assets of a company may prove to be useless as may be the value of the security a government gives for a loan. The justification for this scepticism is well illustrated by the series of dramatic bankruptcies that took place in the early nineteen nineties. Some were due to falling property values which resulted in a reduction of the value of property based securities given for loans. An important consequence of the reduction in the value of securities deposited as guarantees for loans was that banks wanted to reduce the loan facility they provided so that the loan was more closely equated with the value of the security. Another cause was that due to the recession turnover fell and some companies were unable to keep up interest and loan repayments. In cases where debt rescheduling could not be arranged liquidation was often the result.

Sometimes people have a view that a country would not default on paying the interest on a loan or repaying a loan by the due date. Such a view is seriously wrong. As mentioned in Chapter 1, debt rescheduling has increased dramatically since 1979 and has seriously disturbed world capital flows. In the past wars and revolutions have often

given governments an excuse to completely default on loans.

To demonstrate how careful a bank has to be in determining the acceptability of making loans the Swiss Bank Corporation's Country Risk Assessment procedure will now be described. The specially interesting feature of this procedure is the extensive range of factors it takes into account. The list of factors identified is intended to include all those that influence a borrowers ability to repay a loan. This being true for large companies as well as countries. There are five main parts to the procedure to assess each country, which are:- (31)

- 1) Examine the history of the domestic economy and from this examination assess the outlook for the domestic economy.
- 2) Examine the history of the external economy and from this examination assess the outlook for the external economy.
- 3) Examine the history of the country's debt characteristics and from this examination assess the outlook for the country's debt.
- 4) Assess the political risk, unemployment and per capita growth.
- 5) Based on the data collected and the views formed arrive at a judgement about risk potential, from the bank's point of view, of the country being considered.

Each of the five parts covers several topics, each of which is an important indicator in its own right. The domestic economy part could equally well be described as the assessment of the performance indicators as they indicate the economic and structural strengths of a country. Under this heading are included:

1. % real GDP growth over 12 months adjusted for inflation
2. Investment ratio % investment/GDP
3. Investment efficiency i.e.  
$$\frac{\% \text{ GDP growth (3 year average)}}{\text{Investment Ratio (item 2)}}$$
4. % inflation
5. % growth in money supply
6. % real domestic credit creation
7. % fiscal balance/GDP

The external economy part of the assessment deals with the influence of the world market conditions. Under this heading are included:

- competitiveness index
- trade balance
- exports
- imports
- current account balance
- exports/GDP
- export concentration
- imports from Switzerland

The last item is specific to the interests of a Swiss financial institution and could easily be changed to imports from the country considering financial involvement with the country being assessed.

Assessment of the debt characteristics of a country takes into account: total external debt (public and private), internal reserves (excluding gold), external debt service, external debt/exports, external debt service/exports, interest-adjusted current account/interest payments, international reserves/imports.

Assessment of the political/social factors, which form the fourth group of factors, involves qualitative data to a much greater extent than the other factors. Consequently judgements about the significance of the factors must to a very large extent be subjective. The way the assessment of political and social factors is made in the Swiss Bank Corporation's Country Risk Assessment is analogous to the way socio-political factors are assessed in the Risk Ranking Technique described in Chapter 1. In the Country Risk Assessment the evaluation of political/social factors takes account of:-

- 1) The character of the political system and political institutions as well as of the governments' control mechanisms.
- 2) The social and political conflicts between different population groups, caused by economic, religious or ethnic factors, or by language differences.

- 3) The existence of alternative governments or opposition movements, evaluation of their goals and importance.
- 4) Relations with neighbouring countries and trading partners.
- 5) The strategic importance of the country.
- 6) International integration of the country.

The political and social stability is rated on a Scale of 1 to 10, with 1 being the low-risk end of the scale. The scores are divided into four categories (or ranks) as shown in Table 10.

**TABLE 10 Political and Social Stability Categories (or Ranks)**

CATEGORY OR RANK	RISK ASSESSMENT	RATING SCORE
1	Practically nil/low	1 - 3
2	Acceptable	4 - 6
3	High	7 - 9
4	Clearly excessive	10

An example of the application of the Country Risk Assessment procedure to a fictitious country and based on invented numbers is given in Appendix 2. The assessment demonstrates how the conclusions are based on the data from several years. The estimate for 1988 and the outlook are summarized in Table 11. Despite the explicit forecast horizon being limited to about 1 1/2 years the Country Risk Assessment procedure does give an overall picture of a country's economic stability and by implication it gives an

**TABLE 11 Summary of Fictitious Country Risk Assessment**

GROUP	INDICATORS	ESTIMATE 1988	OUTLOOK 1989
Domestic Economy	Real GDP Growth %	- 3.2	1.5
	Investment/GDP (International Average 25%)	14.7	Improving
	Investment efficiency (critical level < .2)	- 0.11	Unchanged
	Inflation %	18.2	Improving
	Money supply growth %	9.8	Unchanged
	Real Domestic Credit Creation %	- 9.4	Up
	Fiscal Balance/GDP %	- 1.7	Deteriorating
	External Economy	Competitiveness Index (1980 = 100)	80
Trade Balance (Goods)		- 0.80	Improving
Exports (Goods & Services)		9.1	Improving
Imports (Goods & Services)		10.3	Up
Current Account Balance		- 0.9	Improving
Exports/GDP %		23	Unchanged
Export concentration		35	Unchanged
Imports from Switzerland		105	Improving
Debt Character- istics	Total External Debt (Public & Private)	28	Deteriorating
	International Reserves excluding gold	1	Improving
	External Debt service	3.4	Deteriorating
	External Debt/exports (Critical level > 150%)	308	Improving
	External Debt Service/exports (Critical level > 25%)	37.3	Improving
	Interest adjusted Current Account/Interest payments	67	Improving
	International Reserves/ Imports	1.2	Improving
	Socio- Political Factors	Political Risk (On a 10 point rating score)	6
Recorded Unemployment Rate		13.5	Unchanged
Per capita GDP growth		- 5.5	- 0.8

indication of credit worthiness of a country. The value of the indication of credit worthiness of a country is dependent on the quality of the data available and in this context the Bank recognizes the importance of the evidence collected by their own staff with experience of the country involved.

The Bank also recognizes that Country Risk Assessment can only be part of the management apparatus of risk management. The assessment techniques have their natural limitations as, to a certain extent, future events are always uncertain. A prudent bank's approach to managing the risks inherent in its loan portfolio will be to diversify its loan portfolio in such a way that the bank can deal with unlikely or unforeseen events. The logical structure of the Country Risk Assessment procedure can provide an insight into the relative merit of the various loan portfolio strategy options available.

The Swiss Bank keep the efficacy of the assessment process under review and refine it iteratively as found necessary. Over the years the number of parameters included in the Country Risk Assessment Process has been increased from 20 to 25. The Assessment Process is only applied to large countries, as the Bank's loans exposure with small countries is not considered to be a problem. The Bank considers that by critically monitoring the economic characteristics of a country for several years gives them a good indication of the credit worthiness of that country.

When a Risk Assessment Report is presented to the Executive Management it is accompanied by a two page brief which draws attention to the findings of the Assessment Report and advises the Executive on the credit worthiness of the country involved. The structure of the Executive brief is described in Appendix 3.

Of the 18 professional economists in the Bank's central economics division about 6 are involved in preparing Country Assessment Reports, but preparing Assessment Reports is not their only job. As all the necessary sources of information are established it takes about 1 week to prepare an Assessment Report for a particular country. The Bank has not computerised preparation of

Assessment Reports as, in their view, the preparation would not be speeded by computerisation particularly as many parts of the Report are matters of judgement not precise facts.

Within the Bank overall responsibility for preparation of the Country Assessment rests with the Bank's Chief Economist, who is also a Vice President of the Bank. The Chief Economist has a meeting each month with the Executive Board. It is from these monthly meetings that requests for preparation and special updating of Assessments flow.

When finance for a major project is considered the acceptability of the proposal is assessed by the Bank's project finance group. In such an assessment the credit worthiness of the Sponsors of the project is assessed. Such an assessment would take into account the experience of the sponsors in handling similar projects. For an assessment of the acceptability of the technical issues involved the Bank tends to use consultants.

Another assessment process that is relevant to the discussion in this chapter is the way the Swiss Bank Corporation assesses the performance of leading Swiss firms to determine the nature of the risks associated with investing in them. To assist investors in public companies the Bank publishes an annual review of about 50 parameters, which they consider to be the essential indicators of the performance of leading Swiss firms. (32) In the review no single parameter is identified as giving an adequate indication of performance. Instead the significance of the data is ranked on a scale from A to C- under three headings: historical performance, dividend policy and transparency. Other similar share or bond rating systems are Standard and Poor's and Moody's. Standard and Poor ratings range from AAA down to D. (33) But they do not overtly allow for transparency in the same way that the Swiss Bank rating method does. Recent major company collapses show how important it is for analysts and investors to understand the transparency of the figures they are presented with. For example reading the annual report of the Bank of Credit Commerce International a year before they went bankrupt it would be impossible to detect that the company was moving rapidly towards bankruptcy.

To investigate to what extent the Swiss Bank's practices have features similar to other banks their practices are now compared with those of two British Banks. The banks are:- Lloyds and National Westminster.

The procedures Lloyds Bank use for assessing the risks involved in lending to foreign countries include assessment of the characteristics of the country involved. Also the bank assesses any proposal against its exposure limit, which is the amount they are willing to lend to that country. The indicators the Bank uses are a combination of judgemental and statistical indicators. The judgemental indicators are more forward looking. They attempt to assess a country's performance in qualitative terms and to actually attach scores to the qualitative judgements so that they end up with an ordinal measure of performance. The statistical scoring system is based on statistics of the past five years. They do not attempt to draw up statistical indicators based on judgements about the future. Such an approach could develop into a guessing game, where those bankers who wish to justify lending money to a country will come up with an optimistic statistical score based on their glorious vision of the country's future as an exporter of tin or whatever it might be. Equally pessimistic sceptical economists could give a low score.

The judgemental factors are listed in Table 12 together with their scoring structure. The statistical factors and their scoring structure are listed in Table 13. The score range allocated to each factor reflects the weighting each factor is considered to warrant. To arrive at an overall index number the statistical and judgemental ratings are summed, the totals multiplied together and the product divided by 100. The practical reason, given by the Bank, for multiplying the total figures together being to amplify differences in scores to facilitate comparison. For specific cases other factors like primary surplus and debt service may be studied.

As with the Swiss Bank Corporation the advice Lloyds Credit Department pass to the Executive is a brief based on their ranking of the risk indicators considered to be associated with a particular proposal. Attention is drawn to the fact

**TABLE 12 Lloyd's Country Risk Analysis Judgemental Factors and Scoring Structure**

<u>COUNTRY RISK ANALYSIS</u>		
A	<u>DOMESTIC ECONOMIC POLICY</u>	<u>MAXIMUM</u>
(1)	Coherence of Policy	5
(2)	Business climate	5
(3)	Stability of Policy	5
(4)	Quality of Bureaucracy	5
		20
B	<u>EXTERNAL ECONOMIC POLICY</u>	
(1)	Debt Management	10
(2)	Handling of Liquidity Crises	5
(3)	Management of Exchange Rate	5
(4)	Management of Trade Policy	5
(5)	Investment Policy	5
		30
C	<u>POLITICAL CHARACTERISTICS</u>	
(1)	Durability	10
(2)	Effectiveness	10
(3)	International Position	5
		25
D	<u>POLITICAL STABILITY</u>	
(1)	Risk of Local War	10
(2)	Risk of Violent Revolution	10
(3)	Political/Social Tensions	5
		25
		-----
	Grand Total - Maximum	100
		===

**TABLE 13 Lloyd's Country Risk Analysis Statistical Factors and Scoring Structure**

1	GNP per capita. (Range US\$0-10,000).	10 (1pt = \$1000)
2	Real GDP, annual growth rate of the last 5 years. (Range 0-5%)	10 (1pt = 1/2%)
3	Gross domestic investment as % of GDP (Range 10-30%)	10 (1pt = 2% over 10%)
4	Export growth in US\$, annual average 1980-84 (Range 0-20%)	10 (1pt = 2%)
5	Export variability score. Measured by the coefficient of variation (CV) of exports of the last 10 years. (Range 0.4-0.1)	10 (1pt = 0.03)
6	Inflation rate over the last 5 years (Range 50-0%)	10 (1pt = 5%)
7	Debt service/foreign exchange receipts. (Range 50-0%)	10 (1pt = 5%)
8	Interest service/foreign exchange receipts (Range 20-0%)	10 (1pt = 2%)
9	Debt/GNP. (Range 100-0%)	10 (1pt = 10%)
10	Debt/foreign exchange receipts (Range 400-0%)	10 (1pt = 40%)

TOTAL

100

===

that Lloyds rank risk factors while the Swiss Bank Corporation simply assess each factor in qualitative terms like improving or deteriorating.

It should also be noted that for general credit assessment Lloyds Bank has considered using a variation they had developed of the Bank of England's scheme for weighting the significance of various types of assets. A simplified description of the scheme is given in Table 14 and consists of scoring assets for rewards and significant risks on a two point system, 0 for bad or neutral rewards and risks, and 1 for good rewards or risks. (34) In the second part of

**TABLE 14 Ranking System of the Factors Considered by  
Lloyds Bank**

**A RISK-REWARD MATRIX**

The scoring system used.

Rewards: 0 bad or neutral, 1 good

Risks: 0 bad or neutral, 1 good

Scoring schedule of representative categories of activity

Activity	Reward	Risk
Wholesale (W)	0	0
Retail (R)	1	0
Government (G)	0	1
Private (P)	1	0
Domestic (D)	0	1
Foreign (F)	0	0

Matrix of scores

Loan	Activity Characteristics			Scores		Total
				Reward	Risk	
R	G	D		1	2	3
R	P	D		2	1	3
R	G	F		1	1	2
R	P	F		2	0	2
W	G	D		0	2	2
W	P	D		1	1	2
W	G	F		0	1	1
W	P	F		1	0	1

the table the scores that it is considered certain activities justify are described. In the schedule retail lending is given a reward score of '1' while wholesale activities are given a score of '0'. In comparing government lending with private sector lending the reward postulated is generally higher for the private sector. Lending to governments is considered to be low risk so it gets a higher ranking score. Finally domestic versus foreign lending there is no special reward, but generally banks regard the risk of domestic lending as less than that of foreign lending as they tend to know more about their home market than they do about foreign markets. Both wholesale and retail business can be associated with government, private domestic and foreign types of activity. This gives an eight by six matrix as shown in the bottom of Table 14. The matrix shows the most acceptable ranking is with domestic retail lending, whether to the public or the private sector. The lowest ranking of one goes to wholesale lending to foreigners, whether governments or private borrowers. Everything else gets a medium ranking of two, but that is based on different combinations of activities.

The National Westminster has for many years used a method of scoring to rank the economic and socio-political factors that influence the acceptability of credit risks.(35)(36) The Bank's representatives abroad are considered important sources of information on which to base their ranking of risk associated with credit to foreign countries. In project financing the National Westminster has among other projects been involved in the arrangements for financing the Channel Tunnel project, which was outlined in Chapter 1. Other large projects the Bank has been involved in financing include:- the coking coal mines in Queensland, Australia, the Hemlo Gold Mine in Canada, Howden Wind Parks in the USA, Dowington Waste Water Treatment plant in the USA and the Forties, Balmoral and Alwyn North fields in the North Sea. In assessing the acceptability of a project, the bank assesses the technical, economic and political risks. (36)

In assessing the technical acceptability account is taken of the proposers capability and experience in dealing successfully with projects of a similar nature. For

assessing many projects the Bank has its own "in-house" specialists in many fields. For example, the bank has its own team of specialists in oil, gas and mining. The Special Financial Services Group which includes project finance, financial engineering and syndication teams has 80 specialists'. (36) But for assessing projects outside the capability of the bank's own experts the bank employs independent outside consultants with the appropriate skills.

In assessing the economic risks the bank pays attention, among other things, to: the possibility of cost overruns, adequacy of reserve, inflation influence on operating costs and market and price fluctuations.

In assessing political risks attention is given to both fiscal and non-fiscal risks.

It appears that the National Westminster methods bear at least a superficial resemblance to the methods used by the Swiss Bank Corporation and Lloyds.

The conclusions that this examination of financial institutions risk assessment practices appears to justify are:-

- 1) There are formal external regulatory controls on the amount of financial risk financial institutions can accept.
- 2) Banks do not share a common set of quantitative criteria by which they judge acceptability of risks.
- 3) There is considerable variety in the methods banks use internally to assess the acceptability of risks. In all cases the executive making the decision about the acceptability of a loan is allowed a large degree of personal judgement.
- 4) Banks concentrate on assessing the economic aspects of risk.
- 5) Although banks are involved in assessing the acceptability of the technical, economic and socio-political aspects of proposals they do not attempt to

make a unified comprehensive assessment of the acceptability in terms of these three factors in the same way the Risk Ranking Technique does.

- 6) The diversity of risk factors banks' consider in assessing the acceptability of proposals give a clear illustration of problems of finding a single indicator of the stability of the economic environment surrounding a proposal, which all decision makers should use.
- 7) The value of a decision based on a presentation that obscures the truth is of doubtful value. The importance of the information on which investment decisions are made being transparent is recognised in the Swiss Bank's method of rating for investment purpose the quality of a company's performance.

## CHAPTER 3

### Theoretical Considerations

In the discussion so far there has been no attempt to justify the decision processes in theoretical terms, as the presentation has been somewhat pragmatic and concentrated on the practical problems associated with assessing risk acceptability. In this chapter an attempt is made to redress the balance by critically examining the extent to which the construction of the Risk Ranking Technique can be justified in theoretical terms. In this case the phrase "theoretical terms" is intended to define a form of reasoning that has the precision that arithmetic has for processes involving numbers or geometric analysis has for processes describing lines. (37) This examination of the quality of the theoretical justification really acts as a prelude to the discussion in later chapters of the problems of making a detailed assessment of a proposal and the alternative methods that may be used.

The starting point for this examination is recognition of the fact that any comprehensive assessment of the decision options has to take account of the technical, economic and socio-political factors. The central concerns are:- how to weight the significance of the factors and how to structure in a logically defensible way the analysis of a complex mixture of qualitative and quantitative data.

Essentially the aim of any method of assessing decision options is to help the decision maker determine which decision option is most likely to successfully satisfy requirements. In constructing the assessment of a particular decision option it is assumed that any factor related to the decision making can be categorised under one of three headings, which are:- technical (T), economic (E) and socio-political (S). The acceptability of each factor being scored in some way against specified criteria. The overall acceptability being determined by integrating the scores of the factors T, E and S. The integrated scores determining how the acceptability of each option can be categorised. Knowledge of each factor is likely to be

imperfect, so a degree of uncertainty must be attached to each score.

In Table 15 the nature of the theoretical concerns about seven aspects of the ranking process are identified. With aspect 1 the concern is whether or not T, E and S adequately describe all the topics that should be considered. This concern has its origins in the suspicion that T, E and S may not, due to limitations on the data available, give a comprehensive description of the options to be considered. The data that has to be used for decision making can never be perfect and completely comprehensive. In the real world, particularly when the proposal being considered is novel, there will be uncertainty about the evidence. Uncertainty about the evidence is a topic that is returned to later, in the discussion of aspect 7. (As defined in Table 15).

The adequacy of the comprehensive description of an option depends on the way T, E and S are defined. The definition of the factors will have to be adjusted to suit the characteristics of each family of decisions considered. With the T and E factors there can be a certain amount of confidence that the factors can be adequately described in quantitative terms. The quantification of the evidence may be soft, nevertheless the criteria for judging the acceptability of the factor can be expressed in hard or at least firm quantified terms. Then as understanding of the proposal develops the quality of the quantification of the evidence can be improved iteratively. With a novel project it may be that the decision has to be made on the basis of soft data and that it will only be when the project is underway that the required hard data will be generated. The data generated may show that the project is unlikely to be successful and should be abandoned. An unacceptable project is always a possible outcome. The very nature of the S factor makes it the most difficult to deal with in quantitative terms. The criticism that is made of decision-aiding approaches related to the S factor include (38):-

- 1) Ethical considerations may not be adequately allowed for.

**TABLE 15 Summary of Theoretical Concerns about ranking procedures**

ASPECT NO	ASPECT DESCRIPTION	THEORETICAL CONCERNS
1	Identification of factors T, E and S	Do these factors adequately represent all the issues that a decision maker should consider
2	Identification of ranking steps and scores for each factor	How many ranks/steps should there be and how should the steps be defined. How should scores be related to Ranks
3	Identify criteria for scoring factors	On what features of the factors should the scoring criteria be based.
4	Identify weighting of significance of each factor	How should the significance of one factor compared to another be related
5	Identify basis for combining factors	Should the overall significance of the factors be considered as being the sum or product of the factors or should they be combined in other ways
6	Combine weighted scores to give overall ranking	Does the overall ranking adequately represent an assessment of the options before the decision maker or is there some bias in the overall Ranking
7	Influence of uncertainty about the data and methodology used can have on ranking	As with any estimate there will be uncertainty about the significance of the numbers used. How the uncertainty should be treated needs justification. Can the consideration given to evaluating uncertainty be related to the size of the decision and the novelty of the decision

- 2) There may be errors in the logic of the assessment due to the difficulty of defining the optimum decision.
- 3) The data that has to be used is incomplete.
- 4) There is bias in the analysis that has to be used due to bias of the analyst.
- 5) The decision making environment has changed since the data was collected and analysed.
- 6) There is a difference between decisions that are forced and democratic decisions which are arrived at by discussion.

The criticisms identified above should be answered when the criteria for scoring the S factor is constructed. This means the scoring criteria for ranking the significance of the S factor tend only to be constant for a limited family of decisions at a particular time. Changes in the decision making environment may change the criteria that are required. This limitation is similar to that proposed for the criteria for scoring the acceptability of T and E. In other words there will be no direct comparability of ranking between families of decisions using different ranking criteria. But it does not reduce the comparability of ranking within a family of decisions in which each decision is based on exactly the same criteria.

Perhaps the most important feature that the criticisms draw attention to is the need for the analyst, ranking decision options, to have an understanding of the ethical implications of the decision options.

The second aspect in Table 15 raises questions about how scoring scales should be related to the acceptability criteria. The central question is: how should the scoring scale for ranking acceptability be designed? It is considered the ranking steps should be sufficient to show something of the shades of acceptability in the decision options and not simply categorize the options as acceptable or not acceptable. Equally it is considered that there should not be so many steps in the ranking that the creditability of the data, on which the ranking would

have to be based, would be stretched too far. It is suggested that four ranking steps would give an adequate description of the shades of acceptability of the various options open to the decision maker. An even number of steps being suggested to overcome the temptation for the analyst to use the neutral middle rank, as being a safe neutral non-committal judgement. Some confidence in the acceptability of such a design is given by the fact that it is similar to the pattern of risk ranks Lord Ashby proposed in his study of the acceptability of environmental risks. (39) In the scoring scale there should be sufficient difference between the steps in the scale to prevent an adverse ranking of one factor being masked. A scale such as 1, 2, 5, 14 would overcome this problem and correct a weakness in the scale described in ref. 12. Further discussion of the theoretical factors influencing the designs of Ranking Scales is given in Appendix 4.

What has just been said about the design of the ranking scales underlines the importance of careful specification of the criteria for scoring. In chapters 5, 6 and 7 the basis for scoring the acceptability of T, E and S factors is explored in some detail and at this point in the study it is only necessary to make some philosophic points about the nature of ideal scoring criteria. With each factor there is a tremendous range of topics to be considered. Simply defining criteria in natural language terms like: not acceptable, acceptable and very acceptable would give criteria that are too soft. Such natural language terms have to be supplemented by some quantitative statements that relate to technical and economic performance and to socio-political acceptability.

The criteria, identified in the later chapters, for T and E factors seem to adequately relate acceptability to quantitative evidence. This does not mean that the criteria cannot be improved. For example, the technical criteria could specifically relate the ranking score to the probability of a successful outcome. Similarly the E factor criteria could be adjusted to include calculation of the rate of return on the total through life investment taking into account all the risks involved. (40)

The problem of identifying suitable criteria for S factors

is more open to criticism. Merkhofer has stated the position in the following terms:- "there exists no currently available decision-aiding approach for social risk decisions that is free from criticism. Furthermore, available approaches have different strengths and weaknesses. It is not possible, therefore, to identify any specific approach as in any absolute sense the 'best'." (41) Given that the decision maker has to make a decision he/she has to find some way of evaluating the significance of an S factor regardless of the possible criticism. A starting assumption for the criteria designer must be that everyone concerned or in any way associated with the proposal will be aware of the content of the proposal and the implications of the proposal in S factor terms. Also it is assumed that the decision making takes place in a democratic society, where everyone is free to express their opinion and attention is paid to the laws of the land. The details of the democratic processes vary from country to country. Examples of the variation in democratic processes are: frequent use of referenda in Switzerland and the frequent use of Public Inquiries in Britain. The possible use of such processes have to be considered as ways of determining the acceptability of S factors in decisions. It would be misleading, to suggest that acceptability in S factor terms could be judged precisely from the outcome of referenda or public inquiries. Such a view would completely ignore the continuous influence of pressure groups in a democratic society. The influence of pressure groups on policy development has been examined by Chicken, in references 42 and 43, so all that need be said here is that they are factors whose impact has to be allowed for in determining the acceptability of an S factor.

Central to determination of public opinion about a proposal is the fact that the public must be informed about the nature of the proposal. In some countries the need for the public to be informed about some risks is entrenched in the law. (44) For example:- the European Commission has passed a Directive which states: "Member states shall ensure that persons liable to be affected by a major accident originating in a notified industrial activity ..... are informed in an appropriate manner of the safety measures and of the correct behaviour to adopt in the event of an accident". (44) In a similar vein the US Congress enacted

an emergency planning and community right to know Act. Also, in general the public also have rights to object to applications for planning approval. The extent to which such rights are used varies from application to application and from country to country. From the above it is suggested that the criteria for ranking the significance of the S factor should be based on an assessment of the acceptability of the proposal to the public who will be at risk from implementation of the proposal. This leaves open the question of how the public's opinion is measured. In some cases sampling might be appropriate and in other cases voting might be appropriate. Criteria for Ranking S factors are discussed in detail in Chapter 7. But with the S factor more than any other factor the data on which the assessment is based is likely to change with time. Public opinion is fickle. Even a comprehensive assessment will only be valid for the time at which it is made, it will not indicate the changes in opinion that pressure group influence brings about in the future.

This survey of the form that criteria for ranking the acceptability of risk could take has shown they have to cover a very wide range of characteristics. The possibility of identifying criteria that would be satisfactory in all decision making situations seems remote and not a goal worth pursuing. It appears more practical to identify the criteria for particular families of decisions. Such an approach would mean that it will only be possible to compare accurately the significance of decisions within a particular family of decisions. Comparison of the acceptability of risks between families of risks could be made, subject to some correlation factor being used to take account of the different principles on which the criteria were based. However, consistency in the logic of ranking decision options should improve the consistency of the quality of decision making. In Table 16 the general principles on which the criteria could be based are summarized.

The fourth, fifth and sixth theoretical aspects of the ranking risks are critical as they relate to how the significance of the three factors T, E and S are weighted and combined. Ideally the ranking would be applied only when the detailed assessment of T, E and S is

**TABLE 16 Summary of the Principles on which Criteria for Ranking Risk should be based**

FACTOR	PRINCIPLES	TYPICAL FORMS
TECHNICAL	<p>Technical performance required, stated in quantitative terms. These requirements would include customer and statutory requirements.</p>	<p>Technical evaluation of the operational life of the project. An assessment of the consequences of the project failing to achieve its objective. An assessment of the capability of those who will implement proposals.</p>
ECONOMIC	<p>For commercial projects the acceptability should be expressed as a rate of return that takes into account the risks involved. For projects of a social welfare nature the benefit of the expenditure should be compared with the benefits of alternative expenditure.</p>	<p>A quantitative assessment of the likely through life investment required and the return on investment. The assessment would include a statement of the associated uncertainty.</p>
SOCIO-POLITICAL	<p>The criteria for assessing acceptability of socio-political factors should take account of the extent to which the population understand the risk they are exposed to and the way in which they have been able to express their views about the acceptability of the risk.</p>	<p>A survey of public opinion on the proposal, or the findings of a public inquiry into the proposal, or the result of a relevant referendum.</p>

complete. In practice the decision might have to be made before the detailed assessments are complete, but there may be opportunities for iteratively refining Ranking as better information becomes available. There will always be a degree of uncertainty associated with the characteristics of each factor, but that is a slightly different problem and one that is returned to in discussion of aspect 7.

The design of the analytical process should be such that T, E and S factors are treated equally, thus avoiding the need to consider them being assessed in some preferred hierarchical order. It is implicit in such an approach that the relationship between the factors is assumed to be recursive, that is there is no direct or indirect feedback between the factors. It is accepted that recursive relationships between the factors may be considered unrealistic and too rigid. (45) The recursive nature of the relationship assumed is justified by the fact that each decision factor considered is defined as being the end product of an iterative assessment process, in which the nature of each factor is explored and interactions between the factors and sub-factors are analysed in order to determine optimum relationships. In other words, before the ranking process starts the proposer will have determined what he/she considers to be the optimum relationship between the various factors related to the proposal.

Given that the ranking factors are specified as being independent and have to be assessed simultaneously the question that has to be answered is: should the factors be treated as having equal significance? To a certain extent the answer depends on the circumstances in which the decision has to be made. For example in a state controlled organization it is possible to envisage that the socio-political factor would predominate, as the minister who is ultimately responsible for the organization may consider that the appropriateness of the decision to the current political climate of overriding importance. In a similar way in wartime the prime minister may consider technical developments that would improve the chances of winning the war many times more important than economic considerations. In free enterprise business situations there is some justification for assuming that the three factors are of equal weight. The justification for this view being that:

unless the proposal is technically sound it will not be an acceptable business proposition, unless the proposal is economically sound it cannot be accepted and if the proposal is not acceptable in socio-political terms it would not be worth pursuing. The way the scoring system is designed should ensure that if one factor is given an "unlikely to be acceptable" score the total score of the proposal will be in the unlikely to be acceptable range. The conclusion that seems to be warranted is that for free enterprise business decisions allocating the three ranking factors equal weight is likely to be acceptable. However, for each application the appropriateness of the weighting scheme should be assessed.

Equal weighting of factors implies that they should be combined in an equal way. Adding the scores together to determine the overall ranking does not interfere with the concept of equality of each factor. If the factor scores are combined by multiplying them together, certainly the numbers produced would be larger. For example a simple 1, 2, 5, 14 scale would give total scores ranging from 1 to 2744 if the scores are multiplied as compared with 3 to 42 if they are added. Complicating the pattern of the rank scores does not appear to endow the ranking with any unique properties, but tends to destroy the simplicity of the scheme.

Accepting the justification for the weighting, and combination of the factors just given means the overall ranking score is a simple arithmetic operation. But simply performing the arithmetical operation does not answer the question of whether or not the ranking obtained gives the Decision Maker sufficient information about the merits of the various options. At least ranking gives a comparison of the options as measured by the values of T, E and S. The comparison is made in a logical and consistent way. One possible weakness of ranking is that it does not present any overt discussion of the strength of demand for the proposal. The adequacy of demand should in practice be tested in building up the assessment of E and to a lesser extent for assessment of the S factor. Calculating E requires that the rate of return on investment is determined. In order to calculate a rate of return the pattern of demand has to be determined, so the adequacy of

the rate of return reflects the adequacy of the demand. S gives a measure of public support for or opposition to the proposal, which is not quite the same as measuring demand. However, support will suggest there is likely to be demand in economic terms. But the opposite is not necessarily true. Opposition may be local and not related to the main centre of demand. This draws attention to the importance of carefully assessing public opinion for determining the value of S. An example of understanding the importance of determining the relevance of measurements of public opinion is given by the opposition to the siting of the rail links and terminals for the Channel Tunnel. The opposition is mainly local and related to problems that can be overcome. Such opposition does not damage the usefulness of ranking but rather underlines the importance of a decision making aid or procedure making due allowance for the impact of public opinion.

The concern about uncertainty mentioned in aspect 7 has implications for all aspects of assessing decision options. In the case of T factors for novel projects there will be considerable uncertainty about predictions of performance and reliability. Only when experience from the completed project is available will it be possible to validate the pre-decision predictions. In such cases T will have been calculated on the basis of advice from the best experts in the field. There is always an option of not making a decision because the evidence is inadequate. But if the chance of making progress is to be taken then the only course is to base the decision on expert opinion. The uncertainty in T will also generate uncertainty in E and S or put another way when there is a lack of good quantitative evidence on which to base the evaluation of T the uncertainty in estimating E and S will be proportionately larger. This is in slight conflict with the assumption made earlier, of the factors being recursive. It would be more precise to say that: by taking account of the uncertainty associated with T, E and S a degree of non-recursiveness is introduced into their characteristics. Certainly the ranking of options is only as good as the data on which it is based. Ordering the decision options available by ranking may not be the only way of presenting the options to the decision maker, but the method is honest, transparent and logical. For many

decision making situations the method should at least give a useful representation of the options available.

In applying ranking it is important to assess the significance of the uncertainties in the data that have to be used. This is perhaps no more than saying that, as with any piece of analysis, a sensitivity analysis should be performed to determine by how much assumptions must change to make a proposition unacceptable. (46) The data available for ranking will vary considerably from project to project. The accuracy being highest when the project is one of a series about which a comprehensive dossier of accurate information has been built up. At the other end of the scale when a project is novel and untested the uncertainty associated with the data will be considerable. The difficulties associated with a novel project must be tackled if progress is to be made. In the technical field some industries, like the aircraft (47) and pharmaceutical, regulators lay down detailed testing programmes that have to be followed to determine the acceptability of new products.

With a novel untested project, for which there is no quantitative data, assessment of acceptability has, at least initially, to be based on data derived from expert opinion. The uncertainties associated with such assessment are larger when opinions are collected in an unstructured way than when they are collected in a carefully designed structured way. In Appendix 5, some general rules are given that should be followed if uncertainty in deriving data from expert opinions is to be minimised.

It has been suggested by Chicken (48) that, in complex cases where there are several options to consider and an identifiable degree of uncertainty, it may be helpful to display the options on a variation of Buckley's decision or pay off matrix. (49) Figure 5 shows this form of presentation for a case where there are four design options and four possible levels of investment. In other words a matrix of sixteen options. From the figure it can be seen that nine of the assumed options are acceptable with some adjustment and one of the four Design Options  $D_4$  is acceptable without restriction even with the minimum investment level  $I_1$ . It is assumed that the Rankings shown

**INVESTMENT**  
LEVEL INCREASING

	<b>I<sub>1</sub></b>	<b>I<sub>2</sub></b>	<b>I<sub>3</sub></b>	<b>I<sub>4</sub></b>
<b>D<sub>4</sub></b>	<b>4</b>	<b>4</b>	<b>4</b>	<b>4</b>
<b>D<sub>3</sub></b>	<b>3</b>	<b>3</b>	<b>4</b>	<b>4</b>
<b>D<sub>2</sub></b>	<b>2</b>	<b>3</b>	<b>3</b>	<b>4</b>
<b>D<sub>1</sub></b>	<b>2</b>	<b>2</b>	<b>2</b>	<b>3</b>

DESIGN OPTIONS

Note. Identification of Risk Rank

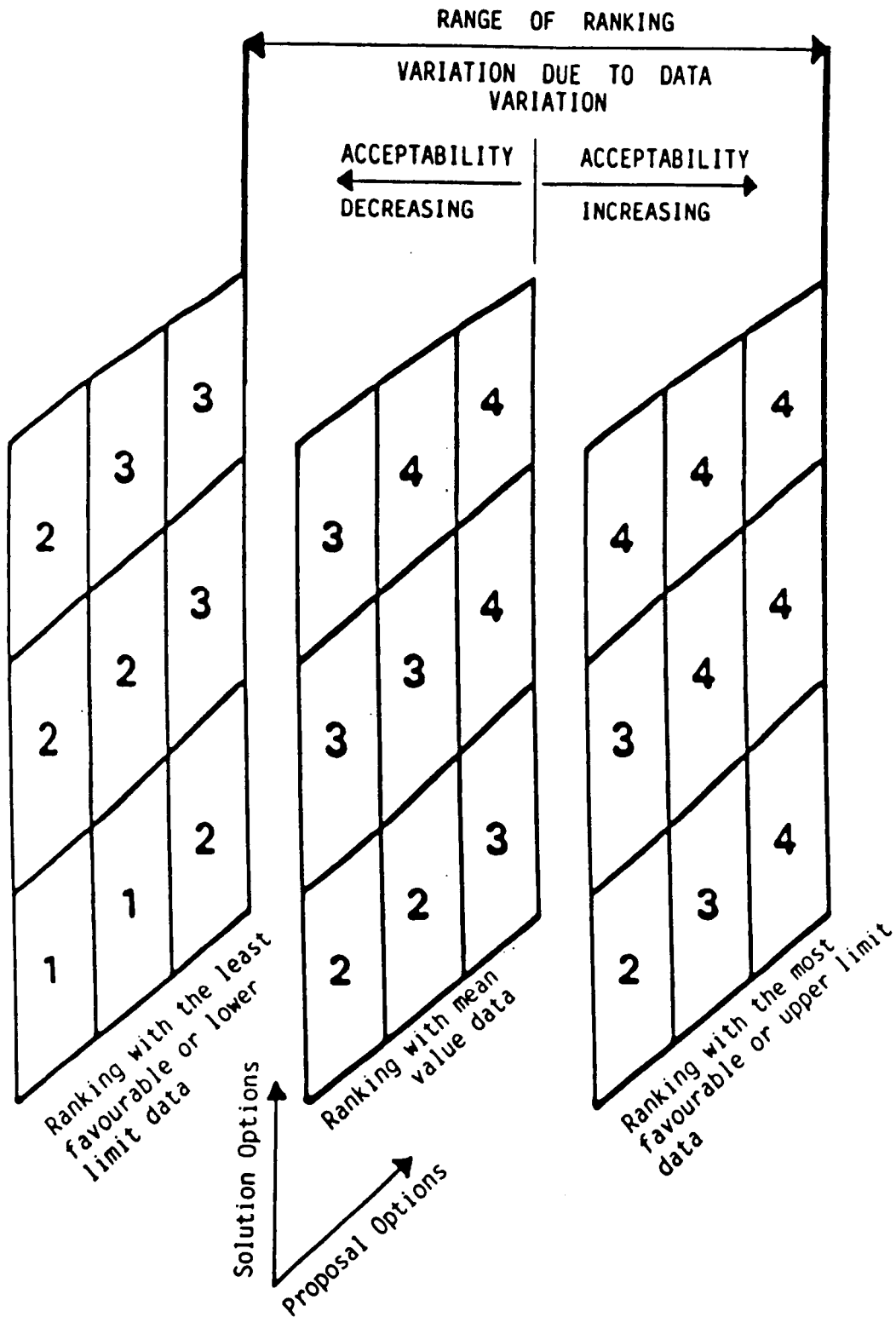
- Rank 1      Unlikely to be acceptable
- Rank 2      Only acceptable if risk can be reduced
- Rank 3      Yes, subject to detailed adjustments of the  
proposal being made
- Rank 4      Acceptable without restriction

(This figure is derived from Figure 7 in ref.12)

**Fig.1 Matrix Display of Ranking Results**

in the matrix are comprehensive Rankings taking fully into account assessment of T, E and S. Figure 1 gives the impression that the rankings are absolute and devoid of error, such an impression is misleading. With each factor there will be an associated degree of uncertainty. Taken together these uncertainties will give a range of rankings. Figure 2 shows diagrammatically how the upper, mean and low levels of ranking resulting from taking into account the uncertainty associated with the data that have to be used can be displayed. In a real life case the proportion of uncertainty associated with each factor may be different. In the hypothetical example displayed at the upper end of the range of data assumed 6 of the 9 options are acceptable without restriction. At the bottom end of the range of uncertainty 2 options are unlikely to be acceptable and 7 are only acceptable if they can be modified.

The matrix presentation shown in Figure 1 and Figure 2 are little more than visual aids and do not contribute significantly to the theoretical analysis of the importance of uncertainty in the data. A slightly better way of assessing the sensitivity of the Ranking is to examine the consequences of changes in the Ranking scores of individual factors. For illustration a base case is considered in which the T factor is scored 2, the E factor is scored 5 and the S factor is scored 2. Using the Ranking Scheme, mentioned earlier, the score gives the base case a Rank 2, which is acceptable only if the risk can be reduced. If the Ranking of the most adversely Ranked factor is given a one rank better Ranking the overall Ranking would change from 2 to 3, which means the overall Ranking would improve to being acceptable subject to some minor changes. If the Ranking of the most adversely Ranked factor is given a one rank worse Ranking it would mean that the whole proposal would be Ranked unlikely to be acceptable. As there is no middle or neutral Rank factors are Ranked either with a tendency to acceptable without restriction (Ranks 3 & 4) or with a tendency to be unlikely to be acceptable (Ranks 1 & 2). The implications of errors in data on Ranking are summarized in Table 17. From the table it can be seen that an error of one Rank may simply over emphasise the tendency of what would be the correct Ranking. An error of two or



**Note:** Identification of Risk Rank

- Rank 1 Unlikely to be acceptable
- Rank 2 Only acceptable if risk can be reduced
- Rank 3 Yes, subject to detailed adjustments of the proposal being made
- Rank 4 Acceptable without restriction

(This figure is derived from Figure 7 in ref.12)

Fig.2 Ranking Matrix Limits

**Table 17 Summary of Implications of Errors or Uncertainty in Ranking**

ERROR IN RANKING	ORIGINAL HIGHEST BASE RANKING FACTOR INCREASING ACCEPTABILITY			
	1	2	3	4
Highest Ranked factor reduced by one Rank	Not possible would stay Rank 1	Becomes unacceptable (Rank 1)	Becomes acceptable subject to major change (Rank 2)	Becomes acceptable subject to minor changes (Rank 3)
Highest Ranked factor increased by one Rank	Becomes acceptable subject to major changes (Rank 2)	Becomes acceptable subject to minor changes (Rank 3)	Becomes acceptable without restriction (Rank 4)	Not possible Would stay Rank 4
Highest Ranked factor reduced by 2 Ranks	Not possible Would stay Rank 1	Not possible Could only become Rank 1	Becomes not acceptable (Rank 1)	Becomes acceptable with major changes (Rank 2)
Highest Ranked factor increased by 2 Ranks	Becomes acceptable with minor changes (Rank 3)	Becomes acceptable without restriction (Rank 4)	Not possible Could only become Rank 4	Not possible Could only become Rank 4
Highest Ranked factor reduced by 3 Ranks	Not possible Would stay Rank 1	Not possible Could only become Rank 1	Not possible Could only become Rank 1	Becomes not acceptable Would become Rank 1
Highest Ranked factor increased by 3 Ranks	Becomes acceptable (Rank 4)	Not possible Could only become Rank 4	Not possible Could only become Rank 4	Not possible Would stay Rank 4

more Ranks distorts the overall Ranking to the extent that it gives a very misleading indication of acceptability. The Ranking concept assumes each Rank represents a fairly wide range of data: the implication being that one Rank error in the assessment of a factor is the most that has to be allowed for.

Some claims have been made for the efficacy of Fuzzy Data Analysis as a way of developing an understanding of the significance of uncertainty about conclusions that have to be based on data that is complex or ill-defined (50). Part of the attraction of Fuzzy Data Analysis is that it offers a way of assessing mathematically a proposition expressed in natural language. When there is considerable volume of data to be analysed use can be made of computer programs such as the Fuzzy Risk Analyze (FRA) (51) or MAFDA (52). A general description of the nature of Fuzzy Analysis is given in Appendix 6.

The critical question is how then can the application of the processes of Fuzzy Analysis improve the assessment of decision options with the Ranking Technique in situations when the assessment has to be based on qualitative data like expert opinion?

Essentially the definition of Ranks codifies qualitative statements about acceptability. One application of Fuzzy Analysis could be assessment of the extent to which expert opinions really fit a particular Rank. But it is not immediately clear what advantage Fuzzy Analysis would have over conventional statistical methods.

A very interesting relevant published demonstration of Fuzzy Set Analysis is the study by Abdul-Fattah and Abulfaraj of the application of Fuzzy Decision Analysis to the selection of sites for nuclear power plants. (52) They considered seven main attributes of the possible sites, which were: 1) topography and oceanography, 2) geology, hydrology and seismology, 3) meteorology, 4) transportation, 5) population, 6) Cooling water and 7) construction, services and domestic water. In addition to the seven main attributes thirty five sub-attributes were considered. The significance of the attributes and sub-attributes were weighted, rated and ranked in terms of

preferability. Then from the ranking of the attributes an overall ranking of preferability was deduced. The steps in the process are shown in Figure 3. The weighting scale used ranged from 0 to 1 and was related to a membership function (0.0, 0.0) was the lowest weighting for an attribute considered very unimportant. At the other end of the scale (1.0,0.0) was the highest rating for an attribute considered very important. The final ranking and degree of preference were calculated using a computer program (MAFDA). For the two sites it was shown that although one site was preferred the degree of preference over the other site was so small, the decision maker would be left with a problem. What the Abdul-Fattah and Abulfaraj study does show is that Fuzzy Analysis can be used to build up a ranking of acceptability from a qualitative description of its characteristics. (52) This seems an effective use of Fuzzy Analysis as 42 attributes had to be considered, which makes the analysis required more complex than required for applications of the Ranking Technique.

Perhaps the most useful role for Fuzzy Analysis would be in the assessment of all the sub-systems that have to be considered to establish the evidence on which the Ranking can be based. Particularly suitable occasions being when Ranking has to be built up using qualitative data that uses consistent natural language to describe the various characteristics that have to be assessed. Fuzzy analysis does not convert an assessment based on qualitative data into an assessment based on quantified data, it merely assesses qualitative data in quantitative terms. It is this aspect of decision making that limits the help of some forms of numerical analysis can give. In decisions that have to be based on hard evidence, such as the acceptability of a medical drug or the design of an airliner, it is unlikely that Fuzzy Analysis of qualitative evidence would be considered acceptable evidence by the relevant regulatory authorities. At the same time it has to be recognized that Fuzzy Analysis methods have been used for solving difficult control problems. When evaluation of evidence or Ranking is required in stochastic terms then conventional statistical analyses are likely to be adequate. The justification for this somewhat arbitrary view is that the type of decision making situation that the

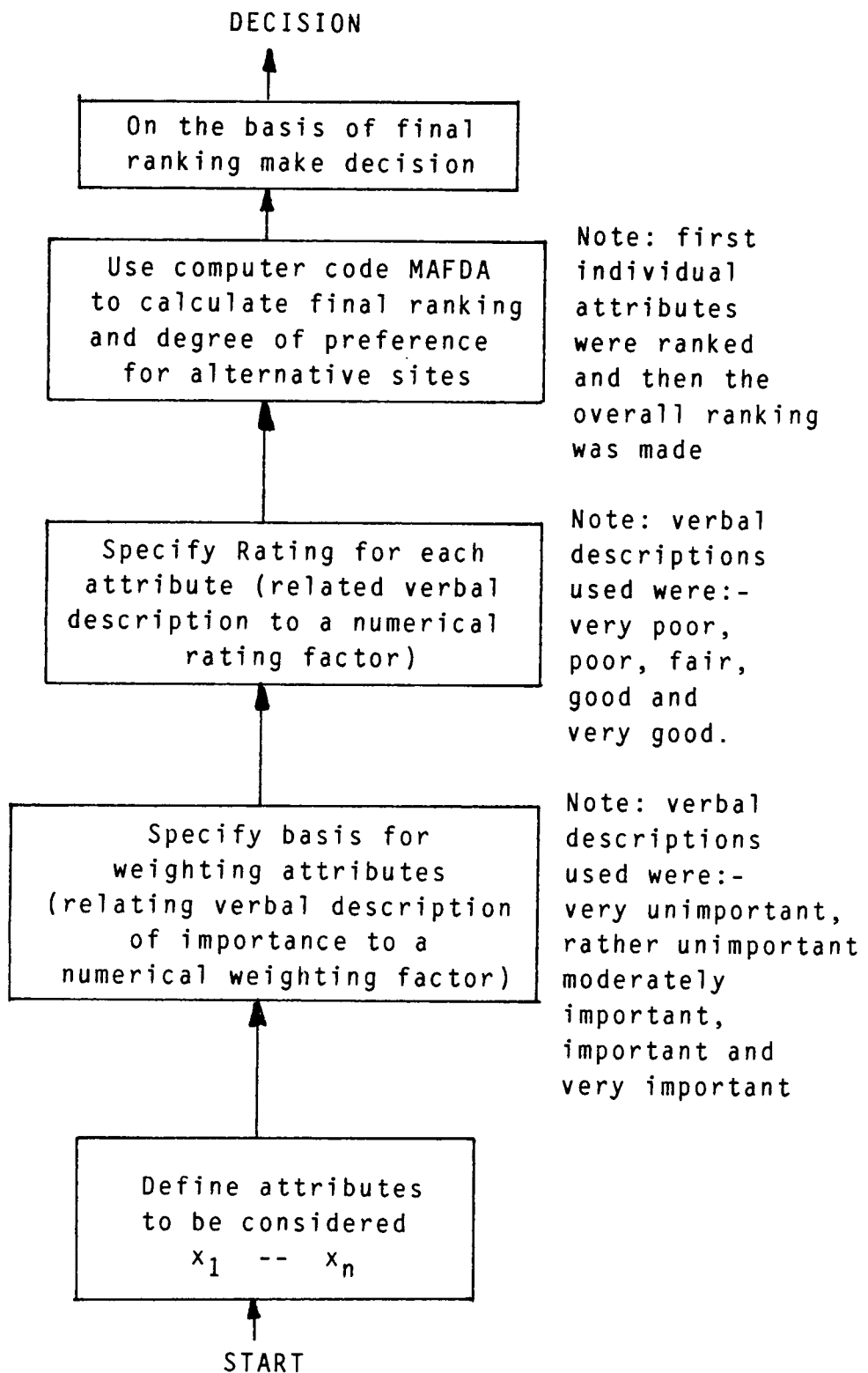


Fig. 3. Fuzzy Analysis used for Power Plant Site Selection

risk ranking is aimed at are those in which each step in the decision making process has to be transparent and justifiable. This means that the process of building up the Ranking must be simple and accurate and easily understood by the lay public. It does not mean that the analytical processes can be infantile but that the rigour of the analysis is clear. It is in the detailed investigations necessary for determining what ranking score is justified that, as already mentioned, it may be Fuzzy Analysis can be used to identify the most preferred data. Such calculations are not required to be submitted as part of the presentation of the Ranking, but may be called in as evidence to substantiate the Rank allocated.

From this examination of the theoretical considerations underlying the risk ranking seven conclusions appear to be justified. These conclusions provide a basis for assessing, in Chapters 8 and 9, the possible alternatives to the risk ranking. The conclusions are:-

- 1) The design of the ranking scale appears to give an adequate distribution of the possible views on acceptability.
- 2) The method of weighting and combining the T, E and S factors seems acceptable and can be varied to match the requirements of special decision making situations.
- 3) The criteria used for scoring the significance of the T, E and S factors can be adjusted to suit particular families of decision making.
- 4) The conclusions from ranking are not absolute. There is, by the very nature of the subject, a degree of uncertainty associated with each stage of the process.
- 5) In some cases the application of conventional statistical methods of analysis can give an understanding of the significance of the associated uncertainties.
- 6) A matrix form of presentation of the ranking of decision options can be used to give the decision maker a clear picture of the ranking of the options and of the influence of uncertainty in the data that has to be used.
- 7) The methods Fuzzy Data Analysis can be used to assess factors described in qualitative terms. Such methods are most useful when the data is collected in a way

that ensures a consistent pattern of words is used to describe the significance of each factor that has to be considered. Fuzzy Analysis does not convert an assessment based on qualitative data into one based on quantified data, if merely assesses qualitative data in quantified terms.

## CHAPTER 4

### Problems of Assessing the Technical Aspects of Risk

Evaluation of the overall acceptability of a major project requires the integration of assessments of all the technical, economic and socio-political factors involved. For a major project evaluation of acceptability in terms of each factor is a considerable task. In this Chapter the problem of assessing the technical aspects of a project are considered. The description given in Chapter 1 of the Channel Crossing project showed something of the nature and magnitude of the technical problems that have to be considered in making decisions about major projects. Although the Channel Tunnel is a major project that is technically quite complex, other projects may be even more complex. In the discussion that follows attention is given to identifying how the acceptability of the technical features of projects can be assessed in a consistent and coherent way, particular attention being given to the problem of evaluating the acceptability of novel projects. Finance for novel projects may be difficult to obtain, simply because the magnitude of the technical risks are not quantified.

Technical factors may consist of a network of interacting components. Analysis of such networks is difficult but not impossible. Techniques have been proposed for analysis of multi-variable systems and these are discussed in Chapter 7 (53). The problem is made more difficult with novel projects, particularly when the variables are only described in qualitative terms. When there is a complete lack of data the most that can be hoped for is the development of a vector giving an indication of the direction and significance of the factors and the magnitude of the uncertainty that can be associated with them. In contemplating modelling technical factors or any other factors it must be remembered, as French has so clearly stated, that if analysis is to help decision makers it must be understandable by them. (54).

When there are no hard quantitative data on which to base a decision recourse has to be made to the qualitative opinions of experts. This problem is not unique to

technical factors it also applies, perhaps with even more force, to economic and socio-political factors. So to set the scene for the discussion that follows in this and the next two chapters the process of obtaining data from experts is considered. With hard quantitative data usually some indication can be obtained of the uncertainty associated with the data. With qualitative data obtained from experts, which may be no more than an informed guess, the uncertainty may be considerable. The errors will be greater if the opinions are collected in an unstructured way than if they are collected in a structured way. If several experts are consulted in a structured way it is at least possible to establish the distribution of their opinions. As mentioned in Chapter 3 some general rules for deriving data from expert opinions is given in Appendix 5.

Selecting experts is a problem in its own right. The procedure the World Bank suggests should be used are detailed in Appendix 7. The procedure is particularly relevant to this study as they rank a consultant's suitability on the basis of three factors which are:- a firm's general experience, their work plan and their key personnel. The importance of each of the three factors is weighted. The typical examples of the Bank's weighting are:- a firm's experience 0.15, the work plan is 0.33 and the typical weighting of key personnel is 0.5. This means that personnel are rated  $3 \frac{1}{3}$  times more important than a firm's experience. The validity of weighting is of course open for discussion, but the assessor must be prepared to justify the weightings adopted.

Having set the scene for discussion about the problems of assessing technical factors, by describing the precautions that must be taken when consulting experts, the more general problems of assessing technical factors can be discussed. It has to be recognized that the understanding of the significance of a factor, no matter whether it is technical, economic or socio-political, may be quite different at the beginning of a project to the understanding of its significance at the end of the project. This point is illustrated diagrammatically in Figure 4. Generally judgements about the significance of factors have to be refined iteratively as a project develops. This is particularly true when a project is

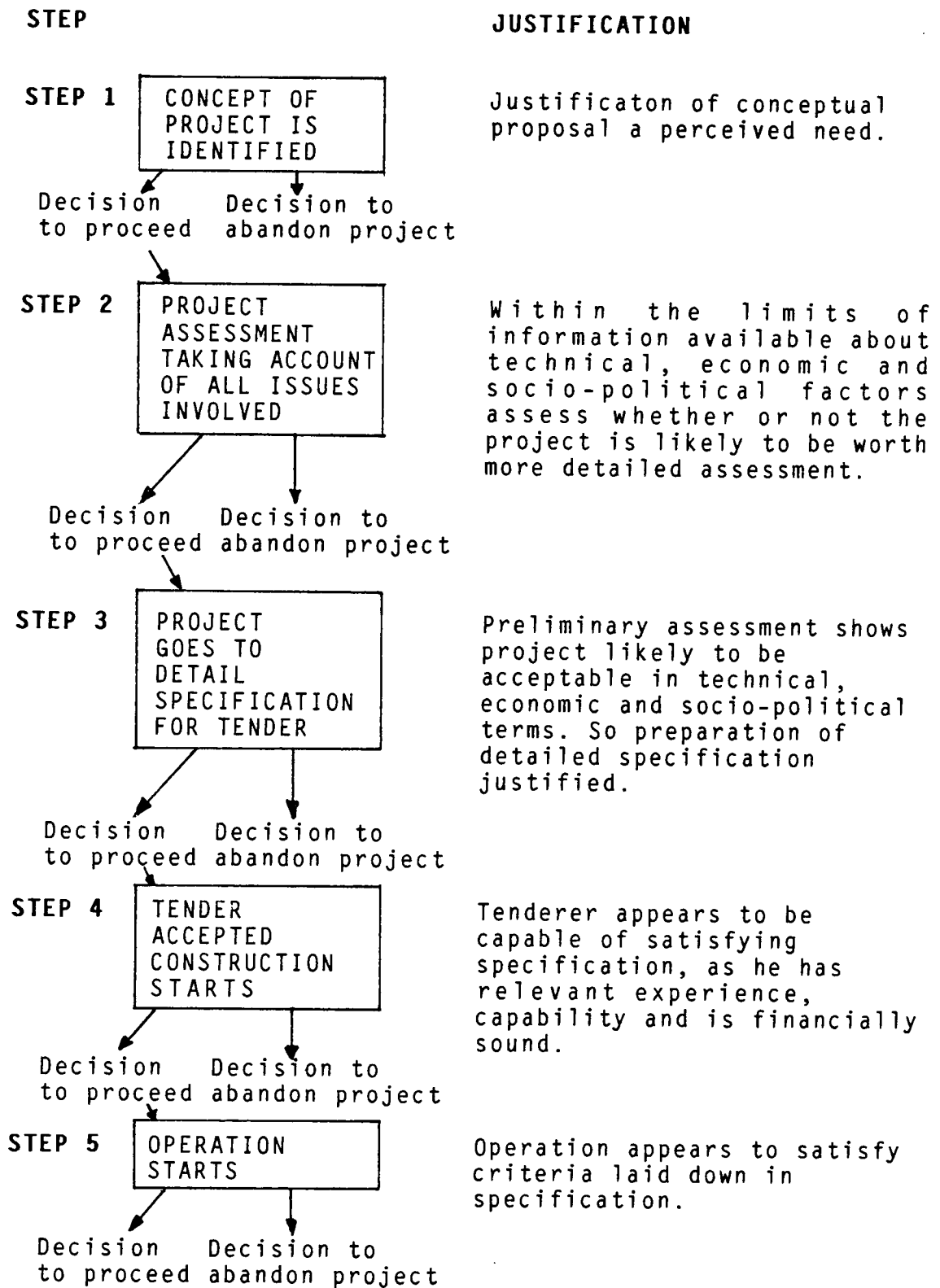


Fig. 4 Essential Steps in the Process of Making A Major Decision.

novel and there are few or no relevant data on which to base judgements. At each decision stage the adequacy of the development of the justification of acceptability has to be assessed. Determination of the overall acceptability of a major project such as a power plant or a new aeroplane requires the collection and evaluation of an enormous amount of evidence and the integration of analyses of many subsystems. At each stage of a project attention has to be focused on different aspects of the decision and often different people are involved with justifying and judging acceptability.

This characteristic metamorphosis in the pattern of actions involved in decision making has been recognized by others. Rosenhead has recognized the problems in his examination of the principles and prospects for problem structuring methods.(55) Checkland's soft system methodology is an adaptive form of enquiry that could be applied to helping to understand how the evaluation process associated with a project is likely to develop.(56)(57) In general Risk Ranking is more akin to hard system engineering assessment with each factor quantified and the understanding of the system being iteratively refined as knowledge develops. Nevertheless Risk Ranking can be adapted to deal with the qualitative statements of expert opinion. It is also possible that a form of Eden's cognitive mapping for strategic options development and analysis (SODA) could help define the changing role of an expert in the process of building up an assessment of the significance of a factor. (58)

One important feature that has to be included in the justification of the technical acceptability of a proposal for a major project is a demonstration that a proposal is likely to satisfy all relevant: regulatory, legal, insurance, planning and environmental requirements. In cases where planning and environmental requirements have to be satisfied it may have to be demonstrated that the design satisfies aesthetic requirements and that all possible discharges of potentially hazardous materials will be within specific limits. It must also be recognised that during the life of a project the understanding of the risks involved and the regulatory requirements may change. A rather dramatic example of the way understanding of the

significance of hazards may change is given by the recognition of the hazards associated with asbestos. For many years a variety of products were made utilising the thermal insulation properties of asbestos. Then it was recognised that exposure to certain types of asbestos could lead to those exposed developing cancer. As a result of this new understanding many claims for compensation were made against manufacturers of asbestos products. It has been reported that a major manufacturer of such products, in the USA, considered declaring itself bankrupt to avoid such claims. (59)

Proving regulatory criteria are properly satisfied can cause delays in completion of a project and result in additional expense. This suggests that the most effective criteria for ranking the acceptability of technical aspects of a proposal are likely to be those that relate in detail to the technical specification that the particular proposal has to satisfy.

If technical requirements are only specified in qualitative terms two main types of problem are generated, they are: 1) The proposer does not have a precisely defined numerical requirement to satisfy. 2) When there is no quantitative target to satisfy, proof that a proposal is acceptable is a matter of judgement. It therefore follows that there may be difficulty in proving that all that is reasonably practicable has been done to make the plant or equipment acceptable.

The problems involved in deciding what is acceptable are considerably easier to solve when the nature of any intrinsic risk is known completely. However, in reality novel projects generally bring in their train new risks that may not be fully understood, so some way of judging their acceptability has to be identified. It may be that for such cases an element of qualitative judgement must be retained in the criteria or else it has to be accepted that justification may have to be substantiated by a specially designed research and development programme. It being accepted that the results of research may show that it would be impractical to complete the project. Obvious examples of this approach are the prototype testing of new designs of aeroplanes and motor cars and testing the

efficacy of new medical drugs.

If a proposal involves public demonstration of acceptability, quantitative evidence about the technical nature and level of risk involved will give confidence that at least the risk is understood. When such evidence is not available the impression will tend to be given that the proposer does not properly understand the implications of his submission. Simply expressing the risk in terms like the probability of failure is low does not help. For a quantitative statement to be acceptable the data used must be proved to be relevant and degree of uncertainty associated with it stated. A quantitative statement based on appropriate reliable data is of more help to the decision maker than a qualitative statement that gives no indication of the possible variation that may be expected in the magnitude of the risk. It is therefore logical to aim to have compliance with technical risk acceptability criteria substantiated in quantitative terms. This leads to the question of: in what units should technical risks be discussed and in what units should ranking criteria be defined.

There are several units that could be used, most obvious candidates are time to failure and fatalities, as these indicate in a very direct way the ultimate life and possible harm that could result. An alternative would be to define the risk in money terms, which is very much the approach of an insurance underwriter. It is appreciated for many applications money may be the appropriate unit. However, defining the technical aspects of risk in money terms may conflict or duplicate the economic assessment of a proposal. Equally, even describing a risk simply in terms of the number of fatalities is ambiguous, as it would not include allowance for non-fatal casualties and may not include delayed fatalities or give a clear indication of direct and indirect material damage. Perhaps the most important characteristics required of criteria for assessing acceptability of technical factors are that they should be easily understandable, interpretable and accepted. This may sound trite but it is fundamental, because unless everyone involved in assessing the acceptability of the risk can understand and agree with the meaning of the criteria there will be no general confidence

in the adequacy of the criteria. Criteria are likely to have clearly defined limits of application, for example: criteria aimed at ensuring the risks associated with chemical plants are acceptable may apply to all chemical plants or only to those manufacturing some particular chemical. Similarly if criteria were intended for universal applications it would imply acceptance of the same level of risk regardless of the activity considered. Such uniformity in decision making would be far removed from the current pattern of life. From the overall criteria partial criteria can be derived. Partial criteria being the criteria that the various subsystems of a proposal have to satisfy. The more complex the proposal the more parts the overall criteria will have to be divided into. The important condition that must be satisfied is that the integrated risk from all the subsystems of the proposal must still satisfy the overall criteria. This means that the criteria that individual subsystems have to satisfy are likely to be more stringent than for the system as a whole.

The discussion so far has dealt essentially with the acceptability of the risks that are an intrinsic part of the hardware that is the subject of the proposal. In this case the term hardware is used in a very loose sense to cover not only all the engineering systems and components involved but also all the human systems involved. Judging the acceptability of the hardware is quite separate to judging the capability and experience of a proposer, but ultimately the two types of judgement have to be combined.

As already mentioned judging the capability and experience of a proposer is not a simple process. The aerospace industry is one industry which illustrates well the nature of the risks with major projects. It is one industry in which there have been some remarkable successes and also some damaging failures. The failures have included the Comet airliner, airships and the TRS2. The way the Lockheed Corporation deals with new novel projects indicates some of the important characteristics that a capable and experienced proposer would be expected to exhibit.

In 1943 Lockheed formed a unit called the Skunk Works, to

concentrate on developing new aircraft. (60) This was conceived as a small specialist unit operating almost separately from the main company but able to call on the services of the parent company. Table 18 summarizes some of the important projects the Skunk Works has been responsible for.

Kelly Johnson, the man responsible for the Skunk Works postulated fourteen rules for the effective management of novel projects. (60) Five of the rules can be slightly paraphrased so that they describe tests that can be applied to assess the likely effectiveness of any project proposal implementation team. The five tests are:-

- 1) The head of the project must have control and responsibility for budget, procurement, engineering, manufacturing and security.
- 2) The number of people involved with the project must be kept to the bare minimum.
- 3) Records must be carefully kept but paperwork kept to a minimum.
- 4) There must be monthly cost reviews of funds spent, committed and expected to be spent in the future.
- 5) Detailed inspection and quality control procedures must be instituted and kept to.

In the example of the Channel Tunnel, described in Chapter 1, a very simple view was taken of the form that criteria for ranking technical factors could take, it did not include any allowance for the experience or capability of the proposer. From the above it can be seen that assessment of the technical factors should include assessments of both the technical hardware and the proposer's capability and experience. have to be combined. Such combination of hard and soft assessments is surrounded by many problems, but the temptation to leave the two types of argument separate must be resisted. (61)

**TABLE 18 Some important projects the Skunk Works has been responsible for**

PROJECT	DESCRIPTION	MAIN PARAMETERS	COMMERCIAL CONSEQUENCES
P-80 Shooting Star Fighter	The world's first operational jet fighter	Prototype completed in 143 days, 37 days under schedule	9000 aircraft built
Saturn Low Cost Passenger Aeroplane	Twin engined high wing airliner	2 prototypes built	Priced out of market by war surplus Douglas C-47
XFV-1 vertical take off aeroplane	Experimental jet prop vertical take off aeroplane	Dual turbine contro-rotating propellers	Navy cancelled project
F104 Starfighter Mach 2 fighter	First operational fighter capable of sustained operation at Mach 2	2 prototypes built in 1 year	2500 aircraft built
C-130 Hercules Transport Plane	Military Transport plane	Prototypes built	2000 aircraft built
Blackbird Reconnaissance aeroplane	Capable of flying at Mach 3 and 80,000 ft. Very low radar cross section	Several versions built	A major technological advance

It is suggested that a comprehensive assessment of the acceptability of the technical risks of a project could be built up in the way shown in Table 19 with the highest Ranking score of the four features considered determining the Ranking for the technical factor as a whole. The scoring scale agrees with the score/acceptability relationship used in Chapter 1 and described in Tables 2 and 4, but is new to the extent that it introduces criteria for both technical hardware and proposers capability and experience. For specific decision making purposes it may be appropriate to simply quantify the relationship between Ranking and the technical factors, the probability of failure and the consequence of failure. An indication of how quantitative statements about the probability of failure and the consequences of failure can be related to qualitative statements about acceptability is given by the way requirements for acceptability are described for Civil aircraft. Figure 5 shows how the Airworthiness Authorities Steering Committee expressed the relationship between quantitative and qualitative statements about acceptability in the Joint Airworthiness Requirements. (61)(62) This is a more recent version than that presented as Figure 3.1 in ref. 12. The new addition being a line showing diagrammatically the reduction in the capability of an aircraft as more hazardous events take place. Concorde was the first aircraft for which a full quantitative risk assessment was made. The safety objective that had to be satisfied was that the probability of a catastrophic accident due to a system failure should be less than  $1 \times 10^{-9}$  for each flight hour. (62) Generally the life limitation is set at 60,000 hours, but for large jet transports this may be extended provided a very detailed structural examination is carried out and the condition of the structure is found to be acceptable (62). In this context it must be remembered that an inspection operation is not 100% perfect, there is only a 50% chance of an inspector detecting a 2 inch long crack. (63). Another view on technical risk acceptability has recently been published by the Health and Safety Executive, which introduced the use of the word tolerability. (64) 'Tolerability' is taken as being a willingness to live with a risk so as to secure certain benefits and in the confidence that the risk is being properly controlled. The term is a little vague as the terms 'benefits' and 'properly controlled' are not

**TABLE 19 Technical Risk Ranking Criteria**

FEATURE	RATING	SCORE*	RANK	EXPLANATION
1) Probability of failure during specified lifetime	Acceptable	1	4	Highest Score of the four features determines the overall Ranking Score and this determines the Rank for technical factors. For example if the highest Score of any feature is 5 the overall score will be 5, if the highest Score is 14 the overall score will be 14, if highest Score is 2 the overall score will be 2.
	Minor changes required	2	3	
	Major changes required	5	2	
	Unacceptable ***	14	1	
2) Consequence of failure	Acceptable **	1	4	
	Needs some reduction	2	3	
	Needs major reduction	5	2	
	Unacceptable ***	14	1	
3) Capability of Proposers	Acceptable	1	4	
	Needs some strengthening	2	3	
	Needs major strengthening	5	2	
	Unacceptable	14	1	
4) Relevant experience of Proposer	Acceptable	1	4	
	Needs to be extended	2	3	
	Needs major extension	5	2	
	Unacceptable	14	1	

\* For discussion of scoring system see Chapter 1 and Appendix 4.

\*\* Risk of premature death of member of the public 1 in  $10^7$  years

\*\*\* Risk of premature death of member of the public 1 in  $10^4$  years

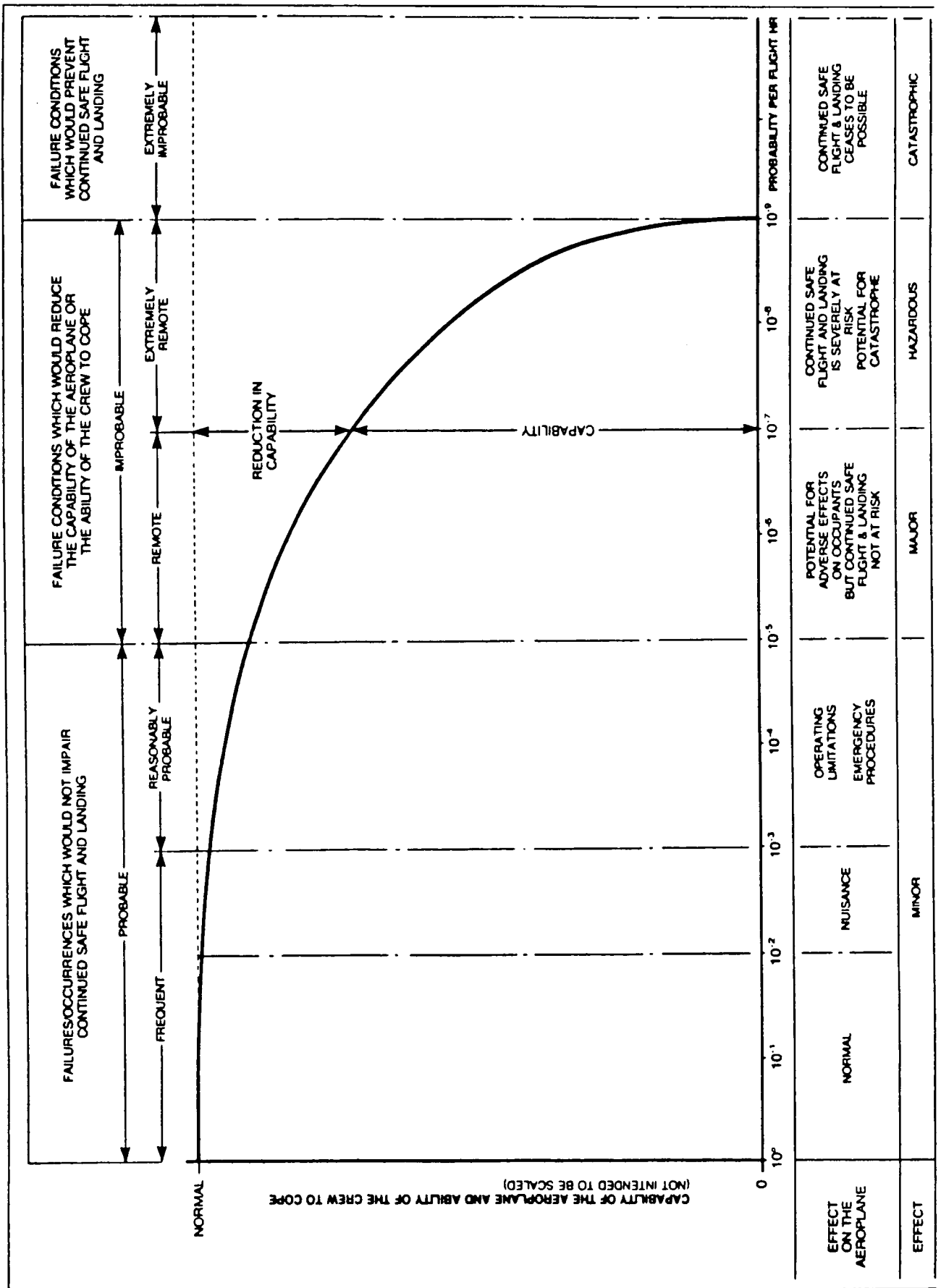


FIGURE 5 QUANTITATIVE AND QUALITATIVE STATEMENT OF JOINT AIRWORTHINESS REQUIREMENT FOR ACCEPTABILITY  
(Reproduced with Permission of the Civil Aviation Authority)

precisely defined. In ref. 64 the Health and Safety Executive use the term risk to denote the chance of a person having a shorter than normal life this is a very specific use of the term risk, which is used in a more general way in this thesis. From ref. 64 Table 20 has been constructed to show what the Health and Safety Executive consider to be tolerable levels of risk.

**Table 20 Tolerable Levels of Risk**

GROUP	RISK OF PREMATURE DEATH PER YEAR
Maximum for workers in any industry	1 in $10^3$
Maximum for any member of the public from a large scale industrial hazard	1 in $10^4$
Range of risk to members of the public living near a nuclear installation from normal operation	1 in $10^5$ to 1 in $10^6$
Range of risk to members of the public living near a nuclear installation from any kind of nuclear accident	1 in $10^6$ to 1 in $10^7$
Risk to average member of the public from normal operation and possible nuclear accidents	less than 1 in $10^7$

Assessment of the capability and experience of a proposer must to a large extent be subjective. The way the World Bank suggests the capability of consultants should be assessed has been mentioned earlier in this Chapter and in

Appendix 7. The degree of confidence in such assessments must take account of the degree of novelty in the subject of the assessment. When a proposal simply repeats some well established design or process there can be confidence that the capability and experience of the proposer can be judged accurately. But when the project is novel there is little foundation for judgements of capability. An example of such difficulty is the problem of obtaining insurance for novel projects. When the Eiffel Tower was being built it was considered such a departure from existing practice that no insurance company would cover the risk. (65) In a similar way today it would be difficult to obtain insurance cover for processes involving genetic engineering. An indication of the way the insurance industry assesses complex technical proposals like insurance of computer systems is given in Appendix 8.

The general conclusions that this chapter suggests are:-

- 1) The criteria it is proposed should be used for determining technical risk acceptability are shown in Table 19. (This is a much broader set of criteria than was proposed in Ref. 12)
- 2) The proposed criteria give a more comprehensive assessment of the technical acceptability of a proposal than the criteria proposed in earlier work and used in Chapter 1 as the basis for assessing the Channel Crossing proposals.
- 3) The detailed criteria adopted to assess Ranking scores for technical factors may have to be tailored to suit each family of proposals.

## CHAPTER 5

### Problems of Assessing the Economic Aspects of Risk

Earlier work by Chicken such as reference 12 on the assessment of the acceptability of the economic aspects of risk did not include discussion of or allowance for the through life costs and benefits. In this chapter an attempt is made to redress the balance by trying to identify the optimum way of assessing the economic aspects of risk acceptability. To simplify the presentation the argument is presented in literal terms and the theoretical aspects of the argument have been consigned to Appendix 9. The wide variety of economic indicators mentioned in Chapter 2 and Appendix 2, that financial institutions use to assess the acceptability of the risks associated with their lending policy suggest there is no single technique of economic analysis that is universally efficacious in assessing the acceptability of risks. To a certain extent the banks' procedure could be described as a search for a consensus view without attaching overriding importance to any one factor. Such an approach may be acceptable for assessing the financial risk associated with a major loan to an under developed country. But, the approach would be unnecessarily complex, perhaps even too indeterminate for simpler decisions such as determining the acceptability of financing the purchase of a new ship or a new aeroplane. In the assessment of the Channel Crossing options, mentioned in Chapter 1, the economic assessment presented to the decision maker was extremely simple, probably too simple, being based just on estimates of return on investment, cost and allowance for variation in cost.

Professor Pearce has put the essential features of the problem in the following way (66):- "If, as economists have repeatedly pointed out for the last two centuries, our wants exceed our capacities to meet them, we must, when choosing one thing, give something else up. This, very simply, is the notion of opportunity cost and an inescapable fact of life. .... What the cost-benefit analyst seeks is a methodology for 'revealing' that underlying valuation." Clearly the heart of the problem is balancing the merits of one form of expenditure against

other possible uses for funds.

Various analytical tools have been developed to assist the decision maker to deal with this problem. Among these tools are: cost-benefit analysis, risk-benefit analysis, risk-cost-benefit analysis, project economic viability, opportunity cost and insurability limits (67). It is not suggested that these methods give exact results, but only that they reveal something of the nature of the underlying valuation. The choice of method and the factors considered are to some extent related to the constraints of the environment in which the decision has to be made and the subject of the decision. The decision making inside a small company would be more constrained by factors like cash flow, debt financing, liquidity and profits than decision making in a government body. Most organisations are subject to constraints on their borrowing. In Britain the lending policy of banks is, as already mentioned in Chapter 2, subject to control by the Bank of England and the Commission of the European Communities. The Bank of England's criticism of banks' property loans is an example of this type of control. (68) Within these constraints the responsible decision makers will aim to ensure that resources are allocated to the most beneficial uses. It is assumed that in building up a picture of costs and benefits both direct and indirect costs and benefits are considered. Attention is drawn to the fact that indirect costs and benefits are often difficult to evaluate and introduce some additional uncertainty into the analysis.

For a completely satisfactory assessment of the cost and benefit aspects of the acceptability of risk the assessment has to include evaluation of the following:-

- 1) The total costs associated with each option.
- 2) The benefits in money terms associated with each option. It must be recognized that, at least initially, all the benefits may not be expressed directly in quantitative terms and there may be problems in converting qualitative statements about benefits into quantitative statements.
- 3) The costs in quantitative terms associated with the

direct and indirect risks inherent in each option.

- 4) The errors and uncertainties associated with the estimates of costs and benefits.
- 5) The overall economic implications of the options considered.

Sometimes the total cost of a project is lightly dismissed as simply being the sum of all expenditures required to bring a project to fruition. Such a definition is misleading, as it overlooks many important indirect costs. Also it overlooks the through life cost of a project. One option might have a low first cost but very high through life costs which would result in the total through life cost being higher than a high first cost option with low through life costs. Similar arguments can be applied to the assessment of through life benefits.

So far the discussion has not touched on the nature of the costs associated with the risks inherent in each option considered. It is important to separate risks from the errors and uncertainties in estimates of costs and benefits. Risks are the expression of the doubts about a proposal achieving its aim while errors and uncertainty refer to the possible variation in the calculation of costs and benefits. Some confusion about the terms stems from phrases like:- the risk of a cost overrun. The following examples of possible outcomes from projects makes the meaning attached to risk clearer: a new aeroplane does not fly, a new car engine has a higher fuel consumption than existing models, a new drug is not effective and a bridge fails before it is put into service. The cost of the risk and the loss of benefit in such cases are obvious. A recent World Bank study of 1778 projects showed 1 in 6 projects exceeded original estimates by 40% and a significant number exceeded original estimate by 80%. (69). When a project involves a novel technology the cost escalation can be a great deal higher. The errors and uncertainties apply to the estimate of both costs and benefits. In some ways the errors and uncertainties associated with benefits may be larger than with estimates of costs. The difference being partly due to the ephemeral nature of some benefits and that some benefits are

intrinsically hard to quantify. The benefits that are particularly hard to quantify are those connected with social projects. The problem being associated with the difficulty of valuing non-traded goods or services (70). Examples of non-traded benefits are noise-abatement, pollution control, trade protection and nature reserves. Any attempt to value such benefits reveals the magnitude of the problem. Often assessment of the value of non-traded benefits is based on estimates of willingness to pay for the benefit.

If the comparison of costs and benefits is made in subjective qualitative terms the conclusions tend to be quite artificial. Quantification, or at least ordinal ranking, is necessary for an assessment to have an adequate level of realism. (71)

One variation of conventional cost-benefit analysis that has been developed to deal with the element of risk in cost-benefit analysis is risk-cost-benefit analysis. Shrader-Frechette states that in the sixties risk-cost-benefit analysis was incorporated into the planning and budgeting procedures of many US federal agencies in the defence, aerospace and energy fields. (72) Essentially risk-cost-benefit analysis is a method of weighting and integrating the value attributed to the three factors for each option considered. The integrated values obtained serving as the basis for, what is claimed to be, sounder comparison of each option. Ideally for complete risk-cost-benefit analysis of a proposal all the implications of the proposal for all involved with the project should be evaluated. In order for such an assessment to be useful there has to be a very detailed understanding of the distribution of risks, costs and benefits. The economic features about a country or the financial performance figures of a company that banks' consider when they are assessing credit worthiness give an indication of the range of influences that have to be taken into account in evaluating any economic risk or risk weighting factor.

An important facet of the argument is expressed by the question 'Who bears the costs and who bears the benefits associated with the activity?' The argument is fairly simple when the risks, costs and benefits considered are

borne entirely by the same party. More generally the costs and benefits are divided between several parties. This gives rise to the moral question about how the benefits and burdens should be distributed. The following quotation from a Congressional Hearing, mentioned in ref. 12, goes some way towards identifying a solution to the problem in a way that helps to keep the discussion about the distribution of the burdens of risk in perspective. (73)

'The first moral question to be asked is this: "How ought benefits and risks be distributed?" It is a good rule of thumb to assume that no policy based directly on risk-benefit analysis will automatically distribute benefits and burdens fairly. That will happen only as the result of a deliberate additional effort. A very heavy burden of risk on one group, while another group gains most of the benefits, is clearly inequitable.....'

The deduction that seems obvious from the above quotation is that the risk and benefits and their distribution, must be expressed in quantified terms that enable the equity of their distribution to be assessed. It is only when the discussion can be held in numerical terms that the fairness of a proposal can be judged.

Insurance is one commercial way of distributing the burden of risk. The cost of obtaining insurance cover is not a fixed factor as it depends, to some extent, on the state of the market. For example, the view has sometimes been expressed that when insurance rates are high and the insurance markets are "premium hungry" insurers would cut their premiums, hoping that any losses due to claims greater than premium income would be covered by investment income. On some occasions employer's liability risks have been accepted at a premium of 60% of the annual claims experienced over the previous 5 years. (74)

It is important to recognize that the value fixed for insurance purposes may not be the same as the total cost burden.(75) Typically indirect losses such as: production

losses, terrorism, costs of retraining new staff, costs of cleaning up after an accident and investigating an accident are not covered. The insurance value of risk covered assumes the risk is known and understood. If the risk is not understood it would be virtually impossible to obtain insurance cover.

From this broad review of the problems of assessing the economic aspects of risk acceptability assessment, some conclusions can be drawn about the considerations that have to be taken into account in developing criteria for Ranking the acceptability of economic factors. The optimum way of assessing the Ranking of acceptability of economic factors would be one that gives repeatable, easily explainable and reliable results. These three requirements are mentioned to draw attention to the fact that the assessment technique should, with data of similar quality, give results of similar value to the assessment of any proposals they are applied to. The requirements are quite exacting and are not intended as aspersions on the efficacy of methods of economic analysis, but to expose the need to obtain consistent, predictable and easily understandable results. If over the years the methods of analysis used do not give results that are, in general, seen to predict the outcome of proposals accurately the methods will be discredited and decision making procedures based on them distrusted. For example the estimating procedures used for the Sydney Opera House and Concorde would be regarded as doubtful, as in both cases costs escalated to about ten times the original estimate, the estimating errors were massive. (69) Similarly the estimating procedure used for the Thames Barrier, which cost about twenty times the original estimate, would at best be considered doubtful. (69) The serious escalation of the costs of the Channel Tunnel show how quickly the original estimates of the cost of the project mentioned at the beginning of this study, can become out of date.(76) Not all projects cost more than the original estimate, but the risk of cost overruns are higher with novel projects than with projects that simply repeat an earlier successful proposal.

For two important reasons the requirement of easily understandable results is of vital importance in the design of assessment procedures of economic factors associated

with major decisions. The reasons are:-

- 1) Often decisions are exposed to public scrutiny and have to be defended openly to a lay public.
- 2) The results of the assessment may as in the case of the Swiss Bank Corporation's Management Brief, mentioned in Chapter 2, have to be presented to some busy senior executive in a simple direct easily understood way.

These requirements do not mean that all the supporting analysis has to be crude and simple. It merely means that the analysis has to result in conclusions that are easily explainable and easily defensible. Accepting that the Ranking Technique provides a way of presenting the results of analysis in an understandable way the basic question is: on which economic parameters should the Ranking score be based? Possible bases for Ranking are reviewed in Table 21. In every case allowance has to be made for errors in the data used. The errors may, as already mentioned, be massive.

Basing acceptability on a review of all economic parameters is a special case, which has a useful role in assessing the acceptability of the risks associated with a major project in a country with a poor economic record, or in a country where the cost of the project represents a significant proportion of the country's gross national product. A company's financial performance data is a fairly conventional basis for assessing a company's credit worthiness for a loan or its value as an investment. But, the method tells nothing of the benefit of the enterprise or the added benefit that will result from making a loan to the company. Considering simply capital cost also ignores many important economic issues like benefit or risk, but the terms could be adjusted by a factor to take them into account. Return on investment can give a more comprehensive view of the economic significance of a proposal providing the calculation of return on investment takes into account the costs, losses and benefits that accrue to people not directly involved in the project being considered. Opportunity cost analysis introduces another dimension, as it attempts to evaluate the comparative value

**TABLE 21 Possible Bases for Ranking Economic Factors**

BASIS	COMMENT
Review of a Company's financial performance data	This is used for assessing the credit worthiness of a company for a loan or the quality of a company as an investment.
Review of all economic parameters	This is appropriate for assessing the credit risks associated with a particular country. It is also appropriate for assessing projects where the cost is a significant proportion of a country's Gross National Product.
Capital cost	Simple straight forward, but does not take into account questions like the return on investment or benefit.
Agreed return on investment	Gives an indication of the likely commercial value of the proposal. Can be adjusted to take account of all costs and benefits borne by the public.
Opportunity cost	Gives an indication of the value of alternatives. The problem is to identify all the relevant alternatives.
Cost/benefit	Draws attention to the magnitude of related gains and losses. The problem is comprehensive identification of all costs and benefits involved. Risk/cost/benefit is a refinement of the method.
Non-Dimensional comparison of total cost	An ordinal non-dimensional ranking of cost provides a way of comparing options. Only really suitable for use inside an organisation.
Through life costs and benefits	If the assessment is made so that it takes account of all direct and indirect costs and benefits throughout the life of the project it gives a comprehensive assessment of the economic implications of a proposal.
Risk/Capital Ratio	Needs care to ensure that the calculation of total risk includes all direct and indirect risks. This method indicates whether or not a proposer has sufficient funds to cover all risks.

of alternative forms of expenditure. The problem with opportunity cost analysis is identifying all the alternatives that should be considered. Cost/benefit analysis is a very flexible analytical method and can be used to make a comprehensive assessment of all the gains and losses. The intrinsic problems are identifying all the costs and benefits that have to be considered, the degree of uncertainty in the calculation and the life of the project over which the costs and benefits have to be integrated.

None of the methods discussed so far overtly include any assessment of a proposer's ability to pay claims for compensation that may arise during the life of the project. The way claims for compensation due to asbestos induced diseases forced Johns Manville to consider bankruptcy, which was mentioned in Chapter 4, gives a clear indication of the importance of this factor. To save introducing an additional factor into the analysis it is assumed that estimates of costs include an allowance for either providing adequate insurance cover for all claims for compensation or maintaining sufficient reserves to cover any claims that may arise.

Ordinal non-dimensional ranking of cost provides a way project cost options can be compared, but it tends to obscure the amount of money involved. In some cases it might be possible, as in the case of capital cost discussed earlier, to apply the method to company total cost taking into account indirect losses and benefits.

The most promising of the bases for Ranking economic factors can be derived from the through life cost approach. If the through life assessment is based on costs and benefits and is calculated by integrating all direct and indirect benefits less all direct and indirect costs, which can be attributed to a project throughout its life, it would give a sound basis for comparing the economic significance of the options that have to be considered. Assessment of all positive and negative, direct and indirect benefits and costs is not without problems. The costs must include allowance for funding any compensation claims that may arise.

The question that remains is what is the most suitable criteria for assessing the acceptability Ranking of economic factors. There is perhaps no single answer. The criteria really have to be adapted to the particular decision being dealt with. But for families of decisions the criteria could be the same. For example criteria based on a review of all economic parameters may be suitable for all cases where the credit worthiness of a country had to be determined, and return on investment would be a sound basis for assessing a modest commercial project. Simply considering the return on investment ignores the influence on national expenditure and is difficult to apply realistically to proposals related to some topics like defence or social payments. In theory opportunity cost should give the best indication of the merits of alternatives, but the method is fraught with difficulties as for any proposal all the real alternatives may be hard to identify. Similar limitations apply to cost/benefit analysis. Any process of determining alternatives must, take into account the whole life cost involved and ideally the whole life benefit. Some additional discussion of calculations of through life cost is given in Appendix 9.

Given the doubts expressed about the feasibility of finding universal criteria for assessing the Ranking that economic factors justify, it is suggested that for many cases Ranking of acceptability of the economic factors could be made on the basis of the through life cost and benefits, the calculation taking into account all direct and indirect costs and benefits. It also has to be accepted that the calculation has to include a factor to allow for the risk of the project not being completed. Such a factor may be a compound factor, which includes allowance for all the features of the economic environment that may cause a project to fail. In Table 22 the possible relationship between through life costs and benefits and the Ranking score are set out. It is assumed that the calculation of through life costs and benefits includes an appropriate factor for compensation claims. It is recognized that simply postulating a ranking criteria does not: resolve the moral question of how the costs of benefits should be distributed, answer questions about the macro economic

TABLE 22 Possible Relationship Between Economic Factors and the Ranking Score

ACCEPTABILITY	ECONOMIC FACTORS	SCORE*	EQUIVALENT RISK ACCEPTABILITY RANK
Unlikely to be acceptable	Through life benefits - through life costs significantly lower than alternatives.	14	1
Only acceptable if risk can be reduced	Through life benefits - through life costs marginally lower than alternatives.	5	2
Yes, subject to detailed adjustments to the proposal being made	Through life benefits - through life costs higher than alternatives but some doubts about errors and uncertainties in the data used.	2	3
Yes, without restriction	Through life benefits - through life costs higher than alternatives. No doubts after making due allowance for all possible errors and uncertainties.	1	4

\* For discussion of scoring system see Chapter 4 and Appendix 4.

significance of the proposal or explain how the calculation should be made. The moral question is partly answered by assessing public reaction to a proposal and this question is discussed further in the next Chapter under the heading of socio-political factors.

## CHAPTER 6

### Problems of Assessing the Socio-Political Aspects of Risk

In earlier work, Chapter 7 of reference 12, the problems involved in assessing socio-political factors were discussed adequately for the purpose of this study. So this chapter merely presents a precis of those arguments with some additional comments on the difficulty of such assessments by Merkhofer and Lindblom. Because of the nature of socio-political factors the problems involved in assessing their significance in decision making are quite different to the problems of assessing technical and economic factors. Socio-political aspects of a decision are concerned with what ought to be, such decisions are quite different from technical judgements which are concerned with what can be done.

In the Ranking Technique socio-political factors are specified as including all the factors that influence decisions, which are not grouped under the heading of either technical or economic factors. The essential characteristic of this very broad group is that it describes all the shades of public opinion and influence that have to be taken into account in determining the acceptability of a proposal to the public. The spectrum of public opinion ranges from the views of individuals to the views of political parties. For an assessment to be useful to a decision maker it must be a balanced unbiased assessment of socio-political factors related to the public acceptability of a proposal. The importance of such an assessment was stressed in the Layfield report on the Public Inquiry into a proposal to build a pressurized water nuclear reactor at Sizewell. In the report Layfield drew attention to the need for better communication with the public and better understanding of the public's views about the acceptability of nuclear plant. (77) The need to understand the public's view is not peculiar to proposals relating to nuclear plant but applies to all proposals that have an impact on the public, whether it is: the rail link across Kent to the Channel Tunnel, the operation of the Health Service, the construction of a Motorway, the siting of an airport or the siting of chemical plant.

The views of Merkhofer and Lindblom help to put the problems into perspective. In his study of decision science and social risk management Merkhofer states "Social choice theory takes the perspective that the appropriate criteria for social decisions is not the preference of some single decision maker but rather a rational synthesis of the preferences of all those individuals who will be affected by the decision. The theory is thus concerned with finding decision rules or procedures by which preferences specified by individuals may be incorporated into the decision process". (78) Then in relation to ethical concerns Merkhofer raises two questions that are central to the design of ethical social decision making systems. The questions are:- 1) Which principles of ethics should be left to individual choice and which should be universally enforced? 2) Should ethical principles be stated in terms of ends or in terms of means? (79) Merkhofer concludes that: "Although analysis can help identify alternatives that are 'best' according to some specified criterion, it cannot objectively resolve conflicts of interest ..... Analysis can clarify a decision; it can also obscure it in technical and mathematical abstraction." (80)

Lindblom's outlook on the problem is slightly different as he is concerned with the policy-making process from the political stand point. Nevertheless, his views are very relevant to this examination of the problems of assessing socio-political factors, as the type of major decision that is being considered often has to be made in the political arena. The particularly relevant points he makes are:-

- 1) Even in democracies not everyone is motivated to vote on issues that may affect them or the interests of the people they represent. (81)
- 2) Not all the people who may vote are correctly informed about the issues they may vote on. (82)
- 3) Interest groups are a legitimate way for people to attempt to influence decision making. But the influence of an interest group is no greater than the weight given to it by the proximate policy maker. (83)  
(In the context of this study the proximate policy

maker can be interpreted as the person presenting an analysis of the decision options to a decision maker.)

The inescapable characteristic of socio-political factors data is that they are soft, in other words they are hard to quantify with any precision. The data that will be available will be derived from public inquiries, opinion surveys, voting, consultation and epidemiological studies. It has to be appreciated that each survey method has its strengths and weaknesses. An essential prerequisite of any attempt to make a sound assessment of the acceptability of the socio-political aspects of a decision is that everyone concerned, whose opinion has to be considered, has an adequate understanding of the technical and economic implications of the proposal. No honest unbiased assessment of public acceptability can be made unless the nature of the proposal is first explained to the public concerned in terms they understand.

Ideally views about the acceptability of a project should be collected from all those in the population who could, or think they could, be affected by the project. In practice it is not possible to draw a precise circle around the section of the population concerned about a particular proposal and only deal with the people inside that circle. In mathematical terms it is a Fuzzy Set of people that have to be considered, so great care is needed in defining the section of the population that has to be considered. At the same time it has to be recognized that there is likely to be a considerable degree of uncertainty about the confidence that can be placed in the views collected.

Once the population whose views must be sought is identified the next question is how should their views be obtained. Simply asking for a 'yes' or 'no' answer to the question "How acceptable do you consider the project is?", only gives a superficial view of the acceptability of the project. It is better to try and build up a feeling for the shades of opinion on a proposal and the alternatives in an iterative way. This procedure could be regarded as a form of the Delphi technique or even arbitration in which a consensus view is built up iteratively.

It is also necessary to recognize that the ideal situation

where all the people in the section of the population involved are provided with details, that they understand, of the technical and economic issues involved, can rarely be achieved in practice. Therefore any sample will include people whose knowledge is a mixture of: precise fact, belief, various levels of partial understanding and biased views propounded by interest groups. When there are strong political pressures involved impartial assessment is of paramount importance and the assessor must take care to ensure his assessment of socio-political factors is based on genuine representative views of the population involved. This problem of finding genuine representative views arises in any survey of opinion.

Having recognized something of the inherent limitations on the socio-political data that can be obtained the next question to consider is how the data can be obtained. There are four main techniques for assessing peoples' views on acceptability. Each technique has its own special characteristics and is more suitable for some applications than others. The techniques are summarized and their strengths and limitations commented on in Table 23, which has been developed from an earlier analysis of assessment techniques presented in reference 84. It is only possible to assess acceptability using epidemiological data if there is past experience that exactly matches the proposal being considered. The data must match the proposal being considered in terms of: technical specification, the current state of knowledge and the opinions of the group involved. It would be misleading to expect that opinion about the acceptability in the 19th century of a lead works in a town would give any indication of opinion in the 1990's about the acceptability of remote siting of a nuclear power reactor. Equally data about the acceptability of the siting of a bakery gives no indication of the acceptability of a factory based on a process employing genetic engineering.

The main problems with the consultation process are:- ensuring that those being consulted really understand the issue they are being consulted about, that they know the views of any public they represent and are accepted as representing that public. There would be no merit in consulting only farmers if only 10% of the community

**TABLE 23 Techniques for Assessing Acceptability of Socio-political Factors**

METHOD	STRENGTHS	LIMITATION	COMMENT
Epi- demio- logical studies	Relates what has already been accepted to environment of decision being considered	Past experience may not be relevant to the future. Does not represent a commitment by the public involved.	Such studies identify past areas of concern, but do not predict present or future concerns or reaction to novel proposals
Consul- tation	Quick, provided appropriate machinery for consultation already exists. Can give a permanent form of contact between the public and the project and the public and decision makers.	Those consulted may not represent the views of the whole community affected by the proposal in question. May be difficult to organize when national boundaries have to be crossed Does not represent a commitment by the public involved.	The success of this method depends upon those consulted being fully aware of the views of the community concerned, and understandably the issues involved. Some forms of can take 2 or 3 years to arrive at a view.
Sampling	A sample survey can provide structured evidence about views on acceptability	Does not give everyone a chance to express their views about what is acceptable. Does not represent a commitment by the public involved.	The sample surveyed must be taken directly from the population affected by the decision and for the results of the sampling process to really help the decision maker the population sampled must understand the issues involved
Voting	It is the most comprehensive way of establishing the views and wishes of a particular population	Not appropriate for all projects particularly small ones. Expensive and slow to arrange. Unless some form of compulsion is used not everyone will vote. Not necessarily binding on either party involved.	If the result is clear it gives the decision maker positive guidance on the action the population consider should be taken. If the verdict is marginal the issue is not efficiently resolved for the decision maker.

\*This is a modified version of Table 11 in ref.12

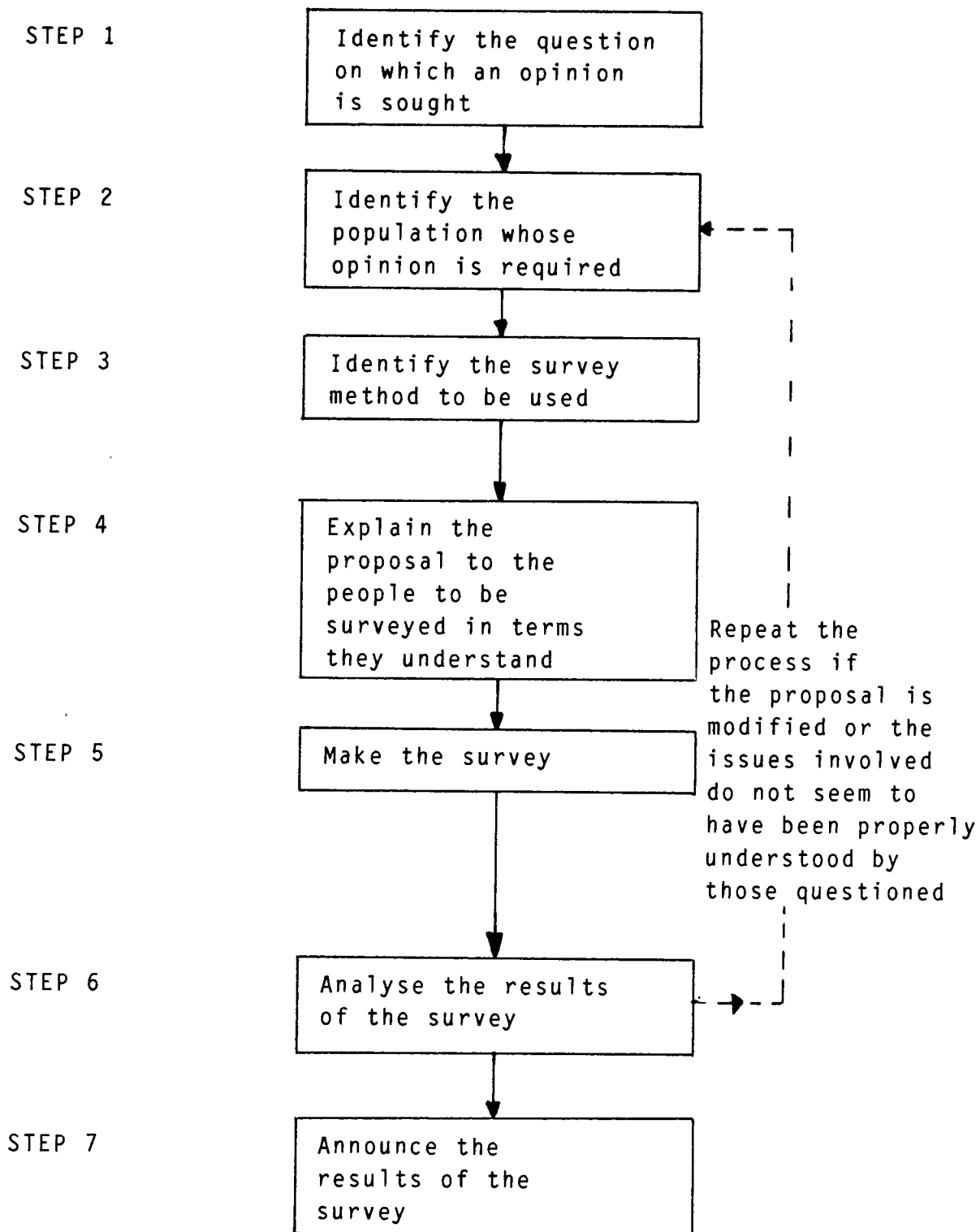
involved were farmers. It would be more effective to consult a group in which all interested parties were represented in the same proportion as they were in the section of population affected by the proposal.

Sampling opinion is a statistically valid way of assessing opinion and is likely to yield more helpful and defensible information than epidemiological data. Provided, and it is an important proviso, that the sample is properly structured and the population sampled is the relevant population.

Voting is in many ways the ideal democratic way of assessing the public acceptability of a proposition. However, it is not appropriate for all decisions. It may be appropriate for large decisions in the public sector but not for decisions in the private sector. Voting is generally a very slow and expensive process. Some reduction in cost could be achieved by simply limiting the voting to the region likely to be affected by the proposal, this may simply be a city or country area. If the practice were to become generally adopted it is easy to envisage that the nation's administrative system would become blocked and the decision making process slowed down.

As already mentioned, the extent to which lay people are willing and capable of making an accurate assessment of the acceptability of a proposal depends on their knowledge of and interest in the proposal and their understanding of its implications. Without an understanding of the significance of the essential features of a proposal the public are in no position to judge its acceptability and any judgement they make would have little value. This does not mean that without proper understanding of the subject the public will not express views. It simply means the analyst must be careful to avoid dealing in myths and legends, whilst at the same time accepting that myths and legends may characterise people's views on a particular subject.

Whatever method of collecting information is used seven essential steps have to be taken. The seven steps are shown in Fig. 6. The steps as shown might have to be repeated if the proposal is modified or the people questioned do not seem to have understood the implications



\*This Figure is a development of Figure 4 in ref. 12

Fig. 6 Steps in the Opinion Survey Process\*

of the proposal. If a sampling process is used it is possible for the issues to be explained to the people questioned and to include questions that test the understanding they have of the problems involved. It is the responsibility of the analyst to make certain that the people questioned have understood the questions asked. An acceptable decision making process will be one in which both analyst and public share the view that the implications of a proposal have been fairly explained and opinions correctly assessed.

Six recent major surveys of public opinion illustrate the capability and limitations of survey methods. These surveys were discussed at some length in reference 12. The surveys are: Surrey University study of the perception of the acceptability of risk, (85) the IAEA/IIASA study of the acceptability of various energy sources, (86) the Swedish referendum on nuclear power, (87) the two Swiss votes on opposition to nuclear power, (87) the Dutch survey of opinion on industrial risks in the Rijnmond area, (88)(89)(90) and the European Communities surveys of public opinion the acceptability of various sources of power. (91) The findings and limitations of the methods are summarised in Table 24.

The conclusions that seem to be justified about the problems of assessing socio-political factors are:-

- 1) The Socio-political factors related to complex decisions can be evaluated by carefully designed surveys.
- 2) Changes in opinion that take place over a period as short as two years can be detected by conventional survey methods.
- 3) Variations in views can be detected over a relatively small geographical area.
- 4) For an effective survey to be made the nature of the risk must be explained to the population being surveyed.

**TABLE 24 Findings and Limitations of six opinion surveys**

SURVEY	DESIGN	FINDINGS	LIMITATIONS
SURREY UNIVERSITY SURVEY OF PERCEPTION OF RISK (85)	Opinion of 1189 people sought on depth of unease about smoking, nuclear plant, chemical plant, work, air pollution and the home.	Average concern 6.5 times average worry and worry 4.2 times average anxiety. Greatest concern smoking. Greatest worry and anxiety the home.	Opinion limited to the time at which the views were taken. Did not cover all common risks for example does not include road risks.
IAEA/IIASA ACCEPTABILITY OF VARIOUS ENERGY SOURCES (86)	Opinion of 224 people sought on acceptability of: nuclear, coal, oil, hydro and solar power.	Opinion found not to be in favour of nuclear. This correctly forecast outcome of national referendum held shortly afterwards.	It represents the lower limit for size of sample.
SWEDISH REFERENDUM ON NUCLEAR POWER (87)	Referendum to determine views on nuclear power policy. Preceded by campaign to educate public.	75.7% of the population voted. 58% voted for nuclear power. 38% voted positively against.	After Chernobyl opinion changed Endorsing the view that a survey is only valid for the time it is taken.
SWISS REFERENDUM INITIATIVES ON NUCLEAR POWER (87)	Two referenda within three months. One on limiting licences to 25 yrs and liability to 90yrs, the other was for a modification to the Swiss Atomic Energy Act.	The first was rejected by 51.7% to 48.3%. 49% of the electorate voted. The second was supported by 69% but only 37% voted.	Although the Swiss are used to referendums, if used frequently interest falls. The method is slow - but binding on the government.
DUTCH SURVEY OF RISK ACCEPTABILITY PART OF FINDING AN ACCEPTABLE SITE FOR A MAJOR LNG TERMINAL (88) (89) (90)	600 people questioned. Special questionnaire SITE model (Sense of insecurity with respect to threat from Physical Environment).	15% of those asked refused to be interviewed.	Findings not binding on government. Only explored shades of opinion.
EEC SURVEY OF ACCEPTABILITY OF VARIOUS TYPES OF POWER. (91)	20 questions to 9,911 people throughout the Community on risk of living nearby certain installations; carried out in '78, '82 and '84.	Differences in opinion between member states and over the years more people considered chemical and explosives factories more hazardous than a furniture factory.	Extent of comparison limited by the range of questions asked.

- 5) A sample opinion survey does not represent any kind of commitment by the people being surveyed, whereas voting procedures may be binding.
- 6) For the decision maker considering a major public project there may be considerable uncertainty about the validity of the assessment of public acceptability unless it is based on the results of a voting procedure.
- 7) For small non-controversial projects surveys of the public's view of the acceptability of a proposal may not be justified.

In a society that lays any claim to being democratic when a decision involves determining the acceptability of a proposal either to the public in general or a particular section of the public, the opinion of the relevant public must be assessed in the most precise terms possible. Ideally the assessment should be quantitative. Although voting is the most positive way of making such a quantitative assessment in a binding way it is accepted that for many purposes a properly designed opinion survey may give an adequate assessment of opinion. For small or local projects consultation procedures may be an adequate way of assessing public opinion about the acceptability of a project.

From the examination of the efficacy of various methods of assessing the acceptability of a proposal in socio-political terms the conclusions that are considered to be justified about the criteria that should be used for assessing such factors in general and for Risk Ranking purposes in particular are:- 1) The assessment of the acceptability of the socio-political aspects of a proposal should as far as possible be assessed on a quantitative basis. 2) A possible relationship between socio-political factors and the Ranking acceptability score is described in Table 25. 3) Ranking on the basis outlined in Table 25 could be described as being based on an assessment of public opinion about acceptability of the proposal. 4) The approach described in Table 25 is rather different to the way the Swiss Bank Corporation assesses political and social factors which was described in Chapter 2 and

**TABLE 25 Possible Relationship between Socio-Political Factors and the Ranking Score\***

ACCEPTABILITY	SOCIO-POLITICAL FACTORS	SCORE**	EQUIVALENT RISK ACCEPT- ABILITY RANK
Unlikely to be acceptable	Less than 1/3 of the pop- population judged to be in favour of the proposal	14	1
Only acceptable if risk can be reduced	Between 1/3 and 1/2 of the relevant population judged to be in favour of the proposal	5	2
Yes, subject to detailed adjust- ments to the prop- osal being made	Between 1/2 and 2/3 of the relevant population judged to be in favour of the proposal	2	3
Yes without restriction	Over 2/3 of the relevant pop- ulation judged to be in favour of the proposal	1	4

\* Except for the scoring scale this figure is the same as Table 17 of ref.12

\*\*For discussion of scoring system see Chapter 1 and Appendix 8

Appendix 2. The Bank is more concerned to assess the political and social stability of a country and not just the public acceptability of a project. 5) The difference between the Bank's criteria for assessment of socio-political factors and the proposal for Risk Ranking shows the importance of tailoring the Criteria for assessing acceptability to match exactly the requirements of each family of applications.

## CHAPTER 7

### Possible Alternatives

The earlier chapters concentrated on comprehensive assessment of decision options using the Risk Ranking Technique and the methods used by financial institutions. In this chapter a critical examination is made of the possible alternatives to those methods. Before launching into examination of alternatives the perspective from which the examination is made must be stated. Essentially the perspective is that of the potential user. The aim being to evaluate currently available genera of techniques for assessing decision options to determine to what extent they have the capability to fulfill a comprehensive assessment role, such as that performed by the Risk Ranking Technique, or whether they just have the potential to complement or supplement comprehensive assessment in some way.

The Ranking Technique is considered to fall somewhere between the techniques conventionally considered to be hard quantitative methods and the soft qualitative methods. Hard quantitative methods are those based on numerical analysis of the parameters of the problem. Soft methods being those appropriate for problems in which the boundaries are ill defined and for which there is no relevant quantitative data. The aim of this examination of alternatives is made clearer by recognition of the fact that the role envisaged for any comprehensive assessment is to summarize, weight and integrate for the decision maker, the conclusions about acceptability justified by detailed assessment of every aspect of each option available. In other words comprehensive assessment is the last step in the assessment process as it integrates the results of all the assessments of individual factors.

The typical decision making situation in which it is envisaged comprehensive assessment will be used is where an assessment has to be made, of the acceptability of various solutions to a complex project. The circumstances of the decision making processes being such that the decision maker has to be prepared to defend the decision to a large lay public. As part of such defence it has to be possible

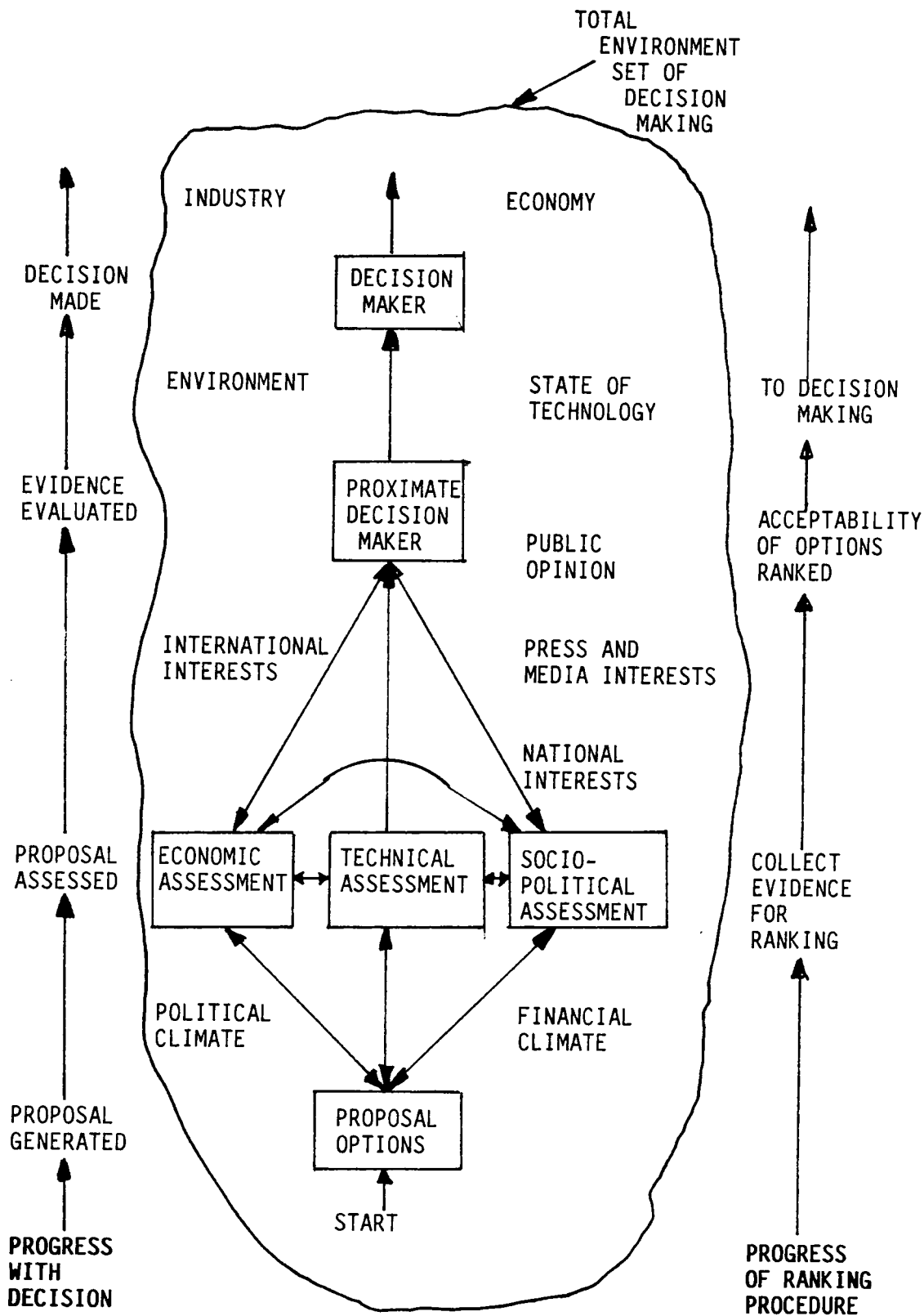
to demonstrate that all the technical, economic and socio-political factors involved have been considered in adequate depth. Such decision making situations may be found in major public companies, major spending departments of local and national governments and inter-governmental bodies. Typical of such decisions are: decisions about whether or not to build a new kind of chemical works, decisions about whether or not to build a power station on a particular site and decisions about the site of a new hypermarket. This description of the potential role of comprehensive assessment is simply to illustrate the characteristics that other techniques should have to be considered as possible alternatives to comprehensive assessment and should not be interpreted as limiting possible applications of techniques like Risk Ranking.

From the description of the role envisaged for comprehensive assessment it is possible to visualise a model of decision making that describes the circumstances in which the role may be played. The model visualised is shown diagrammatically in Fig 7. From the diagram it can be seen that the decision making process of interest is surrounded by an environmental set containing many factors that may influence and interact with the decision making process. The diagram also shows that in the environment there will be interactions that will: generate proposals, support the proposal and others that will be opposed to the proposal.

At the minimum the decision maker will have two options to consider. One option being to accept a proposal and the other option being to reject the proposal. In practice there are at least two more options which are: no decision is taken and the proposal is returned for revision. Once a proposal is generated it will have to be assessed. The comprehensive assessment process should as already discussed evaluate the technical, economic and socio-political issues involved and attempt to identify the advantages and disadvantages of each option.

Generally the assessors are separated, in some way, from the decision makers. This means the findings of the assessors are passed to the decision maker through a proximate decision maker. When all the evidence has been





Note! Double ended arrows indicate there may be iterative development

Fig.7 Diagrammatic Representation of Decision Making Process

collected it is structured for decision making and passed to the decision maker who has the ultimate responsibility for making the decision. In practice the procedure is rarely so simple; there may be many iterative developments in the proposal as it passes between proposer, assessor, proximate decision maker and decision maker. These iterations may be required to take account of: changes in technology, better understanding of the relevant technology, changes in the economic climate, changes in the pattern of demand and change in the socio-political climate. It is assumed that the issues involved are not trifling matters, in other words some form of de minimus test has been applied to eliminate trivial issues. (91) In some cases it may be helpful to use a Risk Ranking philosophy to determine which risks inherent in the proposal can be ignored.

Now to examine possible alternative methods. The methods are categorised under three headings which are: comprehensive alternative methods, supplementary methods and complementary methods. Comprehensive alternatives are those techniques than can entirely replace the Ranking Technique or any other method of comprehensive assessment. Complementary methods are techniques that could add something to the comprehensiveness of the Ranking Technique. Supplementary methods are techniques that could overcome deficiencies in the Ranking Technique. Clearly the techniques labeled complementary or supplementary are not complete alternatives to comprehensive assessment as they do not look at all the factors associated with decisions in the comprehensive depth the Ranking Technique does, but they may have a vital supporting role by providing the type of evidence required to Rank the Acceptability of the various factors considered.

The main characteristics of the comprehensive alternative methods are shown in Table 26, the main characteristics of the supplementary methods are shown in Table 27 and the main characteristics of the complementary methods are shown in Table 28.

The comprehensive alternatives described in Table 26 are listed in order of the increasing quantitative detail they are structured to take into account in arriving at their

**TABLE 26 The Main Characteristics of Comprehensive Alternatives to the Risk Ranking Technique**

POSSIBLE ALTERNATIVE	POTENTIAL ROLE	LIMITATIONS
Direct presentation of evidence with guidance on acceptability	Can be used in cases where the decision maker wishes to make his own assessment of the evidence	As it does not include any systematic comparative analysis of the options it does not improve understanding of the significance of the evidence
Direct instruction about acceptability in natural language	Cases where no quantitative justification is considered necessary	Defence of method difficult without support from detailed quantitative evidence
Review by experts	When a proposal is novel it may be useful to know the degree of support from experts who have some relevant experience	Could be seen as a way of avoiding responsibility for decision. Advice from experts has to be assessed and weighted. The experts consulted should either individually or collectively have an understanding of the technical economic and socio-political issues involved
Public Debate	When public participation in the decision making process is judged to be required	May be a slow process. Does not ensure that the decision is universally acceptable. Does not always deal with all the issues involved in a consistent manner
System Analysis (92)	Can be used to identify interacting factors involved and establish their relative significance	The procedures are more aimed at establishing relationships than producing a quantitative comparison of the significance of the various factors can also be considered as a supplementary technique
Statistical methodology such as Bayesian inference (93) multivariate analysis	May give indication of possible outcomes in cases where the data is inadequate	Findings may be difficult to present to a lay public. Confidence in findings low when the analysis is based on inadequate data
Computerised simulation analysis of the options. Possibly based on a system with either artificial intelligence or an expert system	When all options and uncertainties have to be explored in detail and the interaction between the various factors is known	Confidence in method would have to be established. With a novel proposal it could give misleading results, if proposal is outside the range of the expert systems used. For the system to be effective reliable relevant quantitative data would have to be available.

**TABLE 27 The Main Characteristics of Supplementary Alternatives to the Risk Ranking Technique**

POSSIBLE ALTERNATIVE	POTENTIAL ROLE	LIMITATIONS
Soft System Methodology (94)	An aid to building up an understanding of the factors and relations that have to be considered. (This influenced the early development of the Ranking Technique)	It mainly concentrates on identifying the pattern of relationships associated with decisions. It does not normally quantify the significance of relationships
Cognitive Mapping (95)	To determine the interaction of factors and determine their relationship with goals about which decisions are required (This also influenced the early development of the Ranking Technique)	It is more concerned with determining the commitment to action than assessing the merit of particular courses of action
Game Theory (96) & (97)	Metagame and hypergame approach can be used to explore outcomes of decisions when several organisations are involved in implementing the decision	Simply concerned with determining the most likely outcome of a decision
Risk Analysis (98) & (99)	Although Risk Analysis is built into the Risk Ranking Technique, Risk Analysis can also be used to explore the consequence of the decision and the chance of decision being implemented	Does not necessarily take into account technical, economic and socio-political factors
Probability Modelling (100)	Probability Modelling can be used to perform a very similar role to Risk Analysis	Limitations similar to Risk Analysis, it could be regarded simply as a variant of Risk Analysis
Multivariate Analysis (101) & (102) (Appendix 10)	Can be used to express the relationship between the factors involved in mathematical terms	To be effective really requires considerable quantitative data about factors included in the analysis. Such data may not be available for novel systems.
Credit Worthiness	To assess proposers acceptability for a loan to finance a project	Concentrates on determining the credit worthiness of the proposer and in general gives scant attention to other aspects of a proposal

**TABLE 28 The Main Characteristics of Complementary Alternatives to the Risk Ranking Technique**

POSSIBLE ALTERNATIVES	POTENTIAL ROLE	LIMITATIONS
Robustness Analysis (104)	To structure the examination of the findings of any quantified analysis including the Ranking Technique and focus attention on the possibilities of various outcomes in a variety of possible futures.	Requires some quantitative data to be available about the factor or factors investigated
Forecasting Techniques (105)	To help determine the future significance of the various factors considered	Only relevant when the factors involved in the decision considered have to relate to some time in the future for which the characteristics are predictable
Resource Allocation (100)	To assess the merits of the resource allocation of the technical, economic factors available.	Justification of the resource allocation tends to be limited to technical and economic factors.
Regression Analysis (101)	To try and predict the future quantitative significance of every factor from analysis of past experience	Regression analysis can only really contribute to understanding the significance of options when future conditions are expected to relate to past experience
Decision Trees (100)(106)	To build up a picture of the relationship between the subsidiary decisions and factor	Comprehensive Decision Making only deals with the end product of decision trees, as it is concerned with the final decision
Arbitration (100)	For novel projects arbitration between experts about the values that should be used for factors for which there is no data. Can also be used to establish common ground between various groups in the population	Arbitration only helps to identify the extreme views. The compromise adopted is not necessarily the ideal decision

conclusions. For example direct presentation of evidence and natural language presentation of a judgement does not necessarily involve any quantitative statement of the relative merits of one option as compared with another. The most significant weakness of such approaches is that it is not a prerequisite that they have a rigid structure that requires specific factors to be taken into account in a consistent way. A review of a proposal by experts is likely to be made in very qualitative terms, but it is essential that consultation is structured, as described in Appendix 5, so that the distribution of opinions on all aspects of the proposal being studied can be assessed statistically.

One important variation of the conventional expert consultation approach, that is particularly useful in the context of decision making process in a company, is the decision conference. The decision conference is a meeting, which may be a regular meeting, to decide collectively with all the company's experts the best decision to adopt.

Important decision conferences may be held away from the normal working environment to facilitate concentration. This method is used by ICI, who have found that the process of reaching a decision is often helped by using a facilitator.(103) The facilitator is unlikely to be an expert in the subject of the decision but he will be an expert in helping the group to reach a decision. He will help bring problems to the surface and suggest ways the problems may be dealt with. Decision conferences can be regarded as a very special form of expert consultation. They are special in the way the range of topics considered is limited and in the way the range of experts consulted is preselected.

System Analysis can be useful in building a model of the interactions associated with a proposal, particularly the socio-political interactions. Identification of the interactions can lead to detailed quantitative assessment of all the relevant factors. The problem with System Analysis is its flexibility. The virtue of flexibility means that it may be difficult to ensure comparable consistent results, as the analysis does not have to be applied in exactly the same way each time. The influence

of System Analysis on the development of the Ranking Technique is recognized and it could be argued that the Ranking Technique is a codified application of System Analysis.

Statistical methods including multivariate analysis and computer simulation using expert systems can, provided they are based on accurate data relevant to the proposal being assessed, give a good insight into the acceptability of risks. In very broad terms Risk Ranking could be described as belonging to the multivariate family of techniques. When proposals involve some novel process the use of expert systems may be inappropriate as the expert system may not include relevant information from which to construct advice. If the appropriate data is available multivariate analysis can be incorporated into or form the basis of a computerised simulation program. In this context it is noted that there are some interesting computer programs being developed using multivariate techniques to assess the acceptability of risk. A particularly relevant development is the RISIKO-DIALOG program that is being developed by the St. Gallen Institut fur Versicherungswirtschaft. (107) Although the program is designed specifically for comprehensive assessment of insurance risks it could be adapted for comprehensively assessing a wider spectrum of risks.

The categorisation of the various decision aiding techniques into supplementary or complementary techniques is somewhat arbitrary, but it exposes some fundamental limitations to their capability and their potential roles. There is a considerable degree of overlap in some of the techniques, as some of them are flexible enough to be developed as either supplementary techniques or complementary techniques or even as alternatives to comprehensive assessment procedures like the Risk Ranking Technique. Perhaps the most important difference between the techniques is between those that attempt to assess the significance and impact of all the variables associated with a proposition and those techniques that are simply concerned with exploring the uncertainty associated with a single variable.

The criteria for assessing the usefulness of the various

techniques is whether or not they represent an improvement of the logic of the Ranking Technique or significantly improve the quality of understanding of the factors involved. In making this assessment care had to be taken to avoid encouraging the use of techniques that would obscure the influence of the factors.

Now to consider the characteristics of the supplementary methods summarized in Table 27. The most difficult method to categorise is soft system methodology, as in some ways because of the comprehensiveness of its nature it could be considered a complete alternative to comprehensive techniques like the Ranking Technique. (92) But because it does not attempt to make a quantitative assessment of the significance of the various factors identified as being involved perhaps the most useful contribution Soft System Methodology can make is at the preliminary stage of assessing a particular decision problem. At that stage Soft System Methodology can help to identify the interactions that have to be allowed for in the assessment.

The central characteristic of Cognitive Mapping is production of a map of all the issues concerned with a decision. The issues including driving forces and restrictions. In some ways Cognitive Mapping could be considered as assessing the balance of pressures for decision options available. It does not attempt to quantify the relative merit of the options.

Game Theory in all its various forms is basically concerned with exploring all the likely outcomes of a decision and determining which is the most probable outcome. (95) (96) It could be argued that the way Game Theory explores uncertainty is only slightly different to the way it was suggested, in Chapter 3, that the Ranking Technique could be used to explore uncertainty.

Risk Analysis could be described as an overused phrase and because it is used in so many ways it can be misunderstood. In the context of this study it is intended to cover statistically based techniques used to assess the probability of various possible outcomes from various sub-systems of a proposal.(98)(99) Such techniques include network analysis. In relation to the Risk Ranking

Technique the supplementary role foreseen for Risk Analysis is in determining the probability of the assessment of the values used for each Ranking factor and the overall Ranking being correct. As with Game Theory exploring the probability of the Ranking being correct has been effectively covered by the three dimensional matrix procedure described in Chapter 3.

The boundary between what is called Probability Modelling and Risk Analysis is very fuzzy and many of the analytical processes have similar forms. (101) This means the comments that have been made about Risk Analysis also hold for Probability Modelling.

Multivariate Analysis techniques, which are concerned with determining the relationships between sets of variables, are perhaps less widely used. (101) (102) This may be partly due to the difficulty, particularly with novel projects, in obtaining sufficient data about the relationships between the variables. However, analysis of complex multivariate situations such as associated with political decisions has been tackled (105), and also as already mentioned computer programs such as RISIKO-DIALOG are being developed for the insurance industry (107). Complex models may not simulate the real world exactly; they may be in error either because they under-identify or over-identify the variables involved and their interactions. During the life of a project as additional data becomes available, such errors could be iteratively reduced. Further discussion of the role of multivariate analysis is given in Appendix 10.

Credit Worthiness is a specialist technique developed and used by financial institutions. The method is essentially aimed at determining the proposers ability to repay a loan or to pay for goods or services. Concern about the technical and socio-political aspects of a proposal are almost incidental and perhaps limited to assessing the proposers experience in doing what he says he wants to do and assessing his capability to do what he says he wants to. With regard to comprehensive assessment Credit Worthiness generates information that would be appropriate to include in some cases in the economic part of a comprehensive assessment. Typically this kind of

assessment would show how much allowance should be made for possible failure of suppliers during the life of a project. It could also be integrated into the assessment of capability and experience described in Chapter 4.

Differentiating between supplementary and complementary techniques is not as simple and clear as the words suggest. In several cases, particularly Forecasting Resource Allocation, Decision Trees, Arbitration and Credit Worthiness, it is possible to visualise that on suitable occasions the techniques could fulfil either supplementary or complementary roles. In the discussion that follows attention is concentrated on the complementary role, but where appropriate an indication is given of the potential supplementary role.

The essential feature of Robustness Analysis is determination of the range of predicted values that result from uncertainty in the data and the futures considered. (104) In many ways Robustness Analysis represents a form of sensitivity analysis. It has already been demonstrated in Chapter 3 that a three dimensional matrix can be used to display the variation in Ranking that could be expected from variation in the data that has to be used. The complementary function Robustness Analysis could play in relation to the Ranking Technique is as an alternative to a three dimensional matrix as a way of displaying the consequences of variations in the data used and the future considered.

Forecasting the future is inherently fallible, no matter how good the crystal ball or the oracle that is consulted (106). Only if there is extensive experience with the subject of a proposal and if the environment in which the proposal is to be realised is exactly the same as past experience is there any chance of correctly forecasting the outcome of a proposal. In the Ranking Technique, there is an element of forecasting the likely outcome of a proposal as life and return on investment have to be investigated. By their very nature aids to decision making build up their conclusions on estimates of outcomes. To help solve this problem the influence of variations in the data used for Ranking can be explored in a systematic way, as already described.

Resource allocation provides a way of comparing and optimising the benefit or profit from particular courses of action. (98) Generally the comparison is based on the parameters of total benefit and total cost. The method could perhaps be used as a simplified alternative for assessing the acceptability of economic factors for Ranking. If used in such a way care would have to be taken to ensure that net benefits were measured in through life terms. The method does not have the potential for being developed into a comprehensive assessment technique which optimises benefit in terms of technical, economic and socio-political factors.

To be able to derive the equations for regression analysis there has to be relevant data available that can be used for the derivation of constants. Without such data the equations are no more than intuitive guesses. When the decision involves some novel process for which there is no data regression analysis has no real role. It could be used for assessing the confidence in some factors. For example regression analysis could be used to estimate the overspend typically associated with government funded novel projects or it could be used to estimate the proportion of the population likely to be opposed to siting a petrochemical plant near a residential area. (108) This means that the role of regression analysis in relation to comprehensive assessment is limited to helping to determine the likely magnitude of sub-factors used in the assessment of factor Ranking scores in Risk Ranking.

Decision trees are used in several guises, which can include influence diagrams and event trees. (100)(106) Essentially the technique helps to structure the decomposition of a decision into its component parts which can then be analysed. Provided appropriate data are available the method can show the significance of the individual components and identify where changes are most required to make a particular option more acceptable. Although the use of decision trees is mainly in helping to build up an understanding of the significance of the individual factors, a decision tree could be constructed in a way that one branch represented technical factors and other branches represented economic and socio-political factors.

Arbitration is a difficult form of analysis to categorise. It can be used to assess the room that negotiating parties have to manoeuvre in in order to find a mutually-agreeable settlement. The technique could provide a useful basis for assessing the significance of socio-political factors for comprehensive assessment. Also the technique could be used to negotiate acceptance of the final Ranking of acceptability with the parties involved in making the decision about which option is most acceptable.

This brief review of the main types of decision making aids, which could be considered as offering the decision maker an alternative to the Risk Ranking Technique, suggests several conclusions are justified. The criteria used to determine the justification for the conclusions are:-

- 1) Does the alternative improve the comprehensive assessment of the technical, economic and socio-political factors associated with a particular decision.
- 2) Is the assessment that the alternative technique gives transparent and easily defensible to both the media and the lay public.
- 3) Does the alternative give a better assessment of the significance of possible variations in data and the environment in which the decision has to be implemented than the Risk Ranking Technique.
- 4) Is the alternative flexible and can it be adjusted to give consistent results for various families of decisions.

One important general conclusion that must be recognized is that the efficacy of any technique depends on the quality of the data that can be used. For an assessment to be balanced the data about each option must be of similar quality.

The natural language alternatives such as: direct presentation of evidence, direct recommendation, review by experts and public debate do not give results that are

inherently more reliable than the Risk Ranking. The problem with such methods is that they can be biased by the views of the people involved.

System Analysis does not really justify the title of a comprehensive alternative. The main merit of System Analysis is that it structures the identification of the actors and interactions that should be considered. The method could suggest weightings that should be given to particular factors that have to be considered in arriving at a decision.

Both statistical and computer techniques can help to understand the significance of the data available. In cases where computer simulation is possible it may give insights into the way major parameters of the decision vary. The value of such explorations is of course limited by the quality of the data used and the model used.

Multivariate analysis and Comprehensive Risk Ranking can be considered as members of the same family of statistical methods. Multivariate analysis requires construction of a system of equations that fully describe the decision options. Without relevant data to allow the constants and indices in the various equations to be determined the method really only amounts to a theoretical novelty. If relevant data is available the method could be used to build a computer simulation model of the decision process. The RISIKO-DIALOG program being developed is an example of such a model.

Of the supplementary techniques considered soft system methodology and cognitive mapping mainly have a role in identifying actions and interactions that have to be considered. Game Theory, Risk Analysis and Probability Modelling are essentially concerned with trying to quantify the possible outcomes of the various options considered. They can also be used to explore the implications of various possible futures. The exploration of possible futures with the Risk Ranking Technique has not been discussed, so far, but exploration of possible futures could simply be considered as a further stage of investigating the consequences of variation in data.

Credit Worthiness is only an assessment of an organisations financial strength and ability to deal with a certain level of financial commitment, it does not imply any judgement about the value of the work they do. It could form part of the assessment of an organisations capability and experience.

Of the complementary alternatives Robustness Analysis and Forecasting Techniques can be grouped together as their special contribution is rating the acceptability of options under various possible future environments. Interest in the techniques is not that they endow the analysis of possible future conditions with special accuracy but more that they draw attention to the need for the decision maker to consider the future may be different from expectation.

Regression Analysis, including multivariate analysis, assume future experience will have a form that can be related mathematically to past experience. To even start on such analysis relevant data is required. Perhaps the most that can be said for Regression Analysis is that, if data is available, it may identify possible futures.

Decision Trees help to build up a picture of the relationship between subsidiary decisions and the overall view, the efficacy of the method depends on the data available.

Arbitration is a rather different kind of technique and is more related to the natural language techniques mentioned as possible comprehensive alternatives. The special merit of the technique is that with appropriate arbitrators it could provide a way of reaching agreement on how socio-political issues can be solved. The success of the arbitration being related to the extent to which the arbitrators represent the population involved and are aware of the population's views.

From this examination of possible alternatives to the Risk Ranking Technique for comprehensive assessment the final conclusion that appears to be warranted is that apart from computer simulation and multivariate analysis none of the techniques considered is quite as comprehensive in concept as the Risk Ranking Technique. Many of the techniques

considered have their own specialist niche, even though they are not complete alternatives to comprehensive assessment. Despite not being an alternative they can still provide valuable inputs.

## CHAPTER 8

### Comparison of the Efficacy of Alternative Methods of Analysis

To assess the validity of the views expressed in Chapter 7 about the efficacy of the methods of assessing the risk acceptability the potential efficacy was tested on three well known major projects that had been described by Chicken in ref. 12. The three cases considered were:- the proposal for a new oil refinery on Canvey Island, the proposal for a liquified natural gas terminal at Rijnmond in the Netherlands and the Channel Crossing proposal. The description of the cases is based closely on that given in ref. 12, but the comparison of the methods of analysis is new. The perspective from which the efficacy of the various methods is judged is that of the person responsible for deciding which decision option should be adopted. It is assumed that the decision maker will wish to have a comprehensive assessment of the acceptability of the risks associated with each option.

The assessment methods considered are:-

- (1) Simple direct presentation of the evidence available with guidance about which option is most acceptable.
- (2) Direct natural language recommendations about acceptability.
- (3) Review by experts.
- (4) Public debate.
- (5) System analysis.
- (6) Statistical analysis of the options.
- (7) Computerised simulation analysis of the options.
- (8) Soft system methodology.
- (9) Cognitive mapping.
- (10) Game theory.
- (11) Risk analysis.
- (12) Probability modelling.
- (13) Multivariate analysis.
- (14) Robustness analysis.
- (15) Forecasting technique.
- (16) Resource allocation.
- (17) Regression analysis.
- (18) Decision trees.

(19) Arbitration.

In examining the methods, particular attention is given to determining to what extent they give a complete and comprehensive assessment of the options the decision maker has to consider. The evaluation of the three cases is as follows:-

The Canvey Island Project

The Canvey Island project involved a proposal by United Refineries Ltd., to build an oil refinery with a capacity of four million tonnes/year on Canvey Island. Canvey Island is located on the North Shore of the Thames twenty-seven miles east of London. The island measures approximately nine miles by two and a half miles. About 33,000 people live in the area. In the area there are tank storage installations for: Texaco Ltd. and London and Coastal Oil Wharves Ltd., also the British Gas Corporation have a methane terminal there. Close to Canvey Island and in the general area covered by the proposed development Shell U.K. Oil and the Mobil Oil Company have large oil refineries, also Calor Gas Ltd. have a plant for filling cylinders with liquified petroleum gases. In 1973 outline consent to build the refinery had been granted.

As a result of a Public Inquiry into the desirability of revoking the planning permission that had been granted, in 1976, the Government asked the Health and Safety Commission to make an assessment of the acceptability of the risks associated with existing installations and the cost of the assessment was £400,000 (108). Three years after the first Canvey Island study report the results of a second more detailed study of the issue were published (109). It is on the basis of the information published in these two reports that the assessment is made of the potential of the various aids to decision making.

From the first study it was concluded that the risks associated with the various industrial installations would be reduced if certain modifications were made. The conclusion was also drawn that provided certain design and operational conditions were satisfied, there would be no health or safety objection to the construction of the

proposed new refineries. The main objective of the second report, which was published three years after the first, was to show the result of making the modifications identified in the first report and to show the result of improvements in the data and improvements in the risk assessment methodology. The first report showed the annual risk of death to an individual in the area covered by the study was  $7.40 \times 10^{-4}$  per year. In the second report it was shown that the average risk figure had been reduced to  $0.35 \times 10^{-4}$  per year.

At the time of the first report the acceptability of the level of risk associated with the project was doubtful. The technical risks were not acceptable, as the regulatory body required modifications to be made. The economic aspects of the risks were judged to be acceptable, as the owners of the various installations involved were willing to modify them and to continue to operate them. Concern about the socio-political aspects was high, as it was considered necessary to hold a Public Inquiry and to commission detailed studies of the significance of the risks.

By the time the second report was issued in 1981, the significance of the various factors related to acceptability of risk had changed considerably. The work done in the three years following publication of the first report allowed estimates of the technical significance of the risks to be reduced, making them more acceptable. The economics of the situation had changed dramatically as United Refineries did not go ahead with the project.

The special characteristics of this case are that there were four main actors who were:- the Government, the Public, the Oil Company and the Technical Assessors who provided the evidence on which the two reports were based. Another important characteristic of the case is that the decision making process was very slow, it took five years from the time the Health and Safety Commission was asked to prepare the first report to the time the second report was presented. By the time the findings of the second report were announced, United Refineries had lost interest in the development. It was, after all, nearly ten years since they started work on the project and the market and

their plans had changed. The Canvey Island case is interesting, as it is one of the first cases in which a quantified assessment of the technical aspects of the potential risks to the public was presented to the proximate decision makers. At the time the first report was being prepared none of the Companies on the Canvey Island site had quantified assessments of the potential hazards associated with their plants. This case illustrates the equal importance of the technical, economic and socio-political factors, and that if one factor, like economic acceptability, shows the proposal to be unacceptable the proposal as a whole becomes unacceptable.

Now to consider how the efficacy of the Risk Ranking Technique aid to decision making compares with the possible alternatives when applied to the Canvey Island. The alternatives are discussed in the same order that they were dealt with in Chapter 7 and as identified at the beginning of this chapter. First comprehensive alternatives are considered, then supplementary alternatives and, finally, complimentary alternatives.

Seven comprehensive alternatives were identified, the alternatives being:-

- (1) Direct presentation on the basis of evidence.
- (2) Direct natural language recommendation.
- (3) Review by experts.
- (4) Public debate.
- (5) Systems analysis.
- (6) Some form of statistical argument perhaps based on Bayesian Inference or Fuzzy Data Analysis.
- (7) Computer simulation.

The problem with direct presentation on the basis of evidence or direct natural language recommendation as compared with the Risk Ranking Technique is that they give the proposer no advance indication of the criteria the decision maker will adopt to determine acceptability. The decision maker might have some quantitative criteria in mind when he makes his decision, or he may adopt a form of subjective reasoning known only to himself. In both cases there is no indication of the range of factors to be considered or weight given to the various factors involved.

If these methods had been used in the Canvey Island decision, it would not have been possible to show on what basis the decision was justified.

Review by experts is very close to what actually took place. The experts in practice concentrated on the risk to the public and did not concern themselves with the economics. The socio-political implications were dealt with by having a Public Enquiry. It could be argued that the review by experts was in the Canvey Island case only advice to the decision maker on the technical acceptability of the proposal and that the decision maker was left with the problem of determining the significance of the other factors. However, ultimately the role of economics was central to the whole decision, as when the proposer decided there was no longer any need for the refinery that was the end of the project.

The Public Inquiry and the public examination of the official reports on the proposal allowed a certain amount of public debate on the acceptability of the technical aspects of the proposal. The debate was not of a form that allowed the public view to be assessed quantitatively in a way that could be binding on the decision maker.

If the proposer had used system analysis he might have identified all the actors influencing the decision about the acceptability of his proposal. This would have enabled him to assess the nature of the opposition to his proposal and thus determine the course of action he should follow to avoid or at least minimize the interminable delays he was faced with. System analysis does not provide a direct alternative to the Risk Ranking Technique but, by identifying actors concerned, it can help by structuring the assessment of socio-political factors.

In considering the efficacy of advanced statistical methods compared with the Ranking Technique, it is important to remember that the Ranking Technique is intended to provide the decision maker with a rational, coherent and consistent way of making decisions which is transparent and understandable by the lay public. The most useful role of advanced statistical methods is in helping the decision maker's supporting team to assess the significance of the

evidence available. The methods in themselves do not provide a comprehensive assessment of the proposal of the type given by the Ranking Technique.

The feasibility of developing a computer simulation as a potential aid to decision making is a very complex question. If all the information related to a decision is known and the way the variables are interconnected is known a sound simulation model of the acceptability of a proposal can be constructed, which will allow the implications of the uncertainties associated with the variables and interconnections to be explored. The RISIKO-DIALOG program, mentioned in Chapter 7, is an example of such a program. Risk Ranking could be built into the program so that the Risk Ranking could be explored. With a decision related to a novel project for which there is no substantial body of data, the benefit of computer simulation appears doubtful as there would be no data on which to base the simulation. In such circumstances the simplicity of the Risk Ranking Technique seems to have the advantage of speed and simplicity over complete and comprehensive computer simulation of the whole decision process.

Six supplementary alternatives to Risk Ranking were identified in Chapter 7. They are:-

- (1) Soft System Methodology.
- (2) Cognitive Mapping.
- (3) Game Theory.
- (4) Risk Analysis.
- (5) Probability Modelling.
- (6) Multivariate Analysis.

The comment on the potential role and comparative value of Soft System Methodology is very similar to what has already been mentioned under Comprehensive Alternatives about System Analysis. Soft System Methodology can help to identify the factors that should be considered in the assessment of the acceptability of various options. If, in the Canvey Island case, United Refineries Ltd had identified all the groups who would be concerned with their proposal and had assessed the strengths of the groups and what was required to satisfy them, they might have saved a

lot of delay in a decision being reached. In other words, the conclusion is that Soft System Methodology can help Risk Ranking by identifying factors that should be considered in building a Ranking system, but Soft System Methodology in no way replaces Risk Ranking.

Cognitive Mapping could, where the decision is novel, aid those assessing the options by helping to identify exactly what criteria are appropriate for determining the acceptability of the options available. Cognitive Mapping could be regarded as an aid for helping the decision assessor to decide, for a particular family of decisions, what criteria should be used to assess the options.

Game Theory, particularly when mixed motive games are considered, and the Risk Ranking Technique can have roles in which they support each other. The information collected for Risk Ranking can help the mixed motive game assessor to explore possible outcomes more realistically. The three dimensional matrix of Ranking, Fig.2, shows how possible outcomes can be rated. To a certain extent, the essential elements of Game Theory could be considered as being built into Risk Ranking. If the potential of Risk Ranking or Game Theory had been exploited in the Canvey Island case, perhaps some of the actors would have withdrawn from a very protracted game with a negative outcome.

Risk Analysis is a generic term that covers many methods of analysis, most being concerned with attempting to quantify various aspects of the risk associated with a decision, the overall estimate being built up from the various components of the systems involved. Generally, risk is assessed in either technical or financial terms. The Canvey Island reports (108) (109) are good illustrations of the way definition of technical risk acceptability criteria associated with a particular project may be developed iteratively and the time and effort required to develop evidence that the criteria have been satisfied. The Risk Ranking Technique is an attempt to extend conventional risk analysis, so that by taking account of the risk or uncertainty associated with the technical, economic and socio-political aspects of a proposal, a comprehensive assessment is built up of the acceptability of the risks

involved.

The remarks just made about Risk Analysis apply equally to Probability Modelling; for the purpose of this study the two terms could be considered as synonymous.

The use of Multivariate Analysis, particularly in the form envisaged by Hilton (105), consists essentially of building up a mathematical model for assessing the acceptability of the options related to a particular proposal. Such a mathematical model would be a pre-requisite for the construction of a computer simulation of the type mentioned in Chapter 7 as a possible comprehensive alternative to Risk Ranking. No attempt was made to apply multivariate analysis or computer simulation to the assessment of the Canvey Island project, possibly because of the extensive data and analytical effort requirements to construct adequate mathematical models of a complex issue like the Canvey Island decision.

Each of the supplementary alternatives considered could, to a certain extent, help the exploitation of Risk Ranking methodology determine the best decision. The Soft System related methodologies can help identify the actors that should be considered, and the mathematically related methods can help the quantification of the significance of the various factors. In practice, Risk Analysis, using the term risk to mean possible harm to the public, was the only technique applied in the assessment of the Canvey Island case.

Six complementary alternatives to the Risk Ranking Technique were identified in Chapter 7. The alternatives identified are:-

- (1) Robustness Analysis.
- (2) Forecasting Technique.
- (3) Resource Allocation.
- (4) Regression Analysis.
- (5) Decision Trees.
- (6) Arbitration.

By their nature complementary alternatives to Risk Ranking are not strictly alternatives, more exactly they

are methods that add some deeper understanding of the significance of the factors that influence the acceptability of a decision option. Both Robustness Analysis and Forecasting Techniques attempt to take account of possible future situations in which the decisions are expected to be effective. The Risk Ranking Technique, as described, is intended to be applied to assessing the acceptability of the various decision options on the basis of their through life implications, which implies a range of possible futures have to be considered. If United Refineries had been able to predict the delays, changes in market conditions and the issues raised by the technical risk assessment, they might not have embarked on the Canvey Island project.

Resource Allocation generally attempts to compare the merits of options in terms of the relationship of total benefit and total cost. This approach ignores socio-political problems and questions about the technical feasibility of an option. It assumes the significance of all factors associated with a decision can be measured in money terms. Resource Allocation does not really offer a comprehensive assessment of the type offered by the Risk Ranking Technique and it does not seem to be a method that would have helped the Canvey Island decision makers.

Regression Analysis and Decision Trees are tools that the assessor uses to build up the information required in the construction of the Risk Ranking. The usefulness of Regression Analysis depends to a large extent on the decision being one of a family of decisions about which there are relevant data. United Refineries should have had sufficient experience in building refineries and been able to predict the kind of delays to expect if they did not present a technically justified case. Decision Trees can be used to build up an overall assessment of a project by constructing the tree from the various components that the decision can be decomposed into. Decision Trees could, like other methods, have helped United Refineries identify the possible delays they would be faced with if they did not present a fully justified case.

Arbitration Analysis might have helped United Refineries to understand their position in negotiations related to

obtaining Planning Permission. This is an aspect of decision making partly covered by the Risk Ranking Technique, which includes an assessment of the socio-political acceptability of a project. Arbitration Analysis goes a little further by attempting to assess on what terms negotiators might agree about the acceptability of a proposal. In the context of Risk Ranking this could be the extent to which public opinion is likely to move towards accepting a particular proposal.

To complete the picture of the Canvey Island project, in Table 29 a Ranking of the acceptability of the Canvey Island risks is given. The assessment was made post-hoc and based essentially on the information given in references (108) and (109). Although the evidence was not ideal, particularly with respect to data on the economic and socio-political aspects, it does show how the Ranking Technique can give a logical comprehensive analysis of acceptability. The Table also shows how the Ranking of acceptability can be refined as better data becomes available, and reflects changes in the pattern of concerns that take place with time. The Canvey Island case also illustrates the tremendous amount of preparatory work that has to be done before a major project can be embarked on and funding is required. It also shows how relatively quickly market conditions can change and demand for a project disappear.

**Table 29 Ranking of the Canvey Island Risks**

BASIS	SCORES OF SUB-FACTORS			RANK
	Technical	Economic	Socio-Political	
First Report (108)	5	1	5	2 (acceptable only if risks reduced)
Second Report (109)	1	5	2	2 (acceptable subject to economic demand improving)

## The Rijnmond Gas Terminal Project

The history of the Rijnmond case is complicated and has its origins in the early 1970s when plans were made to import large quantities of liquified natural gas (LNG) from Algeria (110). The two main contenders for the site were Rotterdam and Eemshaven. The decision involved the Dutch Cabinet, several Government Departments, the local Government Authorities of the areas concerned and public meetings. Safety implications and public perception of the acceptability or risk were important factors in deciding which site should be selected. The case is particularly interesting for the fact that local politics appear to have been a more important influence on the final decision than marginal differences in the quantified estimates of the risks to life involved. (110)

Discussion about which was the most acceptable site can be divided into three rounds. Round 'A' was the period up to the final signing of the contract for the supply of LNG and included the preliminary search for a terminal site. Round 'B' involved the Cabinet, several Government Departments and at this stage it was recognized that siting of an LNG terminal involved several issues such as: energy policy, the environment, safety, land use and regional planning. At the beginning of this round Rotterdam was the preferred site and discussions were held with the local Authorities in the region. These included the Province of Zuid-Holland, Rijnmond Public Authority and the City of Rotterdam. The discussions showed that the Authorities, particularly the Rijnmond Public Authority, were likely to apply stringent safety requirements to any LNG terminal. The involvement of the Rijnmond Public Authority is the reason the decision became known as the 'Rijnmond Decision'. In simple terms, it was considered that discussion of these safety requirements was likely to delay the start of delivering LNG and this led to Eemshaven being considered in more detail as the site for the terminal. Round 'C' was the final round which ended with the Cabinet deciding in favour of Eemshaven.

In April 1978 the Rotterdam and Groningen local authorities were each given three months in which to

formulate their views on the acceptability of an LNG terminal in their area. During this period there were formal Council debates and public meetings at which the public and interest groups could express their views. The views of the Local Authorities were presented to the Cabinet in June 1978. In August 1978 the Cabinet announced its preference for Eemshaven, primarily on socio-economic regional industrial grounds. The decision was debated at considerable length in Parliament and finally approved in October 1978.

The view has been expressed that, in part, the reason that the decision went in favour of Eemshaven was that the Governor of Groningen was a skillful Politician and a long standing member of one of the parties in power (110). In this context the final decision appears to have been guided more by political opportunity than by consistent government policies, strategies or decision procedures. This in many ways underlines the significance of the socio-political factors in any assessment of acceptability. Attention must also be drawn to the fact that the decision was in conflict with the official advice of the Interdepartmental Coordinating Committee for North Sea Affairs (ICONA) (110). The official ICONA report can be criticised because it intentionally did not consider either local risk perception in relation to public and official acceptance of LNG or the political importance attached by some interested parties to the siting of the terminal. In other words, the ICONA report overlooked the major socio-political influences on the decision.(110)

Although ICONA can be criticised for not considering local opinion, it was the only co-ordinating body that included representatives of all the relevant ministries and in preparing its advice attempted to take account of national policy.(110) ICONA advised that from their evaluation of economics, energy policy and environmental impact they preferred the Maasvlakte site near the Hook von Holland for the LNG terminal. The ICONA view on the risks associated with the Maasvlakte and Eemshaven sites was that the risks with both sites were approximately equal. (110)

The Local Authorities, the Trade Unions were in favour of Eemshaven. (110) The Environmentalist Groups, Shipowners

Association and Electricity Corporation were against Eemshaven. (110) The Shipowners saw some navigation and operational problems and some risks could be associated with Eemshaven. The Electricity Corporation saw some risk to their existing coal-fired power station (110).

The characteristics of the Rijnmond Decision and the scope it presented for assistance from various decision making aids are quite different from those presented by the Canvey Island Case. The Rijnmond Decision was centred on socio-political factors with technical and economic factors being somewhat subsidiary, whereas the Canvey Island Decision was initially centred on technical factors. This difference in the characteristics of the Rijnmond Decision gives a different pattern to the possible alternatives to the Ranking Technique. Already the relative merit of nineteen possible alternative methods of analysis has been shown in relation to the Canvey Island Project. So attention is concentrated on the alternatives whose role in relation to the Rijnmond Decision is potentially significantly different to their role in relation to the Canvey Island case.

The relative merit of direct presentational methods is the same in both cases. The role of the review by experts is very different in the two cases. In the Canvey Island Case the technical assessment was central to the whole discussion of the acceptability of the proposal. In the case of the Rijnmond Decision the advice of the official experts in the form of ICONA was not followed. Perhaps the weakness of the ICONA advice was that it was neither technically specific nor fully comprehensive, it was more just a distillation of departmental views. For expert opinion to be respected, it must be seen to be independent and comprehensive.

Public debate and the collection of public views about the Rijnmond Decision options was rather more structured than in the Canvey Island case. It seems fair to suggest that unless the role of public debate in the decision making process is clearly defined, its role can be unpredictable. The Risk Ranking Technique attempts to avoid this problem by being specific about the criteria that should be used for judging the acceptability of socio-political factors.

The potential role of statistical methods and computer simulation is judged to be about the same for both the Canvey Island and the Rijnmond cases.

In the Canvey Island case the potential of the six supplementary alternatives to Risk Ranking were examined. The conclusions drawn about the efficacy of these techniques in the Canvey Island case apply equally to the Rijnmond case.

With the complementary alternatives to Risk Ranking, the conclusions drawn about each technique in the Canvey Island case are also equally justified in the Rijnmond case. The two cases appear to underline the importance of including some element of testing the possible future merits of a proposal in the assessment of its acceptability. This view draws attention to the possible contribution of Robustness Analysis and Forecasting Techniques to assessing how acceptability may vary with time. The Rijnmond case illustrates how the formal arbitration process built into the Dutch procedure was used effectively. The procedure consisted of time limited debate at local level, discussion in Cabinet and debate in Parliament. It is interesting to speculate on the extent to which Arbitration Analysis would have forecast the outcome and helped the decision maker.

On the basis of the evidence available a Risk Ranking was made of the Maasvlakte and Eemshaven sites and the results of the Ranking are shown in Table 30 (110). The technical risk of an accident at Maasvlakte was estimated to be slightly higher than at Eemshaven and there was slightly more political support for the Eemshaven site. The table shows how the Risk Ranking Technique can present a comprehensive assessment of the merits of two decision options. Like the Canvey Island case the Rijnmond case shows how extensive the work is that has to be undertaken to get a project approved before it can be started and major funding committed. Anyone financing a major project, or indeed any project, has to be certain that all the preliminary work required to get the project approved has been completed satisfactorily before funding for the project is released.

**Table 30 Ranking of the Maasvlakte and Emmshaven Sites**

OPTION	SCORES OF SUB-FACTORS			RANK
	TECHNICAL	ECONOMIC	SOCIO-POLITICAL	
MAASVLAKTE	1	1	2	3
EEMSHAVEN	1	1	1	4

### The Channel Crossing

The essential features of the Channel Crossing Options have already been given in Chapter 1 and a Ranking presented in Table 6, but to enable the possible role potential of alternative methods of evaluating decision options to be discussed with more confidence, a few more background details of the project are given.

Discussion of a fixed link across the Channel has been going on for nearly 200 years.(111) Following the Anglo-French summit meeting in London in September 1981, an expert study group was established to evaluate the technical and economic arguments for a fixed Channel link.(112) The group advised that they considered the balance of advantage lay with bored twin rail tunnels with a vehicle shuttle.(112) Discussions about the acceptability of the various proposals came to something of a climax at the end of 1985 when the Transport Secretary, Nicholas Ridley, announced that he was then of the opinion that work on the project must start within two years. (113) Ten schemes were submitted, but attention was concentrated on four main proposals. Consultants were employed to analyse the schemes and their reports were presented to the Department of Transport in December 1985. Nicholas

Ridley announced that instead of a Public Inquiry there would be extensive public consultation (113). The basis for the public consultation being 15 page summaries of the proposals. The British and French Governments announced, in Lille on the 20th January 1986, that they had accepted the rail tunnel proposal.

The four main Channel Crossing proposals considered were: the Eurobridge, the Euroroute, the Channel Tunnel and the Channel Expressway. In addition, the option of not constructing a fixed crossing was considered. The main technical features of the proposals are summarised in Table 3. The technical, economic and socio-political justification of the Ranking of the options are given in Table 5.

For building up the Ranking of the options the evidence that was used was that given in the Official Case presented to the British Parliament.(114) There was no attempt in the Official Case to quantify the magnitude or the probability of the technical risks involved. In the evidence presented attention was not drawn to such facts as: in the Eurobridge proposal, the real experience with the material proposed for the suspension bridge cables was only about one seventh of the proposed life of the material, and with proposals involving tunnels no justification was given for the acceptability of the explosion risk in such long tunnels. The justification for the scoring of each factor is shown in Table 5. Evaluation of the economic implications of the proposals showed that the total cost of the proposals was likely to be a significant factor in the economies of Britain and France. Possible variation in total cost is a factor that has to be considered in any project, as experience has shown that the cost of a major novel project often far exceeds initial estimates. As mentioned in Chapter 1 in quite unrelated projects like the Sydney Opera House and Concorde costs escalated to about ten times their original estimates.(18) The Thames Barrier was originally estimated to cost £23 million and actually cost £461 million (19). In retrospect it seems in the Channel Tunnel Project the question of possible variation in cost was treated lightly. Concern about this aspect of the project has been justified by events, as the cost of the Tunnel has risen dramatically. (20)

The assessment of socio-political factors seems to have been very elementary. Only minor objections by people living in the area of the terminals were reported in the discussion in Parliament and the Press. This is not surprising as no carefully designed survey of public opinion was made. The only surveys made were by local papers and these are considered to be of questionable value.(21)

A special feature of the Channel Tunnel Project decision is that although the agreement of two Governments was required the project is funded by the private sector. An important limitation of the Tunnel decision was that it simply considered the Channel Crossing and not all the implications of the crossing such as:- the improvements required in connecting road and rail services. The essential features of their decision making process was that the decision makers were advised by an expert group and had their decision endorsed by a democratically elected Parliament. The weakness of the decision making process was that it did not detect that the estimates of costs involved were grossly optimistic.

Of the alternative methods that might have exposed some of the weaknesses in the proposal are: Public Debate, Systems Analysis, Soft System Methodology and Forecasting Techniques. The possible contribution of the other techniques being very similar to their possible contribution to the Canvey Island and Rijnmond cases.

In this case the Minister responsible took the decision not to have a Public Inquiry into the proposals. This decision avoided one type of searching public debate and perhaps shortened the decision making process. It is possible that a Public Inquiry would have uncovered weaknesses in: the economic case, the additional expenditure required for improvements in road and rail services and the acceptability of the safety of the design proposed.

Systems Analysis and Soft System Methodology generally would have uncovered the wider implications of the proposals and shown the need to recognise the road and rail implications of the Channel Crossing. These methods may also have identified the need to consider environmental and

safety issues in any decision that claims to be comprehensive in the issues they take into account.

Forecasting Techniques and Robustness Analysis could have provided ways of exploring different possible outcomes of the project. Such exploration may have exposed the possibility of a major increase in cost and its implications.

The Risk Ranking of the options that was presented in Table 6 simply presented a Ranking based on the Official Case. If there had been access to the detailed assessments on which the Official Case was based it may have been possible to construct a three dimensional Ranking Matrix, of the type shown in Fig.3. Such a matrix would have indicated the possible impact on the acceptability of the project of variations in the estimated cost. The Channel Tunnel case shows how important it is to have good quality data on which to base decisions. Unless there is a comprehensive understanding of all the technical problems involved in a project and the cost of their solution the economics of a project can be put in jeopardy.

## CONCLUSIONS

The three case studies have shown the significance of technical, economic and socio-political factors involved in decision making and the role the various alternative aids to decision making could have played in the specific assessment of certain aspects of the cases. The possible contributions of the various methods to the analysis of the three cases considered are summarised in Table 31.

In general terms the system analysis methods were the only methods offering an additional capability not inherent in the Risk Ranking Technique. The particular advantage of system analysis being to identify all the actors involved. Computer simulation of the decision process was not used in the three cases considered. The success of such a method does depend on having a model which accurately represents the proposal and the nature and interactions of all the factors associated with the decision. Building an accurate model to simulate the whole

**TABLE 31 Summary of the Benefit of Alternative Decision Making Aids to the Three Cases Considered**

METHOD	POSSIBLE BENEFIT
Direct Presentation	No advantage
Direct Recommendation	No advantage
Review by experts	Useful if experts cover all disciplines involved
Public Debate	Would help determine public acceptability
System Analysis	Would help to identify actors that have to be considered
Statistical Analysis	Provided data is available helps in quantification of evidence
Computerised Simulation	Within the limits of the model used would allow exploration of uncertainties and options
Soft System Methodology	Would help to identify all actors concerned
Cognitive Mapping	Help identify criteria for judging acceptability
Game Theory	Would allow possible outcomes to be explored
Risk Analysis	Improves understanding of technical and economic risks involved
Probability Modelling	Would have a part to play in risk analysis, game theory and computerised simulation
Multivariate analysis	Could be a foundation for computerised simulation and an aid to Risk Ranking
Credit Worthiness	Assessing financial strength of an organisation
Robustness analysis	Would help to identify future changes and significance of variation in data used
Forecasting Technique	Would help identify possible future changes influencing factors to be considered
Resource Allocation	Assessment of alternative uses of resources
Regression Analysis	Help understand the significance of data available
Decision Trees	Assessment of the significance of the various components of a decision
Arbitration	Finding agreement between parties with conflicting views
Risk Ranking	Comprehensive assessment of all factors involved

decision making process including implementation of the decision is long and difficult task. Achieving adequate precision with such a model for a major decision involving a novel proposal is somewhat doubtful. The value of any model or aid to decision making depends on the quality of the data that can be used.

The Risk Ranking Technique can be adapted to adequately explore the acceptability of decision options under a variety of futures by building a system of three dimensional matrices of Rankings covering all the variations that have to be considered. Analysis of that type would fulfill the role of Robustness Analysis and Forecasting Techniques.

## CHAPTER 9

### Comparison of the Risk Ranking Technique with the methods used by Financial Institutions

Having examined the efficacy of various generic methods of assessing risk acceptability, in this Chapter a case study is presented comparing the efficacy of the Risk Ranking Technique with the methods used by the Swiss Bank. Although in the study as a whole interest ranges from the perorating decision making procedures associated with the development of advice for the Cabinet by Think Tank like organisations (115) to a bank deciding to finance a project in a developing country to the kind of decision making associated with the Polaris project which Professor Nailor described in ref. 116. The case studied is the assessment of the acceptability of a major project in a developing country for which the country concerned needs to borrow money on the international market. After the case study some discussion is given on the way the insurance industry assesses the insurability of the risks involved in a major project.

For the case study it is assumed that the project has reached the stage where all preliminary work has been completed and the proposer wants to start the project as soon as the funding required can be obtained. The project is to build a railway system connecting a potential inland industrial area and a good agricultural area with a port, in a country with the following characteristics:-

Population - 20 million,  
Climate - Mediterranean with Tropical Storms,  
Standard of Living - Subsistence,  
Education Level - Small educated ruling class, 20% of population illiterate. Only one university.  
Government - Single ruling family which now has a progressive outlook and rules with paternalistic care.

The government of the country is stable and concerned to improve the standard of living of the people and to do this by commercial exploitation of the country's natural resources. There is a somewhat unstable country to the north, but this is not considered an immediate threat.

An international development agency made an assessment of the economic potential of the country and recommended that the iron and bauxite ore in the east of the country should be mined and refined locally and metal using industries established around the refineries so that transport costs would be minimised. The possibility of becoming a supplier of finished and part-finished components for the German and Japanese car industries was being explored. The development agency also recommended that the fertile land south of the proposed industrial area should be developed as an area for intensive farming. The intention being that some of the land would be devoted to production of food for local consumption. The rest of the land would be devoted to intensive production of high quality fruit and vegetables for export. To get the industrial and agricultural products to market a railway was considered to be essential to link industrial and agricultural centres with the port, new town and airport.

The government of the country accepted the need for the railway and after having had a detailed design study made by a contractor it decided to try and raise, on the international market, the money required to build the railway. At this stage the decision makers in the market call for the acceptability of the risks involved in funding the project to be assessed by both the Risk Ranking Technique and a methodology based on the Swiss Bank's assessment procedure. This allows the adequacy of the two methods to be compared.

The form of the Risk Ranking Technique used was that described in Chapters 4, 5 and 6. The technical assessment criteria used were as described in Table 19. The economic factor risk ranking criteria were those described in Table 22 and socio-political ranking criteria were as specified in Table 25. The Swiss Bank's assessment was based on their method described in Chapter 2 and Appendix 2. The basic result of the assessment are taken to be those shown in Table 11.

Using the Risk Ranking assessment the proposal was assessed under three headings, which were technical, economic and socio-political. The technical assessment covered: the probability of failure during specified life time,

consequences of failure, capability of proposer and relevant experience of proposer. Assessing the first two questions required that criteria are specified for the acceptable failure probability and consequences. Assessing the capability and experience of the proposer are questions more directly related to cases where the proposer will have direct design and construction responsibility. In this case the government asking for the funding has subcontracted the design and will subcontract the construction. This means that the whole relationship of government and contractors has to be assessed to make certain that there are no gaps or restrictions in the contractual arrangements that could prevent, in some way, contractors fully satisfying technical requirements.

The economic assessment was based on an evaluation of the through life net benefit of the proposal. The project only being acceptable if the through life net benefit is positive. The calculation of the through life net benefit requires that all through life costs are taken into account and these must include loan repayment and interest charges. What is not included in the economic assessment as defined in Table 22 is an evaluation of the economic stability of the country involved. This topic is returned to later in discussion of uncertainty in estimates and the comparison with the Swiss Bank's methodology.

Assessing acceptability in socio-political terms is complex, as the issues covered under this heading tend to have significantly different meanings to different assessors. It is one of the major differences between the Risk Ranking Technique and the Swiss Bank's approach. In Risk Ranking acceptability in socio-political terms is measured by the proportion of the relevant population that are in favour of the project. In the case of the railway proposal the government wanted to undertake the project to improve the standard of living in the country. The government recognised that improving the standard of living would help it resist threats from outside. The government had consulted widely in the country to establish that there was agreement that construction of the railway would be of benefit to the country. The degree of uncertainty associated with the assessment can be presented either as a three dimensional diagram as shown in Figure 8 or in

tabular form as shown in Table 7.

In the Swiss Bank's approach the assessment concentrates on the twenty five parameters listed in Table 11. Most of the information being obtained from the bank's own contacts in the country concerned and so is independent of any gloss the proposer may put on the relevant figures. The assessment showed the country's economy is developing in a way that is likely to enable the government to repay the loan at the agreed rate and to pay interest as it becomes due. The assessment of political risk in the Swiss Bank's method is quite different to that used in the Risk Ranking approach. The Swiss Bank's concerns about political risk are ranked on a scale of 1-10, with regard to the impact of political risk on creditworthiness. A country scored 1 to 3 would have low or no foreseeable risk. A country scored 4 to 6 would have acceptable/moderate risks. A country scored 7 to 9 would have high risks and a score of 10 would mean the risks are unacceptably high. This is quite a different perspective on acceptable risk to that adopted in the Risk Ranking Technique where the socio-political concern is public acceptability.

It must be stressed that where the loan to a country is just for a specific purpose or project the Swiss Bank will in addition to assessing the country's economic creditworthiness have an assessment made of that purpose or project. The assessment may be made by their own staff or they may use external consultants for all or part of the assessment. The assessment will include feasibility and acceptability, but not public acceptability as overtly as in the Risk Ranking approach. The Swiss Bank's method does not give any indication of the degree of uncertainty associated with the assessment.

What conclusions can be drawn from this case study about the efficacy of the Risk Ranking Technique and the Swiss Bank's methodology? The two methodologies are compared in five ways, which are:- 1) intended roles, 2) coverage of technical, economic and socio-political factors, 3) the nature of the theoretical justification for the methods, 4) an analytical critique of the adequacy of the methods, 5) possible future developments. The essential features of the comparison are summarised in Table 32.

**TABLE 32 Summary of Comparison of the Risk Ranking Technique with the Methods used by the Swiss Bank**

FEATURE COMPARED	RISK RANKING TECHNIQUE	METHODS USED BY THE SWISS BANK
Intended Role	Is intended to give an overall assessment of the comprehensive acceptability of major projects. The methods of assessment being in a form that is transparent and justifiable to a lay public.	Essentially intended for internal use and in that role to act as the basis for advice to the Bank's executive on the acceptability of credit risks inherent in proposals.
Coverage of technical, economic and socio-political	Is designed to give a balanced overall view of technical, economic and socio-political factors involved in each option considered. (However, the Technique may be used in the mono-factor form to Rank acceptability of one factor.)	The assessment gives most emphasis to the economic aspects of options. In appropriate cases additional assessment of technical issues is made.
Nature of theoretical justification	Ranking requires an assessment of the significance of each factor. The way the assessments are weighted and combined appears to be sound. The main source of uncertainty is the quality of the data that has to be used. The higher the quality of the data, the more reliable the assessment.	In many ways the Bank's approach could be described as pragmatic. They have identified a number of parameters which by experience they have found gives them a sound indication of the acceptability of proposals.
Critique of the adequacy of the methods	The criteria used for scoring acceptability may not be appropriate for every type of decision and may need to be modified to suit particular applications.	The range of factors considered is more related to assessing credit worthiness of the proposer than the comprehensive acceptability of the proposal. Gives no indication of uncertainty involved
Possible future developments	Broad criteria for Ranking factors have been developed. The criteria may have to be adjusted to fit a wider spectrum of cases. A computer model could be established to allow options and uncertainty to be explored expeditiously.	The theoretical basis for their methods could be refined and assessment of technical and socio-political factors incorporated. Criteria for acceptability could be defined overtly.

The major difference in the role of the Risk Ranking Technique and the role of the techniques used by the Swiss Bank is that: the Risk Ranking Technique is intended to give the decision maker a comprehensive assessment of all the implications of each decision option, which can be defended in public, while the procedures used by the Bank are intended for confidential internal advice to the executive about the credit risks inherent in proposals they consider for loans.

The Risk Ranking Technique has been constructed in a way that covers comprehensively all the factors involved in decision making and is transparent to the public. The Swiss Bank's method gives the main emphasis to the economic aspects of the decisions considered. For assessment of the acceptability of the technical aspects of a proposal the Bank tends to rely on expert opinion without having clearly defined technical criteria a proposal must satisfy. The bank does not attempt to combine mathematically assessment of the factors considered into a single overall rating term, but just develops an overall qualitative view of acceptability.

Attention also has to be drawn to the fact that the Ranking Technique could be used in the mono-factor Ranking form in which the significance of only one factor is assessed. If Ranking based only on one factor is compared with the Swiss Bank technique the only difference between the two methods is just the criteria used to rate acceptability. While it is possible to conceive that the criteria for mono-factor Risk Ranking and the Swiss Bank's methods could be harmonised by adopting the same criteria, such a view would represent a misunderstanding of the roles of the two methods. Risk Ranking is intended for the overall view of acceptability and the Bank's methods are intended for assessing creditworthiness.

Of the twenty five factors the Swiss Bank Corporation assess, twenty four are concerned with economic performance of the country and only one is concerned with political risk. This does not mean that political risk is only considered to have one twenty fifth of the importance of all the other parameters considered. But it does suggest that they believe that for their purpose a range of

economic parameters have to be considered in order to arrive at a justifiable opinion about the acceptability of the relevant economic conditions.

The differences in the theoretical justification between the Risk Ranking Technique and the Swiss Bank's methods are considerable. These differences mainly stem from the differences in the philosophy on which the two approaches are based. The Swiss Bank's approach is essentially pragmatic with the results of the assessment presented in natural language. The Risk Ranking Technique attempts to relate an ordinal index of acceptability to the result of a rigorous quantitative assessment of all the issues involved. The methods of weighting and combining factors in the Risk Ranking Technique are clearly defined and defensible and the whole process is transparent. With the Ranking Technique the proposer has a clear view of the conditions he has to try and satisfy. In the procedures used by the Bank the targets that a proposer has to satisfy are not clearly stated, they could be described as arriving at a decision based on experience.

The starting point for analysis of the adequacy of the two methods is the difference in the aims of the two methods. The methods the Swiss Bank use are essentially aimed at checking that no risks are accepted that could damage the company's profitability. Although the Risk Ranking Technique is aimed at the wider horizon of comprehensive acceptability of the long term benefit to society. While the Risk Ranking Technique could be adjusted to simply assess the risks financial institutions consider the reverse is not true. With any method of assessment the factors assessed and the way their significance is weighted and combined has to match the decision. The weighting and combining of factors is perhaps the most controversial feature of any aid to decision making. Can this be done on any more than an empirical basis? The methods mentioned in Chapter 2, such as the 'Z' test for potential bankruptcy, and the methods banks use to assess applications for loans, the weighting and methods of combining factors are pragmatic and are only acceptable if the predictions they give agree fairly closely with experience. Even if the predictions the methods give fit a particular set of circumstances very well there is no reason for assuming

they will predict outcomes accurately in other sets of circumstances. It is also possible other empirical equations could be devised using quite different parameters would be equally efficacious.

Comparing the methods the Swiss bank uses with the Comprehensive Risk Ranking Technique does give rise to two intriguing questions, which are: 1. In arriving at their decisions do banks take a too short term view? 2. Is the profit margin expected from financing projects of any kind too high? These questions have many implications. Major projects may take five to ten years to complete, a business may take five to ten years to become properly established and it can be three or more years before the pattern of insurance losses is known. If profit is judged on an annual basis it represents what could be described as the retail trading syndrome, which works against accepting proposals that when judged on a through life basis would make a more useful contribution to society. The conclusion that these comments suggest is that when finance of major projects are considered the whole basis for the proposals must be understood and their long term implications assessed in detail. The assessment must include the socio-political implications of the project as it is essential to ensure that the organisations involved do not become associated with a project that is unacceptable to the public at large.

With all methodologies there is some scope for development, as already mentioned, in Chapter 2, the Swiss Bank Corporation iteratively refine their procedures. Similarly the Comprehensive Risk Ranking Technique has been under development since 1973/74. A large part of the development has been as a result of applying the Technique to specific cases. Tailoring the ranking criteria to specific cases could be considered as limiting the Technique's potential for universal application. On the other hand tailoring criteria could, with some justification be considered as merely a way of exploiting the Ranking Technique's potential. Criteria suitable for universal application may turn out to be so general that the element of critical analysis in the Technique would be so diluted that it no longer represents a useful aid to decision making.

The possible future developments of the Bank's assessment methodologies are that: the theoretical basis of the procedure could be refined and the way the factors are weighted and combined made less arbitrary. Also the procedure could be refined in a way that gives a proposer a clear understanding of what is likely to be acceptable.

Having compared the Risk Ranking Technique with the Swiss Bank's methodology for determining acceptability of project risks attention is now given to the methods the insurance industry use to assess the insurability of risks. The aim being to determine if their methods offer any advantage over Risk Ranking and the Swiss Bank's methods.

The way insurance industry deals with aviation risks illustrates how they deal with the risks of complex projects. Aviation insurers offer Products Liability insurance. This is insurance cover for compensation for death or personal injury together with damage or destruction of property suffered by any person through the manufacture, supply or use of aeroplanes. Product liability situations exist if: (117)

- 1) There is the possibility of an accident/incident/occurrence causing death or personal injury together with damage or destruction of property resulting from a product.
- 2) The handling or use of a product in which there exists any defect, fault or condition that can cause harm.

There are five principle causes that can expose a manufacturer to Product Liability they are:-

- 1) Failure by a manufacturer to exercise reasonable care in the design of a product.
- 2) Failure to exercise reasonable care in the selection of materials used in the product.
- 3) Failure to exercise reasonable care in the construction of a product.
- 4) Failure to exercise reasonable care in the testing of a product before it is put into use.

5) Failure to issue warnings and manuals in clear and understandable language as to the safe and proper operation of the product.

The view has been expressed that the Aviation Insurance market is fragile. Doubt has been expressed that the market could withstand a single major catastrophe or a series of minor catastrophes in any one year. In 1986 the maximum limit of liability cover available was 1 billion US dollars and the annual premium income was 150 million US dollars. (117) The insurers attempt to assess trends in losses and to ensure that appropriate funds are available. Four examples illustrate the historical pattern of losses and their magnitude. In 1974 a DC10 was lost. Result: 346 passenger fatalities and Liability settlement of 54,000,000 US dollars. In 1977 two Boeing 747 aircraft collided on Tenerife runway. Result: 550 passenger fatalities and liability settlement 81,500,000 US dollars. In 1979 DC10 crashed. Result: 258 passenger fatalities and liability settlement 104,000,000 US dollars. The last 123 days of 1983 provide the most direct example of how the accident pattern influence premiums. In those 123 days there were 15 total losses and 5 major partial losses valued in total at over 400,000,000 US dollars. The Aviation Insurance market reacted swiftly and dramatically increased premiums. For decisions about premiums aircraft insurers do besides statistical evidence about loss patterns know the quantitative reliability requirements regulators demand aircraft should satisfy. (The regulatory requirements are shown in Figure 5).

In the general sense the criteria for insurability have been defined by Berliner, of the Swiss Reinsurance Company, as consisting of nine parts. (118) The nine parts are:-

- 1) Randomness of loss events.
- 2) Maximum possible loss.
- 3) Average loss per occurrence.
- 4) Average period of time between loss occurrences.
- 5) Insurance premium.
- 6) Moral policy.
- 7) Legal restrictions.
- 8) Public policy.
- 9) Cover limits.

The ways in which insurance criteria limit insurability are summarised in Table 33. The limits are stated in qualitative terms. The limits could be described as defining a set of insurable activities that includes: direct losses due to natural catastrophes, fires, theft, equipment failure and indirect losses such as loss of production and loss of business. The following examples illustrate the nature of indirect losses and their insurability. (119) Loss of profit due to business interruption resulting from strikes is a loss that it would be difficult to obtain cover for. One reason for such cover being difficult is that it would be a form of insurance that could be abused, as the existence of such a policy could be used as a weapon for an employer to use in bargaining with his labour force. In contrast a loss of profits cover could be and often is included in a fire policy. Nationalisation is another type of risk that would be difficult to insure against as the premium would be impossible to calculate and there may be legal restrictions against such insurance. Insurance against kidnapping is also difficult to obtain as it may be abused. Other risks that fall into the uninsurable category are: cover against civil commotion, speculative and entrepreneurial risks.

This outline of the limits the insurance industry uses to define the acceptability of risks shows that although they do not assess technical, economic and socio-political factors in the same terms as the Risk Ranking Technique, they do indirectly make some allowance for them. Technical factors are to some extent covered by the randomness of the loss event, the average period of time between loss occurrences and by the maximum loss and average loss per occurrence criteria. Economic factors are covered by: insurance premium, cover limits and average loss per occurrence criteria. Socio-political factors are partly covered by moral policy, legal restrictions and public policy criteria. Even though the insurance industry takes some account of technical, economic and socio-political factors they do not attempt to rank the results of their assessment in the way the Ranking Technique does. However, the amount of cover they are willing to provide and the premium they charge to a certain extent represent the conclusion they draw from their assessment. Premiums do not correlate exactly with risk, the relationship is

**TABLE 33 Limits of Insurability defined by the Criteria for Insurability**

CRITERIA	LIMITS IMPLIED
Randomness of loss events	It would be difficult to insure an event for which the loss pattern is completely unknown. The larger the insurer's portfolio of loss events the more likely he is to be able to accept a random event risk.
Average loss per occurrence Average time between loss occurrences	These two criteria are linked with the same limit. The insurer will attempt to balance the sum of his losses that is: average loss per occurrence x number of occurrences per year expected in his portfolio, with his premium income. (The Aviation insurance examples given above illustrate this point).
Insurance Premium	The premium is equal to the expected annual loss plus expenses loaded to take account of any uncertainties associated with the proposal.
Moral Policy	This represents the allowance that has to be made for non quantifiable actions that may be taken to reduce or amplify risks.
Legal Restrictions	Limits set by insurance contract law. Limits set by insurance industry's supervisory authorities. Some risks are covered by governments, for example insurance of nuclear reactors.
Public Policy	The extent to which crime, terrorism and social unrest may change the adequacy of an insurance.
Cover Limits	These limits the insurer specifies in the policy to ensure that both parties understand exactly what is covered and that the insurer is not exposed to some ill defined unlimited risk.

subject to modification by market forces.

In this study the discussion has concentrated on the assessment of the acceptability of risks that financial institutions knowingly accept. To complete the picture of risk acceptability some attention must be given to the risks that are part of the insurance company's organisation. These risks can be considered under five major headings, which are:-

1. Risks accepted being larger than funds available.
2. Fraud by staff and clients.
3. Audit Risk.
4. Natural Disasters.
5. Terrorism.

The way risks accepted may be larger than funds available has already been hinted at in relation to aviation insurance. In the banking sphere the provisions a bank has to make for foreign countries defaulting on loan repayments and businesses going bankrupt has recently caused many banks embarrassment to the extent that they have had to call on reserves and sometimes had to reduce dividends to share holders. Sound organisations will try to ensure that their whole portfolio of risks is kept within the financial capability of the organisation. Thornhill has described a check list that could be used for reviewing the adequacy of the arrangements in an organisation for keeping risk portfolio in line with financial capability. (120) The exact form of the check list has to be tailored to the particular organisation it is applied to.

Fraud, which is really theft, can be a very serious financial risk. Often the person perpetrating fraud is an employee of the organisation involved. But fraud is also perpetrated by people outside an organisation; for example false claims about business activity might be made in order to establish creditworthiness for a loan or unjustified claims for compensation for loss might be made. Table 34, which is derived from a study made by Chicken, shows that 35% of the insurance claims related to computer systems were due to theft and this includes fraud. (121)

**Table 34 Causes of Claims for Computer System Losses**

Flood	10.5%
Fire	10.5%
Lightning	5.25%
Theft	35%
Sabotage	18.4%
Strikes	3.5%
Miscellaneous	16.85%

(Derived from data in Table 6 in Ref. 121)

Audit risks includes: fraud of the type already mentioned but also includes failures to diagnose correctly the impact of claims resulting from risks accepted. Such a weakness can mean that the management of an organisation is unaware of the magnitude of their true risk exposure.

Natural disasters are an inescapable fact of life. Floods, fires, lightning and earthquakes are always likely to occur but the risk can generally be reduced by careful siting and careful design. Not all flood and fire risks can be considered natural, broken water pipes can be a cause of flooding which may destroy vital records. Similarly fires may be due to a variety of causes. A fire may put a company out of business. To a certain extent the consequences of damage can be mitigated if an organisation has an effective disaster recovery plan.

Acts of terrorism including kidnapping can have quite dramatic consequences which may not be covered by insurance. It is possible that a company may lose a very effective chief executive who would be very difficult to replace. The frequency and severity of acts of terrorism tends to be increasing. (122)

The comparison of banking and insurance risk assessment procedures with the Risk Ranking Technique suggests several

general conclusions about the assessment of the acceptability risk. The conclusions are:-

- 1) The Risk Ranking, banking and insurance methods represent three different approaches to assessing the acceptability of risks. Although the methodologies are different each strives in its own way to provide criteria for judging acceptability that are effective in the applications they are used for.
- 2) The Risk Ranking Technique is the only one that attempts to be truly comprehensive and bring together the assessment of technical, economic and socio-political aspects of a decision into an overall ordinal rating of the overall acceptability.
- 3) The Risk Ranking Technique is unique in being intended to be transparent to the proposer and give the proposer a clear indication of the requirements that have to be satisfied.
- 4) The theoretical basis for the way the Ranking Technique builds up a comprehensive ranking of acceptability is defensible. The way the banks and the insurance industry build up their view of acceptability is rather more pragmatic. In all cases the quality of any assessment depends on the quality of the data that have to be used. No assessment technique can pretend to give a sound assessment if it has to be based on uncertain data. One advantage of the Risk Ranking Technique is that it provides a logical structure for the analysis of the significance of uncertainties.
- 5) The criteria used for judging acceptability can be tailored to suit the requirements of particular families of decisions. But this does not mean the criteria are perfect and infallible. The difference between the economic criteria proposed for the Ranking Technique and the multiplicity of economic parameters banks consider illustrates something of the variation in the range of parameters it may be necessary to consider in some decision making situations.
- 6) In the process of determining the criteria that should be used to judge acceptability several very deep moral questions have to be answered about what is considered acceptable.
- 7) There is still considerable scope for development of the banking, insurance and Risk Ranking methodologies.

## CHAPTER 10

### The Optimum Method of Assessing Decision Options

In this chapter an attempt is made to answer the most difficult question of this study. The question is: what is the optimum method for assessing decision options? In order to build up an answer to that question six subsidiary questions have to be answered they are:-

1. What will be the environment in which the decision has to be made?
2. What type of decision has the methodology to be able to deal with?
3. From what range of methodologies will the optimum method be selected?
4. What experience has there been with the methods?
5. What data will be available about the proposal the methodology would be used on?
6. How will the efficacy of the methodologies considered be tested?

From the answers to these six questions an attempt is made to draw conclusions about what is likely to be the optimum method and to illustrate it's efficacy by applying it to a hypothetical project.

#### The Decision Environment

The decisions to be considered are major projects of national or even international importance. The decision about the acceptability of the project will be taken either at ministerial or board level and will be subject to extensive public scrutiny. The people taking the decision will be advised by a competent team with the necessary skills and resources to make the necessary detailed assessments about acceptability. The decision process will

consist of five decision steps as shown diagrammatically in Figure 8. The decision steps are:- conceptual design, detail design, placing construction contract, construction and operation. At each stage there is the option to abandon the project if it is considered uneconomic or for some other reason unacceptable.

### **The Type of Decision**

The essential features of the decisions are that: they involve major projects, which by their very nature stretch the resources and capability of all involved. The projects are larger than would fit neatly into the everyday loan decisions of a bank's loans officer. Everyday loans being defined as those the loan officer would decide on his own assessment of a client's proposal. The assessment possibly including analysis of the client's: balance sheet, profit and loss account, retained earnings account and source and application of funds statement. The assessment procedure may include test ratios of some of the figures to determine the commercial viability of the proposal and proposer. (122) But such an assessment would not involve evaluation, to any significant extent, of the associated technical and socio-political factors.

### **Range of Methodologies from which the Optimum Method will be selected**

The methodologies considered will be: The Risk Ranking Technique, those used by financial institutions as described in Chapter 2 and discussed in Chapter 9 and the alternative methods discussed in Chapter 7 and 8.

### **Experience with Methodologies**

As mentioned in Chapter 1 the Risk Ranking Technique has been under development since 1973/74. Subsequent development was funded both by the United Kingdom Atomic Energy Authority and by the Commission of the European Communities. The various stages of the development of the technique have been reported in references 2 to 11. During

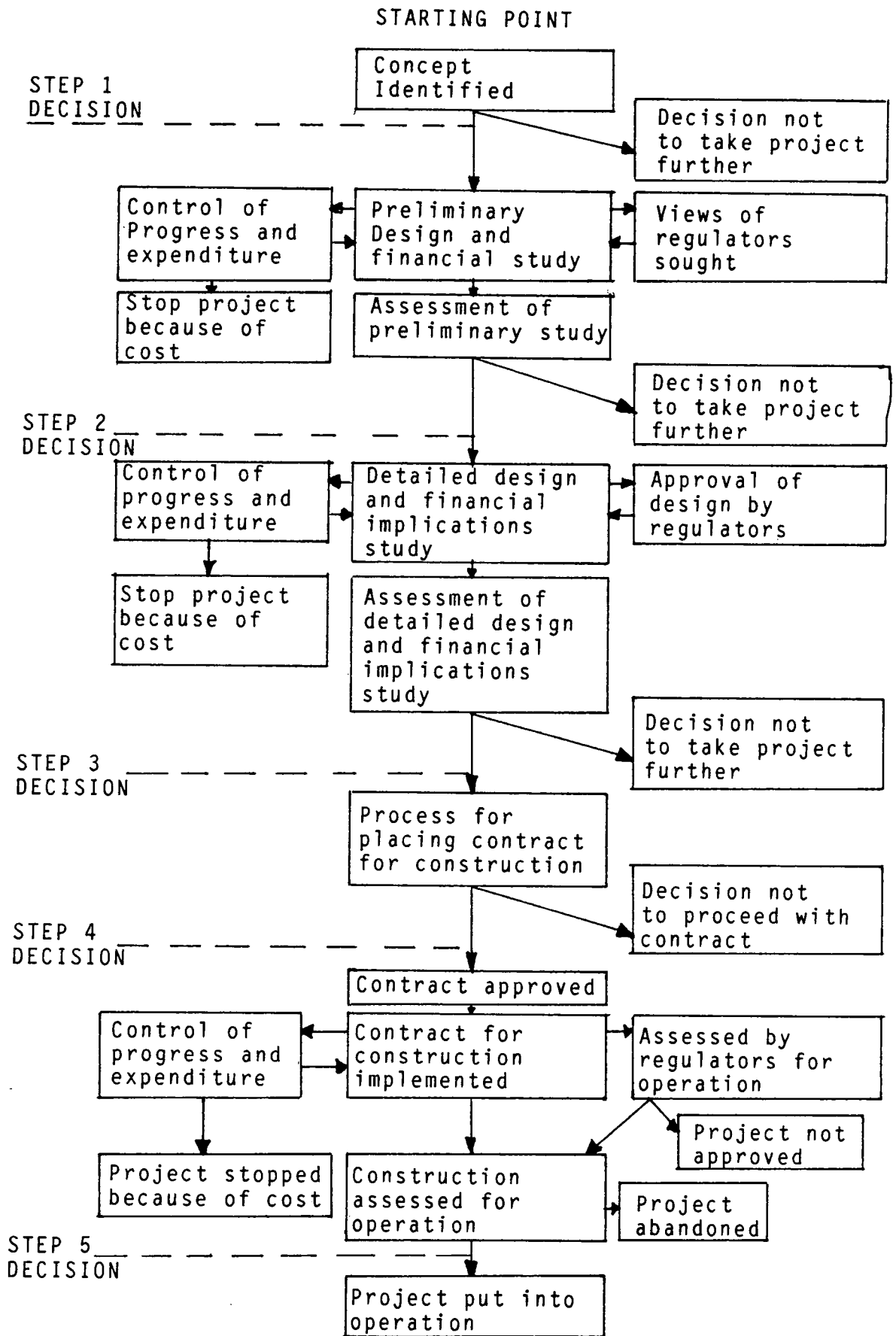


Fig. 8 Decision Making Process Model

the development the technique was applied by Chicken to the assessment of the following decisions: Canvey Island, Moss Morran, Rijnmond, Channel Tunnel and Energy Options. These assessments are described in reference 12.

The methods the financial institutions use have been in use for a number of years and like the Risk Ranking Technique have been subject to iterative development.

### **Details available about proposal to be assessed**

It is assumed that the first decision to be assessed will be the one taken at the conceptual stage and will be based on an outline specification of the proposal. The form an outline specification may take for a hypothetical project to build a 1000 seat aeroplane is shown in Table 35.

### **Determining the efficacy of the methodologies considered**

The main test will be how comprehensive an assessment of the proposal the methodology gives.

The conclusions will identify what are considered to be the appropriate decision option assessment techniques for each stage of the project.

Now using the hypothetical case of a proposal for a 1000 seat airliner the efficacy of the assessment methodologies can be illustrated.

The project is in the realms of possibility and is endowed with several potentially controversial aspects. It is assumed the project has arrived at the conceptual stage so the decision maker will be faced with the problem of deciding whether or not it should be brought to fruition and if it is, how should it be brought to fruition.

There is some governmental involvement so it is not difficult to envisage the type of political considerations that must be taken into account.

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**NAME OF PROJECT:** The 1000 seat aircraft project

**NATURE OF THE PROJECT:** (Specification)

The project is to design, test and manufacture a 1000 seat aircraft that will have a range of 12,000 miles and a life in excess of 100,000 flying hours. A speed of Mach 0.95 (sub-sonic), a service ceiling of 14,000 metres. A cargo variant to be capable of carrying 150 tons of cargo. Capable of landing and taking off from existing airport runways.

**ORGANISATION OF PROJECT:**

The project to be undertaken by a single company set up specially for the purpose with half the 50 million pounds capital provided by the government and half by a single major aircraft manufacturer. The government would underwrite commercial bank loans up to 500 million pounds. In the long term development costs are to be recovered and an adequate return made on the investment. Whatever technical resources the company needs that are not available from the company's own resources are to be bought in at ordinary commercial rates.

**TIMESCALE:**

One year for a preliminary design study.  
Three years for detailed design study and all research and development work required.  
Two years to build a prototype.  
One year for test flying and certification of aircraft.

If after eight years there were not enough orders to make a viable commercial proposition the project would be wound up.

**PROBLEMS ANTICIPATED:**

1. Airlines are unwilling to buy a 1000 seat aeroplane.
  2. Airport owners are unwilling to adapt their airports to handle 1000 seat aircraft.
  3. Countries are unwilling to adapt their transport facilities to the needs of airports handling 1000 seat aircraft.
  4. The insurance market unwilling to insure an aeroplane with 1000 passengers.
  5. 100,000 hour life cannot be achieved.
-

At the beginning of the project the decision has to be made mainly on the basis of qualitative evidence. The decision maker will need to be convinced about the technical, economic and socio-political acceptability of the proposal. He should, at least in an ideal world, be provided with data about the technical, economic and socio-political acceptability of the proposal. This evidence may show different degrees of acceptability for each factor. A simplified matrix of a possible range of degrees of acceptability the evidence may show it given in Table 36.

If the Risk Ranking Technique is used it is possible a ranking of acceptability could be built up as shown in Figure 9. This is a gross simplification of the ranking process, many aspects of the proposal would have to be subject to very detailed evaluation in order to establish the ranking that is justified. As the project proceeds its acceptability will be kept under review. Before a commitment is made to start construction it is likely a major review of the acceptability of the project will be made. During the design period there will have been a considerable improvement in the data available about the project. This will enable the justification for the decision to be put on a sounder base. The type of the improvement in the justification that is likely to take place is indicated in the assessment postulated in Fig. 10.

Now considering why the Risk Ranking Technique should be considered as the optimum method of assessing decision options.

In Chapter 7 and 8 twenty alternative methodologies to Risk Ranking were considered, apart from multivariate methods and computer simulation none of the methods justified the title of a complete alternative. Both multivariate methods and computer simulation have limitations when applied to novel projects for which there is no data. In Chapter 9 the Risk Ranking Technique was compared with the methodologies financial institutions use to assess the acceptability of the risks they may be exposed to. The methods financial institutions use tend to be pragmatic and focussed on assessing the financial risks involved in a proposal.

**Table 36 Matrix of the possible degrees of acceptability shown by the evidence about the proposed 1000 seat aircraft**

<b>Degree of Acceptability</b>	<b>Technical Aspects</b>	<b>Economic Aspects</b>	<b>Socio-political Aspects</b>
Acceptable	Original specification met	Economic return requirements satisfied	No public or political opposition to the project
Acceptable with minor changes	Additional work required to satisfy specification	It will take longer than expected to earn an acceptable return	Some public opposition to the project
Acceptable with major changes	Extensive additional work required to satisfy specification	Additional funding required which may make project uneconomical	Serious public opposition to the project. It may not be possible to reduce opposition
Unacceptable	No way to satisfy specification or acceptable variation of it	Economic targets unlikely to be satisfied	Extensive opposition to the project that cannot be placated

Before reaching a definitive conclusion about what can be identified as the optimum assessment methodology consideration must be given to the fact that in the life of a major project decision making goes through many phases, each with its own characteristics and problems. In Figure 8 five main steps to decision making are identified. The main characteristics of these steps are summarised in Table 37, and in Table 38 the decision assessment methodologies appropriate to each phase of the project are summarised.

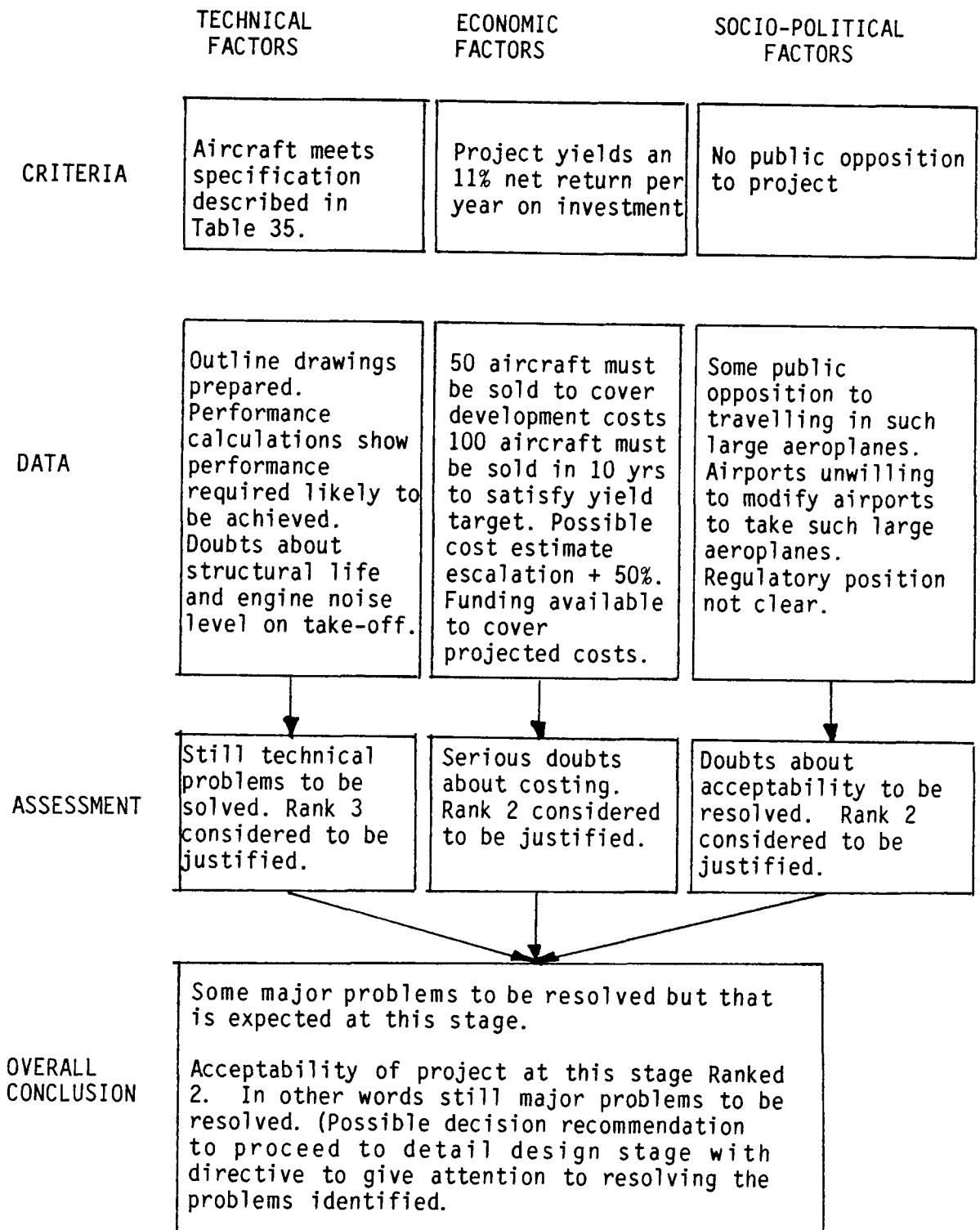


Fig. 9 Assessment of the 1000 Seat Aircraft Project at the end of the Preliminary Design Stage.

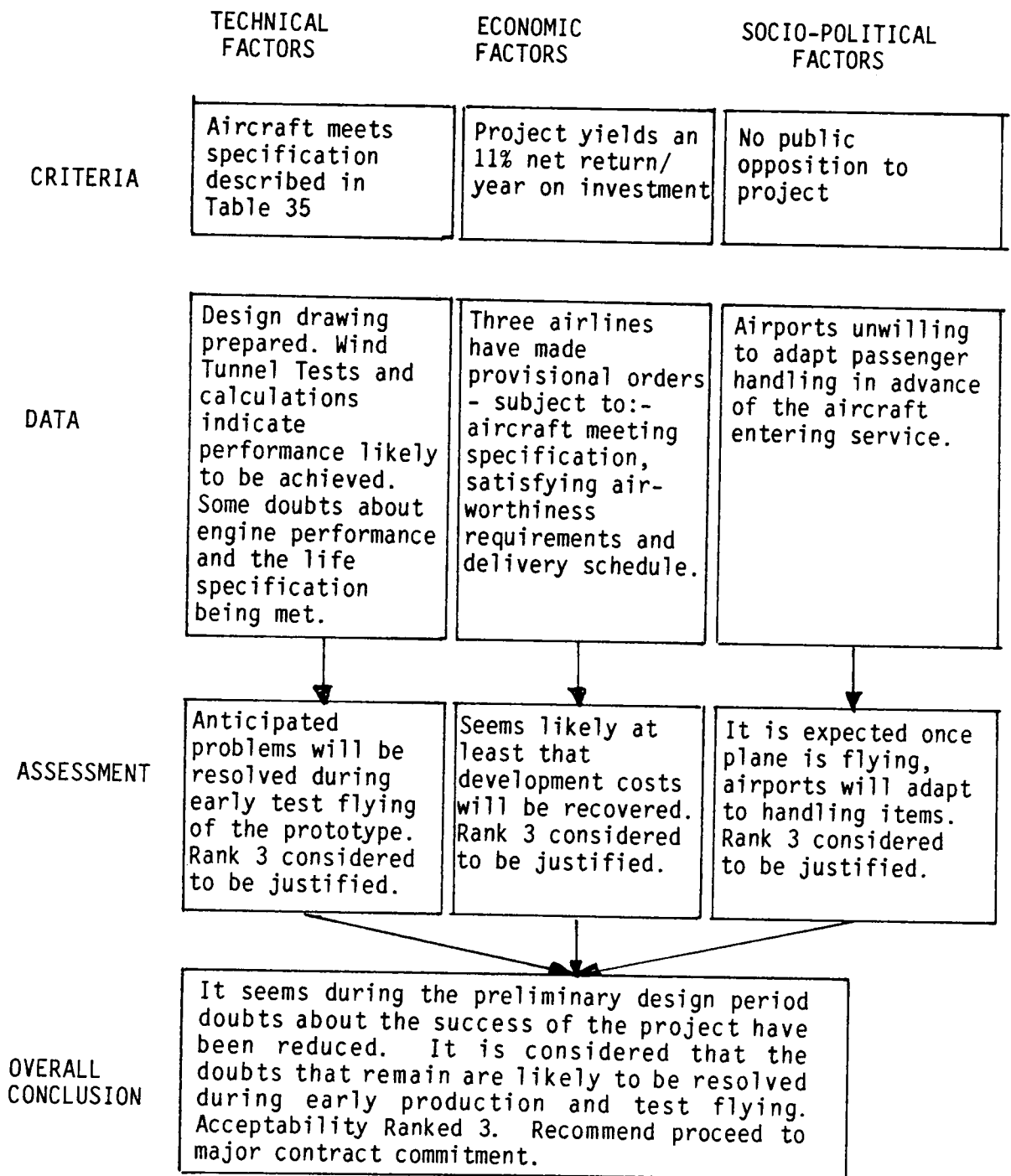


Fig. 10 Assessment of the 1000 Seat Aircraft Project prior to Major Contract Commitment

**Table 37 Characteristics of Major Project Decision Phases**

PHASE	CHARACTERISTICS
1. Preliminary Exploration of concept	<p>No data about the project. Project discussed more in terms of an idea. Preliminary design - calculations experiments - surveys suggest project worthwhile.</p> <p>Decision making on a subjective basis.</p>
2. Detailed design of project	<p>Data starts to emerge. Quantification of essential parameters develops but with quite a large measure of uncertainty.</p> <p>Decision making becomes more objective as it can be based on quantified data.</p>
3. Decision to prepare for construction of the project	<p>Economic implications become clearer. Costs can be defined with greater precision. It can be determined whether or not the project is acceptable to regulatory bodies and in socio-political terms.</p> <p>Decision making can be based on better data.</p>
4. Construction of the project	<p>The project becomes a major financial commitment.</p> <p>Decision making concerned with determining whether or not the project meets all goals set for it.</p>
5. Putting the project into service	<p>Proof becomes available about whether or not the project is acceptable in technical, economic and socio-political terms.</p> <p>Objective Decision making possible on the basis of good quality quantitative data.</p>

**Table 38 Summary of decision assessment methodology appropriate to decision making at each stage of a project**

PHASE	APPROPRIATE DECISION ASSESSMENT METHODOLOGY
1. Preliminary Exploration if concept	<p>At this stage there will be a shortage of data on which to build up a quantified assessment. Decision will be based more on a combination of expert opinion and direct recommendation. Decision making can be structured using the Risk Ranking Technique.</p>
2. Detailed design of project	<p>Quantified data will start to become available and it will be possible to start building up a comprehensive assessment of acceptability using the Risk Ranking Technique. If computer simulation of the proposal is used it will be possible to explore options and uncertainties associated with the decision.</p>
3. Decision to prepare for construction of the project	<p>At this stage there will be a major commitment of funds so a fairly accurate comprehensive assessment of acceptability can be made using the Risk Ranking Technique as there will be sufficient data available to make all the necessary supporting assessments.</p>
4. Construction of the project	<p>At this stage the magnitude of variation in real costs become known and acceptability can be assessed with considerable precision.</p>
5. Putting the project into service	<p>With the construction of the project complete a decision can be made about putting the project into operation. This decision should be based on a comprehensive assessment of all the factors involved. For such an assessment the Risk Ranking Technique is an appropriate tool.</p>

The conclusions that appear to be justified about the phases in decision making are:- 1) During the life of a project the data available changes from virtually no data at the conceptual stage to fairly comprehensive data at the end of the project. 2) At the conceptual stage decisions have to be based mainly on opinion. 3) Then as the project proceeds and more data becomes available the assessment of acceptability can be refined and made more accurate. Assuming the aim is to have a comprehensive assessment of acceptability of decision options it is suggested that the optimum method throughout a project's life is the Risk Ranking Technique. The Technique provides a consistent structure to overall assessment of acceptability, it is recognised that it will have to be supported by other techniques; for example at the conceptual stage expert opinions will be important and at the design stage the techniques for detailed assessment of the various factors are important. Whatever technique is used the assessment will have to be iteratively refined as the project proceeds and better data becomes available.

## CHAPTER 11

### Conclusions

Generally no decision is free from risk and it is the decision maker's task to determine which decision will combine the lowest risk and the highest benefit. In addition the decision maker has to ensure that the regulatory constraints on risk are not contravened. These constraints apply equally, but in different ways, to the financial and technological aspects of proposals. Banks are constrained by regulation to the amount of financial risk they can accept in relation to their assets. Insurance companies have to balance the risks they accept with their potential premium income. Proposers of technological projects besides having to live within the limits of their financial resources generally have to satisfy some regulatory authority's about the acceptability of the technical risks involved. All decisions are also constrained by the subtle and sometimes intangible constraints of socio-political factors.

In order to determine which decision option will give the most acceptable result many aspects of the issues involved have to be assessed. At the top level of decision making, which is the main subject of this study, the decision maker will be concerned to have a comprehensive assessment of all the technical, economic and socio-political factors involved. As has been shown the Risk Ranking Technique is one way of helping the decision maker to arrive at a decision by providing him with a structured comprehensive assessment of all the factors involved. The Technique also provides the decision maker with a consistent way of comparing the significance of the specialised assessment of one factor with the assessments of other factors. For example is a favourable technical assessment likely to be negated by problems in financing the project.

In the Chapters 8 - 10 the efficacy of the Technique was compared with other aids to decision making including the methods used by financial institutions like banks. The comparison with other decision making aids showed that the comprehensive nature of the assessment required for Risk

Ranking make it of more universal assistance in decision making than most other methods considered and it helps to put the findings of other methods of assessment in perspective.

The comparison of the Risk Ranking Technique with the methods used by financial institutions was not just a comparison of similar aids to decision making but rather of different approaches to the problem. For understandable reasons banks concentrate on the economic aspects of the risks they are asked to accept. For example the Swiss Bank Corporation in assessing the acceptability of making a loan to a country considers 24 economic criteria whereas the Risk Ranking Technique determines the Ranking of the acceptability of the economic aspects of a risk on the basis of the assessment of a single economic parameter. But evaluation of the single parameter requires a considerable amount of supplementary assessment. Also, the Ranking Technique gives technical, economic and socio-political factors equal weight. If required the Ranking Technique could be modified to incorporate assessment of more economic parameters and to give economic factors more weight. One factor in the Country Risk Assessment procedure the Swiss Bank Corporation use is assessment of political and social stability on a ten point ranking scale no special weight is attached to this factor, but doubtless it influences the advice the proximate decision maker gives the decision maker. Attention is drawn to the fact that Lloyd's Bank rank the results of their assessment of the significance of the parameters they consider in determining acceptability. In other words Lloyd's Bank attempt to put their findings in ordinal form while the Swiss Bank Corporation, apart from socio-political factors, use qualitative terms like improving or deteriorating to describe the conclusions from their assessment. Assessment of technical issues tend to be treated separately by the banks and if it cannot be done "in house" the advice of outside specialists is sought. In building up their view of the acceptability of a proposal banks assess in a qualitative way the relevant experience and capability of the proposer. This is a feature of decision making that has also been incorporated into the Risk Ranking Technique. The conclusions that seem to be justified from the comparison of the procedures adopted by financial

institutions with Risk Ranking are:-

- 1) The Risk Ranking Technique gives a more comprehensive assessment than the procedures used by financial institutions.
- 2) The financial institutions give more weight to assessment of economic/financial issues than is given by the Risk Ranking Technique in its general form. But the Risk Ranking Technique can be tailored to suit specific applications.
- 3) Both the procedures used by the National Westminster Bank and the Risk Ranking Technique make allowance for the experience and capability of the proposer.
- 4) In some of the banks' procedures they overtly accept parts of the data to be used being judgemental and other parts being statistical. This difference is not so clearly expressed in the Risk Ranking Technique but has to be taken into account when designing the Rank scoring criteria to be specified for a particular application.
- 5) None of the methods take directly into account the capability of the institution itself to accept the financial risks involved. It is tacitly assumed that banks will keep within the required risk asset ratio and that insurance companies have adequate financial resources to cover all claims from risks they have accepted.
- 6) Attention is drawn to the importance of the information on which decisions are based being transparent. If the information obscures the truth any decision based on it is likely to be of doubtful value.

In Chapter 3 an attempt was made to build a theoretical justification for the Ranking Technique. From this examination of the theoretical basis of Ranking the following conclusions are considered to be justified.

- 1) The design of the Ranking Scale appears to give an adequate distribution of the possible views on

acceptability.

- 2) The method of weighting and combining the technical, economic and socio-political factors seems acceptable and can if necessary be varied to match special decision making situations.
- 3) The criteria used for scoring the significance of the economic, technical and socio-political factors may be adjusted to suit particular special families of decisions.
- 4) The conclusions from Ranking are not absolute. There is by the very nature of the subject a degree of uncertainty associated with each stage of the process.
- 5) In some cases, particularly when relevant quantitative data are available, conventional statistical methods including multivariate analysis, fuzzy data analysis and computer simulation can be applied to give a better understanding of the significance of the associated uncertainties.
- 6) A matrix form of presentation of the Ranking of options can be used to give the decision maker a clear picture of the acceptability of the options and of the significance of uncertainty in the data that has to be used. Implications of possible future scenarios can be explored by building Ranking matrices for possible future scenarios.
- 7) The methods of Fuzzy Data Analysis can be used to assess the likely significance of factors described in qualitative terms. Such methods require the data to be collected in a way that ensures a consistent pattern of words is used to describe the level of significance of each factor that has to be considered, and the findings can be refined as better data becomes available.

From the critical assessment made of the way the Ranking Technique should assess technical, economic and socio-political factors the following general conclusions were reached about the assessment of the technical, economic and socio-political aspects of the risks inherent in any

project.

- 1) The technical aspects of risk that should be included in any comprehensive assessment of the acceptability of risk should be based on an assessment of:-
  - i) The probability of failure to satisfy specification for a project sometime during specified lifetime.
  - ii) The consequences of failure.
  - iii) Capability of proposer.
  - iv) Relevant experience of proposer.

Including the capability and experience of the proposer in the Ranking of the technical aspects of a proposal overcomes the criticism of earlier simpler versions of the Risk Ranking Technique.

- 2) The assessment of the economic aspects of risk is somewhat complicated by the wide range of parameters that could be used. Financial institutions may consider many economic or financial performance parameters when assessing the acceptability of a proposal. For major engineering projects economic acceptability may be evaluated on the basis of a simple financial performance parameter. It was concluded that for general purposes the difference between through life costs and benefits would be an appropriate criterion for Ranking economic factors of many major projects. At the same time it was appreciated that at the assessment stage of a predominately financial proposal or a project that involves risks beyond the financial resources of the proposer, a wider range of economic/financial indicators may have to be assessed to Rank the acceptability of the proposal.
- 3) The assessment of the problems associated with Ranking socio-political factors drew attention to the difficulty of quantifying the views about a proposal of all those who may be affected by it. Regardless of the problems involved in determining such views no

assessment can be considered comprehensive unless it incorporates an assessment of the views of the relevant public. It is proposed that the Ranking of the acceptability of socio-political factors associated with a proposal should be based on an assessment of the support for the proposal from the population that may be affected by it. It is recognized that in some circumstances arbitration procedures may be an appropriate way of achieving acceptability in socio-political terms. A prerequisite of such a procedure is that the arbitrators and the people they represent have an adequate understanding of the significance of the proposal.

From the examination of possible alternatives to the Risk Ranking Technique there are a number of quite important conclusions about alternative methods. These conclusions include:-

- 1) The natural language alternatives such as: direct presentation of evidence, direct recommendation, review by experts and public debate do not give results that are inherently more reliable than the Risk Ranking. The problem with such methods is they may be very biased by the views of the people involved.
- 2) System Analysis does not really justify the title of a comprehensive alternative. The main merit of System Analysis is that it structures the identification of the factors and interaction that should be considered. The method may suggest factors, particularly socio-political factors, that should be included in any analysis of decision option and the weighting that should be given to them.
- 3) Statistical and computer techniques can both help to understand the significance of the data available and allow insights to be developed into the way major parameters of the decision may vary. Some computer techniques can allow the consequences of various decisions to be explored by simulation techniques. The value of such explorations is of course limited by the quality of the data used and the adequacy of the computer model.

- 4) Of the supplementary alternatives considered soft system methodology and cognitive mapping mainly have a role in identifying factors and interactions that have to be considered.
- 5) Game Theory, risk analysis and probability modelling are essentially concerned with trying to quantify the possible outcomes of the various options considered. They can also be used to explore the implications of various possible futures. The exploration of possible futures with the Risk Ranking Technique has not been attempted so far, but an indication has been given in 6 above how the Ranking Technique could be used to explore future conditions.
- 6) Multivariate analysis could simply be considered as a sub-set of statistical analysis. In the theoretical sense it is attractive as it involves building up a system of equations that fully describe the decision making process. Without relevant data to allow the constants and interactions in the various situations to be determined the method would really only amount to a theoretical novelty. However, such analysis would be a vital component of any model for computer simulation of decision outcomes.
- 7) Credit worthiness assessments only give an indication of a proposers ability to repay a loan, they give no indication of the value of the project for which the loan is required.
- 8) Of the complementary alternatives Robustness Analysis and Forecasting Techniques can be grouped together as their special contribution is rating the acceptability of options under various possible future environments. These techniques have much in common with Game Theory, Risk Analysis and Probability modelling already mentioned. Interest in the techniques is not that they endow the analysis of possible future conditions with special accuracy but more that they draw attention to the need for the decision maker to consider the future may be different from expectation.

- 9) Regression analysis like multivariate analysis, assumes future experience will have a form that can be related mathematically to past experience. To even start on such analysis relevant data is required. Perhaps the most that can be said for Regression Analysis is that if data is available it may suggest possible futures. But the method is not relevant to the assessment of novel projects for which there are no data.
- 10) Decision Trees help to build up a picture of the relationship between subsidiary decisions. The efficacy of the method depends on the data available.
- 11) Arbitration is a rather different kind of technique and is more related to the natural language techniques mentioned as possible comprehensive alternatives. The special merit of the technique is that with appropriate arbitrators it could provide a way of assessing the significance of socio-political factors.

The post hoc testing of the alternatives to the Risk Ranking Technique on three major decisions and the case study comparing the Risk Ranking Technique with the Swiss Bank procedures appears to reinforce the conclusion that none of the alternative techniques considered is quite as comprehensive in concept as the Risk Ranking Technique. Although some of the techniques may be used as alternatives they are not so rigorous and would not give such consistent results as the Risk Ranking Technique. The conclusions about Risk Ranking that appear to be justified are:-

- 1) Although the Risk Ranking approach and the methods used by banks and the insurance industry are different they all strive to identify criteria for judging acceptability that are efficacious in the application of interest.
- 2) The Risk Ranking Technique attempts to be comprehensive and bring together the assessment of the technical, economic and socio-political aspects of a decision into a single number rating of the overall acceptability.
- 3) The Risk Ranking Technique is transparent to all concerned including the public, it gives everyone a

clear indication of the criteria adopted for assessing acceptability and the degree of acceptability justified by particular evidence.

- 4) The theoretical basis for the way the Ranking Technique builds up a comprehensive Ranking of acceptability is defensible. The way the banks and the insurance industry build up their view of acceptability is more pragmatic. In all cases the quality of any assessment depends on the quality of the data that has to be used. No assessment technique can pretend to give a sound assessment if it has to be based on uncertain data. In such conditions all that can be said for the Risk Ranking Technique is that it provides a logical structure for the analysis and can present the significance of uncertainties in the form of a series of matrices.
- 5) In all the forms of analysis considered the criteria used for judging acceptability can be tailored to suit the requirements of particular families of decisions. But this does not mean the criteria are perfect and infallible. The difference between the economic criteria proposed for the Ranking Technique and the multiplicity of economic parameters banks consider illustrates something of the variation in the range of parameters it may be necessary to take into account in some decision making situations.
- 6) There is considerable scope for development of methods of assessing the relative merit of decision options. Such development should include: developing universally applicable criteria for judging acceptability, combined testing of the various approaches and building a computer model of the assessment process that would allow variations in data and possible futures to be explored expeditiously.
- 7) Although the study concentrated on the way organisations make decisions about the acceptability of the risks that are external to them and they have an option as to whether or not they accept them, the Risk Ranking methodology is equally effective as a tool for assessing the acceptability of the risks that are

internal to an organisation. These internal risks include: commitments being accepted that are greater than the funds available to cover them, theft, fraud, and audit risks.

The overall conclusions that this comparison of aids to decision making justifies are that: sound decision making requires that the technical, economic and socio-political issues involved are thoroughly investigated, the Risk Ranking Technique is an effective tool for making a comprehensive assessment of the technical, economic and socio-political factors that have to be considered in determining the acceptability of major projects. The other aids to decision making considered are either designed for very special purposes such as banking or insurance decisions, or are subsidiary but useful aids to the overall decision making process. There is no reason why the Risk Ranking Technique cannot be adapted to assessing a wide range of families of specialist decisions, provided appropriate criteria are specified for Ranking each factor. The Technique would give as consistent and reliable assessments as the data that have to be used allows.

The final comment that must be made is that: no aid to decision making can ensure that the best decisions are effectively implemented. If the organisations involved do not maintain the necessary capability throughout the life of a project there are likely to be doubts about its satisfactory completion. Projects may fail if economic changes prevent financial institutions from providing finance, or a contractor goes bankrupt, or a government department is not organised in the way required to allow it to implement a decision.

## REFERENCES

- 1 CHICKEN J C Hazard Control Policy in Britain, published Pergamon Press, Oxford 1975
- 2 ASHBY E Reconciling Man with the Environment, published Oxford University Press, London 1978, p99
- 3 CHICKEN J C The Nature of the Problem, presented at the Review Seminar on Risk Management and Acceptability arranged by Scientific and Technical Studies, London 1982
- 4 CHICKEN J C Factors Influencing Nuclear Reactor Safety Policy, presented at the IPSA Annual Meeting in Rio de Janeiro, August 1982
- 5 CHICKEN J C The Dilemma of the Risk Decision Maker, presented at the Xth Regional Congress of the International Radiation Protection Association entitled Comparison of Risks Resulting from Major Human Activities, Avignon, October 1982
- 6 CHICKEN J C and HAYNS M R A Multi-Factor Criterion for Risk Acceptability, presented at the Annual Meeting of the Society for Risk Analysis, Knoxville, USA October 1984
- 7 CHICKEN J C Process Industries, presented at the Safety and Reliability in Europe meeting held in ISPRA, Italy, October 1984
- 8 CHICKEN J C and HAYNS M R Development of a Risk Ranking Technique, presented to the Annual Meeting of the Society for Risk Analysis, Washington, October 1985
- 9 CHICKEN J C Comprehensive Assessment, a paper presented at the first International Conference on Risk Assessment of Chemicals and Nuclear Materials held at the Robens Institute, Surrey University, September 1986
- 10 CHICKEN J C Risk Assessment for Hazardous Installations, published Pergamon Press, Oxford 1986.

- 11 CHICKEN J C EUR 113736 A report entitled Final report on a study of coherence in acceptability criteria for the technical aspects of risks associated with potentially hazardous installations, published by the Commission of the European Community 1988
- 12 CHICKEN J C and HAYNS M R The Risk Ranking Technique in Decision Making, Pergamon Press, Oxford 1989
- 13 CHECKLAND P Systems Thinking, Systems Practice, John Wiley & Sons. Reprinted 1988, p 101
- 14 LINDLEY D V Making Decisions, published John Wiley & Sons, Chichester, Second Edition, 1985, pp 25-27 and p194.
- 15 HOGARTH R M Judgement and Choice, published John Wiley & Sons, Chichester, Second Edition, 1988, p2
- 16 LAYFIELD Sir F Report on the Sizewell 'B' Public Inquiry, published by Her Majesty's Stationery Office, London 1987.
- 17 Channel Fixed Link Environmental Appraisal of Alternative Proposal, Her Majesty's Stationery Office, London, December 1985.
- 18 HALL P Great Planning Disasters, Penguin Books, 1980, p 7.
- 19 HANSARD, House of Commons Official Report Vol 88 No 24 9 December 1985, Col. 707, Her Majesty's Stationery Office, London.
- 20 FELTHAM C Banks Urge Eurotunnel to Seek Extra Funding From Investors. The Times 2 October 1989 p 25.
- 21 HANSARD, House of Commons Report Vol 88 No 24, Op.Cit. Cols 655-688.
- 22 EUR 11465 EN Seminar on applications, Perspectives and Limitations of Comparative Risk Assessment and Risk Management, Nice, September 1988, published by the

- Commission of the European Communities, Luxembourg  
1989, pp322-329
- 23 CHANNON D F Global Banking Strategy, John Wiley & Sons, New York 1988, pp 155-198.
  - 24 SCHWIETERT A Country Risk Assessment: Swiss Bank Corporation's Approach, Economic and Financial prospects No 1 1988 February/March, published by the Swiss Bank Corporation.
  - 25 Council Directive of 17 April 1989 on the own funds of credit institutions. (89/299/EEC), published in the Official Journal of the European Communities. 5:5:89.
  - 26 Council Directive of 18 December 1989 on the solvency ratio for credit institutions (89/647/EEC), published in the Official Journal of the European Communities. 30:12:89.
  - 27 BSD/1990/2 Notice to Institutions Authorised under the Banking Act 1987, Implementation in the United Kingdom of the Directive on own funds of Credit Institutions, Issued by the Bank of England, Banking Supervision Division, London, December 1990.
  - 28 BSD/1990/3 Notice to Institutions Authorised under the Banking Act 1987. Implementation in the United Kingdom of the Solvency Ratio Directive. Issued by the Bank of England, Banking Supervision Division, London, December 1990.
  - 29 DUN & BRADSTREET Speciman Payment Analysis Report, published Dun and Bradstreet Ltd, High Wycombe
  - 30 THORNHILL W T Risk Management for Financial Institutions, published Bankers Publishing Company, Rolling Meadows, Illinois USA, 1990, p107.
  - 31 JUNGE G Country Risk Assessment: Swiss Bank Corporation's Approach, Economic and Financial prospects No 1 1988 February/March, published by the Swiss Bank Corporation.

- 32 Swiss Stock Guide '91 published by the Swiss Bank Corporation ISBN 3-906084-10-8.
- 33 THORNHILL W T Op Cit p74.
- 34 JOHNSON C External Debt Assessment a paper presented to the International Economics Study Group Conference on the 1985 World Development Report, London, November 1985.
- 35 An Introduction to Limited Recourse Finance published by the National Westminster Bank PLC, London.
- 36 Project Finance - Risk Management, The NatWest Approach, published in Trade Finance and Corporate Finance June 1987, published by Euromoney Publications PLC, London.
- 37 SCHMUCKER K J Fuzzy Sets, Natural Language Computations, and Risk Analysis, published by Computer Science Press, Rockville, 1984, p 21.
- 38 MERKHOFER M W Decision Science and Social Risk Management, published D Riedel Publishing Company, Boston, 1987, pp 142-186,
- 39 ASHBY E Reconciling Man with the Environment, Op Cit pp 69-72.
- 40 VAN HORNE J C Financial Management and Policy published Prentice Hall, Englewood Cliffs, New Jersey, 8th edition 1989, pp 190-225.
- 41 MERKHOFER M W Decision Science and Social Risk Management, Op Cit, p 187.
- 42 CHICKEN J C Hazard Control Policy in Britain, published Pergamon Press, Oxford, 1975, pp 78-104.
- 43 CHICKEN J C Nuclear Power Hazard Control Policy, published Pergamon Press, Oxford, 1982, pp 148-204.
- 44 STALLEN P J and COPPOCK R About Risk Communication and

- Risky Communication, Risk Analysis Vol 7 No 4 1987 published by Plenum Press, New York, pp 413-414.
- 45 HILTON G Intermediate Politometrics, published Columbia University Press, New York 1976, pp 219-220.
  - 46 ROSENHEAD J (Editor) Rational Analysis for a Problematic World, published John Wiley & sons, Chichester, 1989, p 18.
  - 47 Joint Airworthiness Requirements, JAR-AWO all weather Operations, published by the Civil Aviation Authority, Cheltenham, July 1985.
  - 48 CHICKEN J C and HAYNS M R The Risk Ranking Technique in Decision Making, published Pergamon Press, Oxford, 1989, pp 89-93.
  - 49 BUCKLEY J J Stochastic Cominance: An approach to Decision Making Under Risk, Risk Analysis Vol 6 No 1 1986, published by Plenum Publishing Corporation, New York.
  - 50 SCHMUCKER K J Fuzzy Set, Natural Language Computations and Risk Analysis, Op cit p 6.
  - 51 SCHMUCKER K J Fuzzy Set, Natural Language Computations and Risk Analysis, Op Cit pp 43-77.
  - 52 ABDUL-FATTAH A-R F, ABULFARAJ W H, Siting of Nuclear Power Plants in Saudi Arabia using Fuzzy Decision Analysis, published in Nuclear Technology Vol 58, September 1982, pp 404-413.
  - 53 HILTON G Intermediate Polimetrics, Columbia University Press, New York, 1982.
  - 54 FRENCH S Editorial Journal of Multi-Criteria Decision Analysis Vol 1, 1-2 (1992) published John Wiley and Sons Ltd, Chichester.
  - 55 ROSENHEAD J Introduction: old and new paradigms of analysis in Rational Analysis for a Problematic World

- ed Rosenhead J, published John Wiley & Sons, Chichester, 1989, pp 1-20.
- 56 CHECKLAND P Systems Thinking Systems Practice published John Wiley and Sons Chichester, reprinted 1988 pp 18-20 and 160-242.
- 57 CHECKLAND P Soft System Methodology in Rational Analysis for a Problematic World, ed Rosenhead J, published John Wiley & Sons, Chichester, 1989, pp 71-100.
- 58 EDEN C Using Cognitive Mapping for Strategic Options Development and Analysis, in Rational Analysis for a Problematic World, published John Wiley & Sons, Chichester, 1989, pp 21-42.
- 59 SELVIDGE J E Corporate Management of Liability Risk, published in New Risk Issues and Management, edited by Louis A. Cox and Paolo F. Ricci, published by Plenum Press, New York, 1990, p12.
- 60 RICH B R The Skunk Works' Management Style - it's no secret, published in Aerospace Vol 16 No 3, March 1989, published by the Royal Aeronautical Society, London.
- 61 TAIT J The Role of Values in Quantitative Decision Making, The Journal of the Operational Research Society Vol 39 No 7 July 1988, pp 669-674, published by the Operational Research Society, Birmingham.
- 62 JAR-25 Joint Airworthiness Requirements. Large Aeroplanes, published by the Civil Aviation Authority, Cheltenham, revised up to 17:3:86.
- 63 SAULL J. W. Objectives of Maintenance - Airworthiness, Aerospace July/August 1987, published by The Royal Aeronautical Society, London, pp41-47.
- 64 The tolerability of risk from nuclear power stations, published for the Health and Safety Executive by Her Majesty's Stationery Office, London, 1988.

- 65 MARREY B Birth of a Landmark, Swissair Gazette, June 1988 p 36.
- 66 PEARCE D W Risk Assessment: Use and Misuse published in The Assessment and Perception of Risk, The Royal Society of London, 1981, p 191.
- 67 BERLINER B Limits of Insurability of Risks, Prentice Hall, Englewood Cliffs, 1982.
- 68 Debt Warning by Bank over property loans, The Times, 14 October 1989, p 17.
- 69 THOMPSON P and PERRY J editors, Engineering Construction Risks, published Thomas Telford, London 1992, p4.
- 70 IRVIN G Modern Cost Benefit Methods, published by the Macmillan Press Ltd, London, 1978, pp 105-117.
- 71 SHRADER-FRECHETTE K S Science Policy, Ethics and Economic Methodology, published D Reidel Publishing Company, Dordrecht, 1985, p 193.
- 72 SHRADER-FRECHETTE K S Science Policy, Ethics and Economic Methodology, Op Cit, p 16.
- 73 MAY W W \$'s for lives: Ethical Considerations in the use of Cost/Benefit Analysis for profit terms: published in Risk Analysis, Vol 2, No 1, March 1982, pp 35-46.
- 74 HICKS A J The Role of Insurance Safety, a paper presented to the OYEZ 1982 Review Seminar on Risk Management and Acceptability, April 1982, London.
- 75 Accident Costing, published by the Risk Management Unit of Reed Stenhouse UK Ltd.
- 76 Chunnel phoney war risks total breakdown, The New Civil Engineer, published by the Institution of Civil Engineers, London, 2 November 1989, p 7.

- 77 LAYFIELD Sir F Report on the Sizewell 'B' Public Inquiry, Summary of Conclusions and Recommendations, published by HMSO, London, 1987, C2, pp 28-29.
- 78 MERKHOFFER M W Decision Science and Social Risk Management, published D Reidel Publishing Company, Dordrecht, 1987, p 65.
- 79 MERKHOFFER M W Decision Science and Social Risk Management, Op Cit, p 180.
- 80 MERKHOFFER M W Decision Science and Social Risk Management, Op Cit, p 202
- 81 LINDBLOM C E The Policy Making Process, published Prentice-Hall Inc, Englewood Cliffs, New Jersey, USA, 1968 pp 44-45.
- 82 LINDBLOM C E The Policy Making Process, Op Cit pp 81-82.
- 83 LINDBLOM C E The Policy-Making Process, Op Cit p 68.
- 84 CHICKEN J C and HAYNS M R The Risk Ranking Technique in Decision Making, published by Pergamon Press, Oxford 1989 pp 41-54.
- 85 BROWN J, LEE T and FIELDING J. Concerns Worry and Anxiety about Hazard with Special Reference to Nuclear Power - a Secondary Analysis of Data Collected by Social Community Planning Research for the Health & Safety Executive, a report issued by the Psychology Department of the University of Surrey.
- 86 THOMAS K, MAURR D, FISHBEIN M, OTWAY H J, HINKLE R A, SIMPSON D, Comparative Study of Public Beliefs about Five Energy Systems. Paper RR-80-15, April 1980 published by the International Institute for Applied Systems Analysis, Laxenburg, Austria.
- 87 Nuclear Power Public Opinion, published by the Nuclear Energy Agency, OECD Paris, 1984 pp 66-72.
- 88 STALLEN P J M and TOMAS A - Public Concern about

- Industrial Hazards, a paper presented at the annual meeting of the Society for Risk Analysis, Washington, USA, October 1985.
- 89 KUNREUTHER H C et al. Risk Analysis and Decision Processes. The Siting of Liquefied Energy Gas Facilities in Four Countries, published by Springer-Verlag, New York, 1983 pp 64 - 97.
  - 90 Public Opinion in the European Community on Energy in 1984, XVII/282/85-EN, a report published by the Commission of the European Communities Directorate-General for Energy.
  - 91 MUMPOWER J An analysis of the de minimis Strategy for Risk Management, Risk Analysis, an official publication of the Society for Risk Analysis, Vol 6, No 4, December 1986, published by Plenum Publishing, New York, pp437-446.
  - 92 CHECKLAND P Systems Thinking, Systems Practice, John Wiley & Sons Ltd, Chichester, First published 1981, reprinted 1988, pp 93-122.
  - 93 IVERSEN G R Bayesian Statistical Inference, Sage University Paper, Sage Publications, Beverley Hills, 1984.
  - 94 CHECKLAND P Soft Systems Methodology, published in Rational Analysis for a Problematic World, edited by Johnathan Rosenhead, published John Wiley & Sons Ltd, Chichester, 1989, pp 71-100.
  - 95 EDEN C Using Cognitive Mapping for Strategic Options Development and Analysis (SODA), published in Rational Analysis for a Problematic World, Op Cit pp 21-42.
  - 96 HOWARD N The Manager as politician and general: the metagoime approach to analysing cooperation and conflict, published in Rational Analysis for a Problematic World, Op Cit pp 239-262.
  - 97 BENNETT P, CROPPER S and HUXHAM C Modelling

- interactive decisions to hypergame focus, published in Rational Analysis for a Problematic World, Op Cit pp 283-314.
- 98 LINDLEY D V Making Decisions, published John Wiley & Sons Ltd, London, Second Edition 1985, p 68.
- 99 WALPOLE R E, MYERS R H Probability for Engineers and Scientists, published Macmillan, New York, Third Edition 1989, pp 274-283.
- 100 PHILLIPS L D Decision Analysis in the 1990's, published in Tutorial Papers in Operational Research, 1989, edited by SHAHANI A and STANTON R, published by the Operational Research Society, Birmingham.
- 101 HILTON G Intermediate Politometrics, published Columbian University Press, New York, 1976, pp 160-280.
- 102 MUNFORD A G and BAILEY Statistical Methods in Operational Research, published in Tutorial Papers in Operational Research, 1988, Op Cit.
- 103 HARVEY JONES J Making it happen, Fontana, London, 1988, p 282.
- 104 ROSENHEAD J Robustness Analysis: keeping your options open, published in Rational Analysis for a Problematic World, Op Cit pp 193-218.
- 105 HILTON G Intermediate Politometrics, Op Cit pp 196-197.
- 106 LINDLEY D V Making Decisions Op.Cit pp139-159
- 107 I. V W JAHRESBERICHT 1991/92, published by the Institut fur Versicherungswirtschaft, St. Gallen, Switzerland p12
- 108 CANVEY: an investigation of potential hazards from operations in the Canvey Island/Thurrock area. A report by the Health and Safety Executive, published by Her Majesty's Stationery Office, London, 1978.
- 109 CANVEY: a second report, a review of potential hazards

- from operations in the Canvey Island/Thurrock area three years after publication of the Canvey Report, published by Her Majesty's Stationery Office, London, 1981, pp14 -15.
- 110 KUNREUTHER H.C. LINNEROTH J. et.al. Risk Analysis and Decision Processes, published by Springer Verlag, Berlin, 1983, pp 105-108.
- 111 The Race to Cross the Channel, The Illustrated London News, Vol 273, Number 7048, November 1985, pp 29-34.
- 112 Cmnd 8561, Fixed Channel Link Report UK/French Study Group. Her Majesty's Stationery Office, London, June 1982.
- 113 Ridley ignores calls for Channel Inquiry, New Civil Engineer, a publication of the Institution of Civil Engineers, 7th November 1985, p.9.
- 114 Channel Fixed Link Environmental Appraisal of Alternative Proposal, Her Majesty's Stationery Office, London, December 1985.
- 115 BLACKSTONE T and PLOWDEN W Inside the Think Tank, published William Heinemann, London, 1988.
- 116 NAILOR P The Nassau Connection, published HMSO, London 1988.
- 117 MEYRICK-JONES J The Insurance Viewpoint Aerospace, Vol.13, No.6, July/August 1986, published by the Royal Aeronautical Society, London pp13-18.
- 118 BERLINER B Limits of Insurability of Risks, published Prentice-Hall Inc, Englewood Cliffs, New Jersey, 1982, pp 3-4.
- 119 BERLINER B Limits of Insurability of Risks, Op Cit pp 112-117.
- 120 THORNHILL W T Risk Management for Financial Institutions, published Bankers Publishing Company, Rolling Meadows, Illinois, 1990, pp 283-285.

- 121 CHICKEN J C A European View on Computer System Insurance, a paper presented at the NCC Information Technology Conference, Blackpool, 1989.
- 122 Terrorism Interdisciplinary Perspectives, edited by Alexander Y and Finger S M, published by The John Jay Press, New York and McGraw-Hill Book Company (UK) Ltd, 1977
- 123 THORNHILL W T Risk Management for Financial Institutions, Op Cit. pp 102-107.

## BIBLIOGRAPHY

### BOOKS

Accident Costing, published by the Risk Management Unit of Reed Stenhouse UK Ltd.

Allen RGD Statistics for Economists, Hutchinson University Library, London, reprinted 1968.

An Introduction to Limited Recourse Finance published by the National Westminster Bank PLC, London.

Ashby E Reconciling Man with the Environment, Oxford University Press, London, 1978 pp69-72.

Berliner B Limits of Insurability of Risks, Prentice-Hall Inc, Englewood Cliffs, NJ 1982.

Blackstone T and Plowden W Inside the Think Tank, published William Heinemann, London 1988.

Braybrooke D and Lindblom C E, a Strategy of Decision, The Free Press, New York, 1963.

Brown R V, Kahr S S and Peterson C, Decision Analysis for the Manager, Holt, Rinehart and Winston, New York, 1974.

Channon D F Global Banking Strategy, John Wiley & Sons, New York 1988, pp155-198.

Checkland P System Thinking, System Practice, John Wiley & Sons, Chichester, 1988 Reprint.

Chicken J C Hazard Control Policy in Britain published Pergamon Press, Oxford, 1975, pp78-104.

Chicken J C Nuclear Power Hazard Control Policy published Pergamon Press, Oxford, 1982, pp148-204

Chicken J C Risk Assessment for Hazardous Installations, published Pergamon Press, Oxford 1986.

Chicken J C and Hayns M R The Risk Ranking Technique in

- Decision Making, Pergamon Press, Oxford 1989.
- Cox L A and Ricci P F Editors, New Risk Issues and Management, Plenum Press, New York, 1990.
- Donne M Leader of the Skies, Rolls Royce, the first seventy five years, published Frederick Muller Ltd. London 1981.
- Fisher R A The Design of Experiments, Oliver and Boyd Edinburgh, reprinted 1953.
- Hall P Great Planning Disasters, Penguin Books, 1980.
- Harvey Jones J Making it happen, Fontana, London, 1988.
- Hilton G Intermediate Politometrics, published Columbia University Press, New York, 1976.
- Hogarth R Judgement and Choice, Second Edition, published John Wiley & Sons, Chichester, 1988
- Horne J C V Financial Management and Policy, Eighth edition, Prentice Hall, Englewood Cliffs, NJ 1989.
- Ilersic A R Statistics, HFL (Publishers) Ltd, London thirteenth edition 1964.
- Irvin G Modern Cost-Benefit Methods, The Macmillan Press Ltd, London, Reprinted 1984.
- Iversen G R Bayesian Statistical Inference, Sage University Paper, Sage Publications, Beverley Hills, 1984.
- Koutsoyiannis A Non-Price Decisions the Firm in a Modern context, The Macmillan Press Ltd, London 1982.
- Kunreuther H C and Lineroth J et.al. Risk Analysis and Decision Processes, published by Springer Verlag, Berlin, 1983.
- Lindblom C E The Policy Making Process, published Prentice-Hall Inc, Englewood Cliffs, New Jersey, USA, 1968.
- Lindley D V Making Decisions, published John Wiley & Sons, London, Second Edition 1985.

Lowe C W Industrial Statistics Vol 1, First Edition, published by Business Books Ltd, London 1969.

Merkhofer M W Decision Science and Social Risk Management, published D Riedel Publishing Company, Boston, 1987.

Miles M B and Huberman A M Qualitative Data Analysis, Sage Publications, Beverley Hills, third printing 1985.

Nailor P The Nassau Connection, published HMSO, London 1988.

Nuclear Power Public Opinion, published by the Nuclear Energy Agency, OECD, Paris, 1984.

Pearce D W The Assessment and Perception of Risk, published by The Royal Society of London, 1981.

Peston M and Coddington A Statistical Decision Theory Civil Service College Occasional papers 7 published HMSO fourth impression 1978.

Philpott B The English Electrical/BAC Lightning, published by Patrick Stephens Ltd., Wellingborough 1984.

Rosenhead J Editor, Rational Analysis for a Problematic World, published John Wiley & sons, Chichester, 1989.

Schmucker K J Fuzzy Sets, Natural Language Computations, and Risk Analysis, published by Computer Science Press, Rockville 1984.

Shahani A, Stainton R (Editors) Tutorial Papers in Operational Research, 1989, published by the Operational Research Society, Birmingham 1989.

Shrader-Frechette K S Science Policy, Ethics and Economic Methodology, published by D Reidel Publishing Company, Dordrecht 1985.

Stevens, Handbook of Experimental Psychology, Vol 1, Second Edition, published John Wiley and Sons, New York, 1988.

Swiss Stock Guide '91, ISBN 3-906084-10-8, published by the Swiss Bank Corporation.

Thornhill W. T. Risk Management for Financial Institutions, published Bankers Publishing Company, Rolling Meadows, Illinois.

Thompson P and Perry J Editors Engineering Construction Risks, published Thomas Telford, London 1992.

Van Horne J C Financial Management and Policy published Prentice Hall, Englewood Cliffs, New Jersey 8th edition 1989.

Walpole R E, Myers R H Probability and Statistics for Engineers and Scientists, published Macmillan, New York, Third Edition 1989.

Wilson R and Crouch E A C Risk Benefit Analysis Ballinger Publishing Co, Cambridge, Massachusetts, 1982.

#### OFFICIAL REPORTS

BSO/1990/2. Notice to Institutions Authorised under the Banking Act 1987, Implementation in the United Kingdom of the Directive on own funds of Credit Institutions, issued by the Bank of England, Banking Supervision Division, London, December 1990.

BSO/1990/3 Notice to Institutions Authorised Under the Banking Act 1987. Implementation in the United Kingdom of the Solvency Ratio Directive. Issued by the Bank of England, Banking Supervision Division, London, December 1990.

Canvey: an investigation of potential hazards from operations in the Canvey Island/Thurrock area. A report by the Health and Safety Executive, published by Her Majesty's Stationery Office, London, 1978.

Canvey: a second report, a review of potential hazards from operations in the Canvey Island/Thurrock area three years after publication of the Canvey Report, published by Her Majesty's Stationery Office, London, 1981.

Catastrophe's in Computer Centres published Tela Insurance Company, Munich, Germany, 1985.

Channel Fixed Link Environmental Appraisal of Alternative Proposal, HMSO, London, December 1985.

Cmd 8561, Fixed Channel Link Report UK/French Study Group, Her Majesty's Stationery Office, London, June 1982.

Council Directive of 17 April 1989 on the own funds of credit institutions (89/299/EEC) published in the Official Journal of the European Communities, 5.5.89.

Computer Insurance published Swiss Reinsurance Company, Zurich, Switzerland, 1987.

Council Directive of 18 December 1989 on the solvency ratio for credit institutions (89/647/EEC) published in the Official Journal of the European Communities, 30.12.89.

Dun and Bradstreet, Speciman Payment Analysis Report, published Dun and Bradstreet Ltd., High Wycombe

Guidelines on use of Consultants by World Bank Borrowers and by the World Bank Executing Agency, published by the World Bank, Washington, 1981.

Hansard, House of Commons Official Report Vol 88 No 24 9 December 1985, Col 707, HMSO, London.

Improving Management in Government: the next steps - report to the Prime Minister HMSO, London 1988.

I .VW Jaresbericht 1991/92 published by the Institut fur Versicherungswirtschaft, St. Gallen, Switzerland, p12

JAR-25 Joint Airworthiness Requirements Large Aeroplanes, published by the Civil Aviation Authority, Cheltenham, revised up to 17:3:86.

Joint Airworthiness Requirements, JAR-AW0 all weather Operations, published by the Civil Aviation Authority, Cheltenham, July 1985.

Layfield Sir F Report on the Sizewell 'B' Public Inquiry,

Summary of conclusions and recommendations, published by HMSO, London 1987.

Preyssl C. Cullingford M.C. Swaton E. Evaluation of compliance of risk-sources when uncertainty and risk-perception aspects are included. Presentation Material, publisher International Atomic Energy, Vienna 1985.

Preyssl C. "Fuzzy Risk" Analysis Theory and Application, published International Atomic Energy Agency, Vienna, 1986.

Public Opinion in the European Community on Energy in 1984, XVII/282/85-EN, a report published by the Commission of the European Communities Directorate-General for Energy.

The Tolerability of Risk from Nuclear Power Stations, published for the Health and Safety Executive by Her Majesty's Stationery Office, London 1988.

#### JOURNALS

Abdul-Fattah A-R F, Abulfaraj W H, Siting of Nuclear Power Plants in Saudi Arabia using Fuzzy Decision Analysis published in Nuclear Technology Vol 58, September 1982, pp404-413.

Brüser A Economic Aspects of Road Transport Projects. The Courier No. 125, January-February 1991, published by the EEC, Brussels.

Buckley J J Stockastic Cominance: An approach to Decision Making Under Risk, Risk Analysis Vol 6 No 1 1986, published by Plenum Publishing Corporation, New York.

Budge I Representations of Political Argument: Applications within Meta-Planning. Political Studies Vol.XXVI Number 4, December 1978.

Chunnel phoney war risks total breakdown, The New Civil Engineer, 2 November 1989, published by the Institution of Civil Engineers, London, p 7.

Edwards E Human Factors in Aviation, Aerospace, Vol 12, Number 6, June/July 1985. Published by the Royal

Aeronautical Society, London.

French S Editorial, Journal of Multi-Criteria Decision Analysis, Vol 1, 1-2 (1992), published John Wiley and Sons Ltd., Chichester.

Ibrekk H and Granger Morgan M Graphical Communication of Uncertain Quantities to Nontechnical People. Risk Analysis, Vol 7, Number 4, December 1987, Plenum Press, New York.

Junge G Country Risk Assessment: Swiss Bank Corporation's Approach, Economic and Financial Prospects No. 1 1988 February/March, published by the Swiss Bank Corporation.

Kathawala Y Applications of Quantitative Techniques in large and small organisations in the United States: an Empirical Analysis. The Journal of the Operational Research Society Vol 39, No.11, pp 981-988, published by Pergamon Press, Oxford 1988

Keller L R and Sarin R K Equity in Social Risk: Some Empirical Observations Risk Analysis Vol 8, No 1, 1988.

Lygo R Picking winners to Safeguard competitiveness in manufacturing, published in the proceeding of the Institution of Mechanical Engineers, London Vol 201, No B2 1987.

MacGregor D and Slovic P Perceived acceptability of Risk, Risk Analysis, Vol 6, No 2, Plenum Press, New York.

Marrey B Birth of a Landmark, Swissair Gazette, June 1988.

May W W \$'s for lives: Ethical Considerations in the use of Cost/Benefit Analysis for profit terms: published in Risk Anaysis, vol 2, No 1, March 1982.

Meyrick-Jones J The Insurance Viewpoint, aerospace Vol. 13. No. 6. July/August 1986, published by the Royal Aeronautical Society, London.

Mingers J and Adlam J Where are the "real" expert

systems? OR INSIGHT Vol 2 Issue 3, July-September 1989 published by the Operational Research Society, Birmingham.

Mumpower J An analysis of the de minimis Strategy for Risk Management, Risk Analysis, an official publication of the Society for Risk Analysis, Vol 6, No 4, December 1986, published by Plenum Publishing, New York.

Norman P. Naveed S. A comparison of expert system and Human Operator performance for Cement Kiln Operation. Journal of the Operational Research Society, Vol. 41. No. 11, November 1990., published by the Operational Research Society Birmingham, pp1007 - 1019.

Project Finance - Risk Management, The Nat West Approach, published in Trade Finance and Corporate Finance, June 1987, published by Euromoney Publications PLC London.

Rich B R The Skunk Works' Management Style - it's no secret, published in Aerospace Vol 16 No 3, March 1989, published by the Royal Aeronautical Society, London.

Ridley ignores calls for Channel Inquiry, New Civil Engineer, a publication of the Institution of Civil Engineers, 7th November 1985, p.9.

Saull J W Objectives of Maintenance - Airworthiness, Aerospace July/August, 1987, published by the Royal Aeronautical Society, London.

Schwietert A Country Risk Assessment: Swiss Bank Corporation's Approach, Economic and Financial prospects No 1 1988 February/March, published by the Swiss Bank Corporation.

Seiler F A Error Propagation for Large Errors, Risk Analysis, Vol 7, No 4, December 1987, published Plenum Press, New York, pp509-518.

Sheehan R Lloyd's versus computer fraud Lloyd's Special Published Lloyd's London.

Stallen P J and Coppock R About Risk Communication and Risky Communication, Risk Analysis Vol 7 No 4, 1987

published by Plenum Press, New York, pp 413-414.

Swiss Re Computer Insurance, published by Swiss Reinsurance Company, Zurich, Switzerland.

Tait J The Role of Values in Quantitative Decision Making, The Journal of the Operational Research Society Vol 39, No 7, July 1988, pp 669-674, published by the Operational Research Society, Birmingham.

#### CONFERENCE PAPERS

Brown J, Lee T and Fielding J. Concerns Worry and Anxiety about Hazard with Special Reference to Nuclear Power - a Secondary Analysis of Data Collected by Social Community Planning Research for the Health & Safety Executive, a report issued by the Psychology Department of the University of Surrey.

Cattaneo F DeSanctis S Garribba S F and Volta G. Learning from Abnormal Occurances; Results of a Fuzzy Analysis. Paper for the PSA '87 Conference, Zurich, Aug.30 - Sept.4 1987.

Chicken J C Comprehensive Assessment, a paper presented at the first International Conference on Risk Assessment of Chemicals and Nuclear Materials held at the Robens Institute, Surrey University, September 1986.

Chicken J C A European View on Computer System Insurance, a paper presented to the NCC Information Technology Conference, Blackpool, 1989.

Chicken J C and Hayns M R Assessing Social Aspects of Risk Acceptability, a paper presented at the SNS/ENS/ANS Conference on Probabilistic Safety Assessment and Risk Management, Zurich, August 1987.

Chicken J C and Hayns M R Comprehensive Safety Criteria, presented at an IMechE meeting, December 1987.

Hayns M R and Unwin S D A method to incorporate Uncertainty and a Degree of Compliance in Safety Goals, paper for conference, San Francisco 1984.

Hicks A J The Role of Insurance Safety, a paper presented to the OYEZ 1982 Review Seminar on Risk Management and Acceptability, April 1982, London

Johnson C External Debt Assessment a paper presented to the International Economics Study Group Conference on the 1985 World Development Report, London November 1985.

Jones-Lee M W The Political Economy of Physical Risk a paper presented at the First International Conference on Risk Assessment of Chemicals and Nuclear Materials, Surrey University, September 1986.

Mosleh A et al The elicitation and use of expert opinion in risk assessment: a critical review. A paper presented at the Probabilistic Safety Assessment and Risk Management Conference, PSA 87, held in Zurich, September 1987.

Solomon K A, Wipple C and Okrent D. More on Insurance and Catastrophic Events: Can we expect de facto Limits on Liability Recoveries? A paper presented at the ANS topical meeting Probabilistic Analysis of Nuclear Reactor Safety, May 1978.

Stallen P J M and Tomas A - Public Concern about Industrial Hazards, a paper presented at the annual meeting of the Society for Risk Analysis, Washington, USA, October 1985.

Stewart T J A Critical Survey on the Status of Multiple Criteria Decision Making Theory and Practice in OMEGA International Journal of Management Science Vol.20, No.5/6, pp 569-586, 1992. Pergamon Press, Oxford

Thomas K, Maurr D, Fishbein M, Otway H J, Hinkle R A, Simpson D. Comparative Study of Public Beliefs about Five Energy Systems. Paper RR-80-15, April 1980 published by the International Institute for Applied Systems Analysis, Laxenburg, Austria.

Vogel R C and Wall I B Some observations on NUREG 1150, A paper presented at the Probabilistic Safety Assessment and Risk Management Conference, PSA 87, held in Zurich, September 1987.

#### NEWSPAPERS

Debit Warning by Bank over property loans, The Times, 14 October 1989

Feltham C Banks urge Eurotunnel to seek Extra Funding from Investors, The Times, 2 October 1989, p 25.

Reid T R Fuzz Logic, but Japan puts it to work, International Herald Tribune, 5-6 January 1991

The Race to Cross the Channel, The Illustrated London News, Vol.273 Number 7048, November 1985

#### LETTERS

Letter dated 14 February 1989 from Steward D Gager of Midland Montagu Ltd to Dr J C Chicken of J C Consultancy Ltd.

Letter dated 25 September 1989 from Ian Calvert, ECGD, to Dr J C Chicken of J C Consultancy Ltd.

## APPENDIX 1

### The Bank of England's Risk Weighting(Ref.1)

#### Risk Weight Categories for Capital Adequacy: On-balance-sheet items

##### A Category 0% weighted

- i) Cash and claims collateralised by cash deposits placed with the lending institution (or CDs and similar instruments issued by and lodged with the reporting institution) and meeting the conditions set out in the Bank's reporting requirements for 0%;
- ii) Gold and other bullion held in own vaults or on an allocated basis;
- iii) Claims (1) on Zone A (2) central governments and central banks including claims on the European Communities;
- iv) Claims (1) guaranteed by Zone A central governments and central banks; (3)
- v) Claims (1) on Zone B central governments and central banks denominated in local currency and funded in that currency;
- vi) Claims (1) guaranteed by Zone B central governments or central banks, where denominated in local currency and funded in that currency; (3)
- vii) Certificates of tax deposit;
- viii) Items in suspense; (4)

##### B Category 10% weighted

- i) Holdings of fixed-interest securities issued (or guaranteed) by Zone A central governments with a residual maturity of 1 year or less, and floating-rate and index-linked securities of any maturity issued or guaranteed by Zone A central governments;
- ii) Claims collateralised by Zone A central government fixed-interest securities of any maturity;

- iii) Holdings of securities issued by Zone B central governments with a residual maturity of 1 year or less and denominated in local currency and funded by liabilities in the same currency;
- iv) Loans to discount houses, gilt-edged market makers, institutions with a money-market dealing relationship with the Bank of England and those Stock Exchange money brokers which operate in the gilt-edged market, where the loans are secured on gilts, UK Treasury bills, eligible local authority and eligible bank bills, or London CDs.

C Category 20% weighted

- i) Holdings of fixed-interest securities issued (or guaranteed) by Zone A central governments with a residual maturity of over 1 year;
- ii) Claims collateralised by Zone A central government fixed-interest securities with a residual maturity of over 1 year;
- iii) Holdings of Zone B central government securities with a maturity of over 1 year denominated in local currency and funded by liabilities in the same currency;
- iv) Claims on multilateral development banks and claims guaranteed by or collateralised by the securities issued by these institutions;
- v) Claims on credit institutions incorporated in the Zone A and claims guaranteed (or accepted or endorsed) by Zone A-incorporated credit institutions;
- vi) On-balance-sheet claims in gold and other bullion on the non-bank market making members of the London Bullion Market Association; (5).
- vii) Claims on credit institutions incorporated in Zone B with a residual maturity of 1 year or less and claims of the same maturity guaranteed by Zone B credit institutions;
- viii) Claims secured by cash deposited with and held by an agent bank acting for a syndicate of which the reporting institution is a member;
- ix) Claims on Zone A public sector entities and

claims guaranteed by such entities. In the United Kingdom, these comprise local authorities and certain non-commercial public bodies;

- x) Claims on discount houses and claims which are guaranteed (or accepted) by discount houses which are unsecured, or secured on assets other than specified in B iv) above;
- xi) Cash items in the process of collection.

**D** Category 50% Weighted

- i) Loans to individuals fully secured by a first priority charge on residential property that is (or is to be) occupied by the borrower or is rented;
- ii) Loans to housing associations registered with the Housing Corporation, Scottish Homes and Tai Cymru that are fully secured by a 'first priority' charge on the residential property which is under development and fully secured by a charge on the housing association's residential property that is being let, and where the project attracts HAG. If HAG is not available, such loans must be fully secured by a 'first priority' charge on residential property that is being let;
- iii) Mortgage sub-participations, where the risk to the sub-participating bank is fully and specifically secured against residential mortgage loans which would themselves qualify for the 50% weight;
- iv) Holdings of securities issued by special purpose mortgage finance vehicles where the risk to the security holders is fully and specifically secured against residential mortgage loans which would themselves qualify for the 50% weight or by assets which qualify for a weight of less than 50% (5), as long as the mortgage loans are fully performing or origination of the vehicle.

**E** Category 100% Weighted

- i) Claims on the non-bank private sector;
- ii) Claims on credit institutions incorporated in

- Zone B with a residual maturity of over 1 year;
- iii) Claims on Zone B central governments and central banks (unless denominated in the national currency and funded in that currency);
  - iv) Claims guaranteed by Zone B central governments or central banks, which are not denominated and funded in the national currency common to the guarantor and borrower;
  - v) Claims on commercial companies owned by the public sector;
  - vi) Claims on Zone B public sector entities;
  - vii) Premises, plant, equipment and other fixed assets;
  - viii) Real estate, trade investments (6) and other assets not otherwise specified;
  - ix) Aggregate net short open foreign exchange position; (7)
  - x) Gross deferred tax assets.

#### **Credit conversion factors for off-balance-sheet risk**

Credit conversion factors should be multiplied by the weights applicable to the category of the counterparty for an on-balance-sheet transaction.

Instruments	Credit conversion Factor
A      Direct credit substitutes, including general guarantees of indebtedness, standby letters of credit serving as financial guarantees, acceptances and endorsements (including 'per aval' endorsements);	100%
B      Sale and repurchase agreements and asset sales with recourse where the credit risk remains with the bank; (8)	100%
C      Forward asset purchases, forward deposits placed and the unpaid part of partly-paid shares and securities,(8) and any other commitments with a certain	100%

drawdown;

D	Transaction-related contingent items not having the character of direct credit substitutes (eg performance bonds, bid bonds, warranties and standby letters of credit related to particular transactions);	50%
E	Short-term self-liquidating trade-related contingent items (such as documentary credits collateralised by the underlying shipments);	20%
F	Note issuance facilities and revolving underwriting facilities; (9)	50%
G	Other commitments (eg formal standby facilities and credit lines) with an original (10) maturity of over 1 year;	50%
H	Similar commitments with an original (10) maturity of up to 1 year, or which can be unconditionally cancelled at any time;	0%
I	Endorsements of bills (including 'per aval' endorsements) which have previously been accepted by a bank.	0%

Multi-options facilities and other composite products should be disaggregated into their component parts, eg into a credit commitment, NIF, etc., and each component part converted according to the above classification. However, components carrying the lowest credit conversion factors should be disregarded to the extent necessary to ensure that the total value of all the components does not exceed the value of the facility.

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#### Notes on Text

1. Other than securities issued by these bodies.
2. Zone A are OECD countries plus those with special lending agreements with IMF, Zone B countries are all other countries.
3. Including lending under ECGD bank guarantee and equivalent schemes in other Zone A countries, but excluding lending against the security of ECGD insurance cover.
4. Where such items do not represent a credit risk but rather a position risk as detailed in the guidance notes to the form BSD1.
5. Until 1 January 1993, from which time such claims will

- be weighted to 100%.
6. Excluding:(i) holdings of capital instruments issued by credit institutions which will be deducted from total capital; and (ii) holdings of capital instruments of other financial institutions which must be deducted according to Article 2(12) and (13) of the Own Funds Directive.
  7. This is a proxy weight for a bank's foreign exchange risk, and will remain in effect until an international framework for capturing foreign exchange risk is agreed. Include the net short open position in gold, silver, platinum and palladium.
  8. These items are to be weighted according to category of the issuer of the security(or the borrower in the underlying loan agreement) and not according to the counterparty with whom the transaction has been entered into. Reverse repos (i.e. purchase and resale agreements where the bank is the receiver of the asset) are treated as collateralised loans, with the risk being measured as an exposure to the counterparty. Where the security temporarily acquired attracts a preferential risk weighting, this is recognised as collateral and the risk weighting of the loan accordingly reduced (e.g. a Zone A government security).
  9. To be applied to the total amount of the institution's underwriting obligations of any maturity. Where the facility has been drawn down by the borrower and the notes are held by anyone other than the reporting institution, its underwriting obligations must continue to be reported as the full nominal amount. (Own holdings of notes underwritten are, however, deducted from the overall value of the commitment, because they are weighted as an on-balance-sheet item.)
  10. Banks may report on the basis of residual maturity until the end of 1992 to assist data collection

## Reference

1. BSD/1990/3 Bank of England's Notice to Institutions authorised under the Banking Act 1987, Implementation in the United Kingdom of the Solvency Ratio, December 1990.

APPENDIX 2

Swiss Bank Corporation's Risk Assessment and Credit Assessment Procedures applied to Fictitious Countries

Summary

Illustrations of the Swiss Bank's Country Risk Assessment Methodology with definition of the terms used.

Country Risk Assessment

INDICATORS		1984	1985	1986	1987	Estimate 1988	Outlook 1989
1. REAL GDP GROWTH	%	5.2	3.1	1.2	-4.5	-3.2	1.5
2. <u>Investment</u> GDP	International average: = 25%	25.6	24.9	24.1	18.5	14.7	↗
3. INVESTMENT EFFICIENCY (1:2)	critical level ≤ 0.2	0.23	0.19	0.13	-0.02	-0.11	↗
4. INFLATION (Period average)	%	18.5	22.3	24.9	52.6	18.2 <sup>1)</sup>	↗
5. MONEY SUPPLY GROWTH (End of period)	%	22.8	18.5	19.6	6.9	9.8 <sup>1)</sup>	↗
6. REAL DOMESTIC CREDIT CREATION	%	16.8	27.9	37.2	-15.0	-9.4 <sup>1)</sup>	up
7. <u>Fiscal Balance</u> GDP	%	-3.5	-5.1	-2.5	-1.8	-1.7	↘
8. COMPETITIVENESS (Real Exchange Rate) INDEX 1980 = 100		109.5	105.4	85.6	84.0	80.0	↗
9. TRADE BALANCE (Goods)	US\$bn	-1.84	-2.95	-3.24	-2.40	-0.80	↗
10. EXPORTS (Goods + Services)	US\$bn	8.60	8.10	8.15	8.30	9.10	↗
11. IMPORTS (Goods + Services)	US\$bn	10.81	11.95	12.54	11.40	10.30	up
12. CURRENT ACCOUNT BALANCE	US\$bn	-1.95	-3.55	-4.12	-2.60	-0.90	↗
13. <u>Exports</u> GDP	%	23.0	20.7	23.5	21.5	23.0	↗
14. EXPORT CONCENTRATION (high = critical) 2)	%	33.4	35.2	36.7	35.6	35.0	↗
15. IMPORTS FROM SWITZERLAND	SFr.m	104.2	110.3	117.9	106.2	105.0	↗
16. TOTAL EXTERNAL DEBT (Public + Private)	US\$bn	16.8	20.9	25.1	27.3	28.0	↘
17. INTERNAT. RESERVES (Excl. Gold)	US\$bn	3.12	1.94	0.95	0.81	1.00	↗
18. EXTERNAL DEBT SERVICE	US\$bn	2.45	2.71	2.96	2.82	3.40	↘
19. <u>External Debt</u> Exports	critical level ≥ 150%	195	258	308	329	308	↗
20. <u>External Debt Service</u> Exports	critical level ≥ 25%	28.5	33.4	36.3	34.0	37.3	↗
21. <u>Interest-Adjusted Current Account</u> Interest Payments	%	-25	-67	-84	-13	67	↗
22. <u>International Reserves</u> Imports	critical level ≤ 3 mths	3.5	1.9	0.9	0.9	1.2	↗
23. POLITICAL RISK	points 1 10	7	7	7	6	6	↗
24. Recorded Unemployment Rate	%	11.2	10.5	11.0	13.4	13.5	↗
25. Per capita GDP Growth	%	2.8	0.7	-1.1	-6.8	-5.5	-0.8

# Definition of Terms used in Country Risk Assessment

Use three symbols as visual aids to monitoring risks:



Ratio has gone beyond an empirically determined **critical level** (applies to indicators 3, 19, 20 and 22)



- Value or ratio has deteriorated very sharply within a 12-month period (**critical change**)



- Ratio both exceeds critical level and has undergone **critical change** within a 12-month period

Look: → = unchanged ↗ = improving ↘ = deteriorating

Asterisk \* = Estimate

NA = Not available

The suggested critical values apply to **developing** countries only and do not necessarily reflect similar risks in the case of **industrialized** countries.

1. **Real GDP growth:** Change in Gross Domestic Product over a 12-month period in %, adjusted for inflation (i.e. in volume terms); growth measure.
2. **Investment ratio:** Gross fixed capital formation (fixed investment) as % of GDP or GNP. The higher the ratio, the higher the potential economic growth. International average: 25%.
3. **Investment efficiency:** 3-year moving average of real GDP growth (no. 1) divided by the average investment ratio (no. 2) for same period. The higher the value, the more efficient the economy; **critical level**  $\leq 0.2$  on average. (Note: values will tend to be lower for more developed countries.)
4. **Inflation:** Change in consumer prices as an annual average in %. One measure of the quality of economic policy.
5. **Money supply** (M1 or other monetary control variable): Annual % change in money supply. Measure of monetary policy and early indicator for future inflation.
6. **Real domestic credit:** Annual % change of the domestic component of money supply (= M2 minus Net Foreign Assets), deflated by consumer price inflation. Measure of domestic monetary disequilibrium (in comparison to real GDP growth) and early indicator for balance-of-payments developments and exchange-rate changes.
7. **Fiscal balance as % of GDP:** General or (if unavailable) central government surplus or deficit as % of GDP. Fiscal policy measure. Since structural (permanent) deficits are more important than cyclical peaks and cross-country comparability is lacking, critical values are not determined.
8. **International competitiveness index (Index of real effective exchange rate):** Compares domestic with foreign inflation, adjusted for exchange-rate changes. Domestic inflation: GDP deflator. Foreign inflation: Trade-weighted changes of GDP deflators of major trading partners, adjusted for exchange-rate changes. A decline in the index (= a real devaluation) indicates an increase in competitiveness.
9. **Trade balance:** Exports minus imports of goods, in bn US\$. Goods are valued at their prices as they leave the exporting country, i.e. f.o.b., without costs of insurance and freight. Chief determinant of the current-account balance (see no. 12).
10. **Exports and imports:** Exports and imports of both goods and services (e.g. tourism, transportation, interest), in bn US\$.
11. **Current account balance:** Trade balance + balance of services + balance of unrequited transfers, in bn US\$; a deficit shows the extent of a country's dependence on foreign resources to satisfy domestic demand, to be financed (a) by drawing down international reserves (see no. 17) and/or (b) by additional borrowing abroad (no. 16).
12. **Share of exports in GDP:** Exports of goods and services (see no. 10) as % of GDP. Index of the openness of the economy, indicating (a) the allocation of domestic resources to the tradable sector and the country's ability to service its external debt and (b) the country's vulnerability to foreign demand shocks.
13. **Export concentration**  
**Either:** Share of main commodity exports in total exports. Main commodity exports (food and other agricultural products, raw materials and metals) as % of total exports. High value indicates high vulnerability to fluctuations in international commodity market conditions.  
**Or:** Merchandise exports to main customers (countries) as % of total merchandise exports. High value indicates dependency on a few major customer markets.
14. **Imports from Switzerland:** Goods imports from Switzerland in m Sfr.
15. **External debt:** Total external debt (gross) of the reporting country in bn US\$ at end of year. Includes short- and long-term debt, IMF lending and interest arrears.
16. **International reserves:** Total official international reserves at end of year, excluding gold. Foreign exchange, Special Drawing Rights, IMF reserves. Liquidity measure.
17. **External debt service:** Interest payments due on total debt + amortization payments due on medium- and long-term debt.
18. **External debt/Exports:** Total external debt as % of export receipts (goods & services). An important debt capacity indicator, since external debt ultimately has to be repaid out of export revenues. **Critical level:**  $\geq 150$ ; **critical change:** approx. 25% increase within a year.
19. **Debt-service ratio:** Annual interest and amortization payments on total external debt as % of export receipts (goods & services). Short-term liquidity measure. **Critical level:**  $\geq 25\%$ ; **critical change:** approx. 50% increase within a year.
20. **Interest coverage:** Current account balance net of interest payments to foreign creditors, as % of interest payments. Indicator of debt-servicing capacity. **100% or more** indicates net current account revenues technically sufficient to cover all interest obligations. **0 or less** indicates net current account revenues technically too small to pay any interest.
21. **Import cover:** Official reserves at year-end (no. 17) divided by average monthly imports (see no. 11). Measure of how long imports could be financed from international reserves. **Critical level:**  $\leq 3$  months; **critical change:** approx. 50% decrease within a year.
22. **Political risk:** Social and political situation rated on a scale of 1-10 with regard to creditworthiness. Scores **1 to 3:** no foreseeable/low risks; **4 to 6:** acceptable/moderate risks; **7 to 9:** high/higher risks; **10:** unacceptable/extremely high risks.
23. **Optional indicators:** Any readily available risk-related indicator or any country-specific indicator.

## Industrial Country Credit Risk Assessment

INDICATORS		1989	1990	1991	1992	Estimate 1993	Outlook 1994
1. REAL GDP GROWTH	%	2.1	0.7	-2.5	-0.8	0.7	1.4
2. GROSS INVESTMENT/GDP	Int. avg. = 25%	23.4	22.1	19.2	19.2	19.1	↗
3. INFLATION	%	7.8	9.5	5.9	3.7	2.1	3.8
4. MONEY SUPPLY GROWTH	%	18.3	15.9	7.9	4.5	3.9	up
5. UNEMPLOYMENT RATE	%	6.2	5.9	8.3	9.9	10.8	11.4
6. GENERAL GOV'T. BALANCE/GDP	critical deficit ≥ 3%	0.9	-1.3	-10.2	-11.1	12.0	→
7. SHORT-TERM INTEREST RATE	%	13.8	14.6	11.1	9.0	5.0	→
8. LONG-TERM YIELD OF GOV'T. BONDS	%	9.6	11.1	9.9	9.1	7.8	→
9. COMPETITIVENESS INDEX	1990=100	98.7	100.7	108.1	107	95.0	up
10. DEVIATION FROM PPP (DM/ <i>nat. currency</i> )	%	14.4	12.3	18.8	15.9	4.4	→
11. INDUSTRIAL PRODUCTION	%	0.5	-0.6	-3.0	-0.3	1.6	3.2
12. REAL AVERAGE EARNINGS INCREASE		1.7	0.6	1.9	1.3	0.8	1.5
13. EXPORTS (GOODS AND SERVICES)	US\$ bn	320.6	380.4	375.6	397.9	414.2	up
14. IMPORTS (GOODS AND SERVICES)	US\$ bn	-348.7	-401.0	-384.6	-424.2	-448.4	up
15. CURRENT ACCOUNT BALANCE	US\$ bn	-35.59	-29.39	-11.44	-20.64	-18.72	→
16. NET DIRECT INVESTMENTS	US\$ bn	-4.95	14.90	3.51	4.0	6.0	↗
17. NET EXTERNAL FINANCIAL ASSETS/GDP	%	13.2	0.7	3.6	4.0	0.5	down
18. NET INTEREST INCOME/EXPORTS	%	-2.0	-3.2	-3.5	-2.0	-2.5	down
19. INVISIBLE BALANCE	US\$ bn	4.8	3.2	7.0	9.0	8.0	→
20. PRIMARY BUDGET/GDP	%	3.3	1.0	-0.9	-4.5	-5.8	down
21. NET INTEREST PAYMENTS/TOT. EXPEND.	Int. avg. = 6.5%	6.3	5.7	4.7	4.7	5.3	up
22. GROSS TOTAL PUBLIC DEBT/GDP	critical level ≥ 60%	37.0	34.9	36.5	41.9	47.4	up
23. GROSS FOREIGN PUBLIC DEBT/GDP	%	6.1	5.4	5.4	5.0	5.0	→
24. FOREIGN CURRENCY DEBT/TOTAL PUBLIC DEBT		4.1	4.5	5.0	5.5	5.8	↗
25. CORPORATE PROFIT GROWTH	%	5.9	4.3	1.1	0.2	2.0	↗
26. INTEREST PAYMENTS/CORPORATE INCOME	%	24.0	26.7	27.0	24.5	19.0	down
27. DEBT/EQUITY (140 largest corporations)	%	36	43	44	44	44	down
28. BUSINESS FAILURES	1989 = 100	100	149	274	367	down	down
29. HOUSEHOLD FINANCIAL LIABILITIES/INCOME		86.6	90.3	90.9	85.2	80.0	down
30. POLITICAL RISK	points 	2	2	2	2	2	2

## Definition of terms used in Industrial Country Credit Risk Assessment

Three symbols as visual aids to monitoring risks:



Value has gone beyond a critical level



= Value or ratio has deteriorated very sharply within a 12-month period (**critical change**)



= Ratio both exceeds critical level and has undergone **critical change** within a 12-month period

Legend: → = unchanged   ↗ = improving   ↘ = deteriorating

\* = Estimate   NA = Not available

**Annual GDP growth:** Change in Gross Domestic Product over a 12-month period in %, adjusted for inflation (i.e. in volume terms); primary measure.

**Gross investment/GDP:** Gross fixed capital formation as % of GDP (or GNP). The higher the ratio, the higher the potential for economic growth. International average: 25%.

**Inflation:** Change in consumer prices as an annual average in %. One measure of quality of economic policy.

**Money supply (M1 or other monetary control variable):** Annual change in money supply. Measure of monetary policy and early indicator for future inflation.

**Unemployment rate:** Ratio of the totally unemployed in labour force in %.

**General Gov't. balance/GDP:** General or (if unavailable) central government surplus or deficit as % of GDP. Fiscal policy measure.

**Short-term interest rate:** 3 month Euro-currency interest rate or any other key money market interest rate. Monetary policy indicator.

**Long-term yield of Gov't. bonds:** Long term treasury bond, if possible 10-year maturity. Indicator of capital market conditions.

**International competitiveness index (index of real effective exchange rate):** Compares domestic with foreign inflation, adjusted for exchange-rate changes. Domestic inflation: GDP deflator. Foreign inflation: Trade-weighted changes of GDP deflators of major trading partners, adjusted for exchange-rate changes. A decline in the index (= a real devaluation) indicates an increase in competitiveness.

**Deviation from PPP:** % deviation of the exchange rate from its purchasing power parity value. A negative sign indicates a potential overvaluation of the currency (devaluation risk). A positive sign stands for an undervaluation. Indicator of currency risk and international competitiveness.

**Optional indicators:** Any readily available risk-rated indicator or any country-specific indicator.

**Exports and imports:** Exports and imports of both goods and services (e.g. tourism, transportation, interest), in bn US\$.

15. **Current account balance:** Trade balance + balance of services + balance of unrequited transfers, in bn US\$; a deficit shows extent of a country's dependence on foreign resources to satisfy domestic demand, to be financed (a) by drawing down international reserves (see no. 17) and/or (b) by additional borrowing abroad (no. 16).
16. **Net direct investments:** Covers all net inflows of equity investment on a balance-of-payments basis. Portfolio investment inflows are not part of direct investment.
17. **Net external financial assets/GDP:** Indicates country's external asset position as % of GDP. A negative sign stands for net indebtedness.
18. **Net interest payments/Exports:** Annual net interest payments on net external debt as % of export receipts (goods & services).
20. **Primary budget/GDP:** Overall general government balance less interest payments on public debt, as % of GDP. Measures sovereign cash flow before any allowances for interest payments.
21. **Net interest payments/Total expenditures:** General gov't net debt interest payments as % of total gov't expenditures. Total expenditures are defined as current receipts minus net lending.
22. **Gross total public debt/GDP:** Domestic and external debt owed by or guaranteed by general government as % of GDP.
23. **Gross foreign public debt/GDP:** External debt owed by or guaranteed by general government as % of GDP.
25. **Corporate profit growth:** Annual % change in corporate profits. If not available, cash flow.
26. **Net debt interest payments/Cash flow:** Measure of corporate sector income gearing.
27. **Debt/Equity:** Corporate sector's borrowed capital as % of its own capital.
28. **Business failures:** Bankruptcies in corporate sector, specified in terms of percentage change or in relation to new business creation or outstanding bank loans.
30. **Political risk:** Social and political situation rated on a scale of 1-10 with regard to creditworthiness. Scores **1 to 3:** no foreseeable/low risks; **4 to 6:** acceptable/moderate risks; **7 to 9:** high/higher risks; **10:** unacceptable/extremely high risks.

### APPENDIX 3

#### **Structure of the Swiss Bank Corporation's Executive Management Brief on the Credit Worthiness of a Country.**

Typically a Credit Worthiness brief discusses outlook and Risk Analysis, politics, domestic economy, trade account and balance of payments and external debt. The brief concludes with advice to the Executive about the implications of the findings of the Risk Monitoring exercise for the Bank's lending policy towards the country involved.

Under the heading Outlook and Risk Analysis the brief gives an assessment of the political stability of the country and an assessment of six indicators of economic stability. The indicators are:- population, GDP, current account balance, total external debt, international reserves and exchange. The way each of the indicators appears to be developing is estimated in qualitative terms like: rising, unchanged and depreciating.

Discussion of political factors covers: results of elections, the programme of the party elected, unrest, strikes, trade union activities and developments in international trade and economic collaboration.

The discussion of domestic economy tends to focus on assessing the prospects for economic growth in the years ahead. In building up an assessment of the prospects for economic growth attention is given to the magnitude of inflationary pressures and the way they are dealt with.

The assessment of trade accounts covers balance of payments, trade prospects, external financing and exchange rate policy. In the assessment attention would be given to whether or not exports were growing.

Discussion of external debt is the last section of the brief, but perhaps the most important. The brief would comment on the debt to exports ratio and whether the situation is sustainable or not. Also the brief would comment on the reality of the country being able to service its debts.

## APPENDIX 4

### Additional Comment on the Scaling of Ranking Factors

Scaling of Ranking Factors, described in the main text, could be described as a subjective attempt to identify the decision that would result in the optimum distribution of resources. In their discussions of distributive justice, Braybrooke and Lindblom (1) drew attention to the fact that even Aristotle recognised that many factors influenced the equitable distribution of resources. In some ways it could be argued that an infinite range of factors have to be considered in determining which decision option will yield the optimum distribution of resources. The Risk Ranking Technique is an attempt to rationalise for the decision maker the number of factors and the number of levels of acceptability that have to be considered.

The four levels of acceptability were chosen as a way of grading acceptability on the basis of the intrinsic properties of each proposition considered. In Fig.8, in the main text, it was shown how a three dimensional matrix of Ranking would result from variation in the data used. In the diagram the mean Ranking is shown evenly spaced between the upper and lower limits. Such even distribution suggests the data may follow a normal distribution, an assumption that may be misleading. Reflecting on the magnitude of cost escalation, mentioned in Chapter 1 of the main text, suggests that in reality the data may be skewed and that a distribution other than normal may be more appropriate. A possible description of the data could be a Weibull distribution with a suitable parameter (2). Such refinement of the analysis may not be justified by the quality of the data available.

A three dimensional matrix, of the type shown in Fig.8, really only represents a snapshot of the decision options as they appear at a particular time. With the passage of time the components of the factors involved in the Ranking matrices will tend to change, and the composition of the matrices will tend to change. The influence of time on the Ranking matrices could be described diagrammatically as a series of matrices distributed along a line representing a time continuum. In many decision making situations, a

decision has to be made at a particular time on the basis of the information then available, so exploration of changes with time is not necessary. However, there are decisions in which changes with time have to be considered. These decisions are of two main types which are:-

1. Decisions that have to be repeated over time.
2. Major decisions which take many years to come to fruition and in that time needs and the environment surrounding the decision change.

In both cases, at the time the decision is made care will have to be taken to ensure that, as far as is practical, time related changes had been allowed for.

Examples of the kind of changes with time that have to be allowed for are:-

1. When a bank makes a loan to a Country abroad, it will evaluate whether or not the economic strength and political stability of the Country has changed significantly since it last made a loan to that Country.
2. Before an insurance company accepts a risk, it will first assess what factors have changed since it last accepted that kind of risk.
3. Adequacy of allowance for changes in borrowing conditions such as: interest rate or repayment condition changes.
4. Before a company embarks on a major construction project lasting several years, it will have to decide whether or not the project will still be wanted when it is complete.

Having summarised how the Risk Ranking Technique allows for variation in the data and the environment of decision making, attention can now be turned to justification of the Ranking Scales postulated and justification of the proposed method of scoring acceptability proposed. The system of scoring proposed was intended to characterise the degree of acceptability of each of the four grades of acceptability

specified. It has been argued in Chapter 6, in the main text, that four Ranking Steps would give an adequate classification of the various shades of acceptability and at the same time avoid a neutral middle ground grade. The selection of a 1,2,5, 14 scoring scale was purely arbitrary and intended to grade the acceptability of each factor in a way that would ensure adverse Rankings would not be obscured in the overall Ranking.

The attribute that is scored is acceptability. The length of the scale chosen was chosen quite arbitrarily, but criteria were specified for determining which grade a particular factor should be allocated. Although the criteria specified for determining Ranking Grade and Score are generally described in numerical terms, they cannot be measured with precision (3). For example, it is very difficult to measure the capability and relevant experience of a proposer, such judgments remain subjective.

Nevertheless, the structured approach of the Risk Ranking Technique provides a consistent way of relating qualitative information to numerical representation. Building up the Ranking process includes two important analytical disciplines, which are ordering the data available and making some ordinal measure of the significance of the data (4). The specification of criteria for scoring provides the ordering of the measurement. The form of ordinal measurement adopted is non-dimensional. This form of measurement was chosen to enable the measurements from disparate factors to be combined. If only one factor, like economics, was being considered it would be possible to contemplate the significance of the factor being measured in dimensional terms. In the case of economics, money would be an appropriate unit of measurement.

One problem with the type of scoring system proposed arises from the environment that normally surrounds the particular type of decision making being considered. The problem is that data for some parts of the assessment of acceptability may be qualitative and for other parts quantitative. In other words, the quality of the data that has to be used may be variable. The qualitative data may arise from consulting experts about acceptability. Some of the procedures that can be adopted in such cases to ensure the results are as consistent as possible are described in

Appendix 5 and ref 5. Presentation of the variation in the quality of the data that has to be used can be achieved with the three dimensional Ranking matrix that has already been described.

In making a critical assessment of the adequacy of the scoring scale, consideration must be given to possible alternatives. Three alternatives are considered - they are: a linear scale, (6) the quadratic/Bier scoring rule (7) and a variation of the  $\beta$  measure of systematic risk (8).

A simple 1,2,3,4 linear scale, while giving a satisfactory identification of each factor in each option, tends to obscure the significance of adverse Ranking of a single factor. Table A4.1 shows how the significance of an individual adverse Ranking can be obscured in the overall Ranking. For the linear Ranking system postulated, for illustrative purposes, it is assumed that:-

1. A factor that is unlikely to be acceptable would have a score of 4 and a Rank 1.
2. A factor that is only likely to be acceptable if the risk can be reduced would have a score of 3 and a Rank 2.
3. A factor that is only acceptable subject to some additional control would have a score of 2 and a Rank 3.
4. A factor that is acceptable without restriction would have a score of 1 and a Rank 4.

The total score range of the overall Rankings would be:-

Rank 1, total score 10-12	Rank 2, total score 7-9
Rank 3, total score 4-6	Rank 4, total score 3

As a linear Ranking score scale can lead to the significance of some adverse factors being obscured, a linear Ranking scale is considered unacceptable.

The quadratic/Bier scoring systems are for the purpose of this study considered to be similar as both are based on a quadratic scoring scale, can be expressed as score =  $(1-P)^2 \times 100$  Equation 1.

where P is the probability of a statement being true.

**TABLE A4.1****Examples of Overall Ranking based on a Linear Scale.**

OPTION	FACTOR SCORE	OVERALL RANK	COMMENT
1	Technical 2 Economic 2 Socio- Political 2	Total score 6 giving an overall Ranking of 3	The Rank 3 fairly reflects the individual scores
2	Technical 2 Economic 4 Socio- Political 2	Total score 8 giving an overall Ranking of 2	In this case the the adverse economic Ranking is obscured
3	Technical 4 Economic 1 Socio- Political 1	Total score 6 giving an overall Ranking of 3	In this case adverse technical Ranking is obscured

In Risk Ranking options are graded under four headings which is different to the Bier/quadratic concept. Simply to follow the quadratic distribution of scores it is assumed that each grade can be represented by the centre point of each quartile between 0 and 1. The centre points giving P the series of values 0.125, 0.375, 0.625 and 0.875. Using these numbers with equation 1 would give the score series 76.56, 39.06, 14.06 and 1.56. Reversing the numbers and rounding gives the series, 2, 14, 39 and 77. To illustrate the efficacy of the scoring system it has been applied to, the pattern of options described in Table A4.1 and the results are shown in Table A4.2. With the quadratic scale, the total score range for the overall Rankings would be:-

Rank 1, total score 81-231      Rank 2, total score 43-117  
Rank 3, total score 18-42      Rank 4, total score 6

**TABLE A4.2 Examples of the Overall Ranking based on a Quadratic/Bier Scale**

OPTION	FACTOR SCORE	OVERALL RANK	COMMENT
1	Technical 14 Economic 14 Socio- Political 14	Total score 42 giving an overall ranking of 3	The Rank 3 fairly reflects individual scores and gives the same result as the linear scale
2	Technical 14 Economic 77 Socio- Political 14	Total score 105 giving an overall Ranking of 2 or 1	Overall Ranking uncertain and the adverse economic Ranking may be obscured
3	Technical 77 Economic 2 Socio- Political	Total score 81 giving an overall Ranking of 2 or 1	Overall Ranking uncertain and the adverse technical Ranking is obscured

The quadratic/Bier Ranking scale does not offer any advantage over the linear scale and can give ambiguous Ranking.

If the risk was being measured purely in financial terms it might be possible to devise a scale based on the  $\beta$  coefficient which is used as an indication of the nature of the risk/return relationship associated with a particular investment (9). The greater  $\beta$  the greater the risk associated with that investment. A  $\beta$  equal to unity suggests that the return on an investment fluctuates proportionately to the markets average return. If  $\beta$  is less than 1, the fluctuation is less than the markets.  $\beta$  does not appear to be an appropriate measure for a comprehensive Ranking scale as it does not seem directly applicable to measure technical and socio-political factors.

Finally, to complete the review of possible scoring scales, the Ranking scale used in the main text is tested against the pattern of decision options used to test the linear and quadratic/Bier scales. In the main text, the scoring scale

1,2,5,14 was used. This gave a total score range for overall Ranking of:-

Rank 1, total score 16-42      Rank 2, total score 7-15  
 Rank 3, total score 4-6      Rank 4, total score 3

The results of the main text scoring scale are given in Table A4.3.

**TABLE A4.3 Test of the Main Text Scoring Scale**

OPTION	FACTOR SCORE	OVERALL RANK	COMMENT
1	Technical 2 Economic 2; Socio- Political 2	Total score 6 giving an overall Ranking of 3	The Rank 3 fairly reflects individual scores as did the linear and quadratic/Bier scales
2	Technical 2 Economic 14 Socio- Political 2	Total score 18 giving an overall Ranking of 1	The Rank 1 draws attention to the importance of the most critically Ranked factor
3	Technical 14 Economic 1 Socio- Political 1	Total score 16 giving an overall Ranking of 1	The Rank 1 draws attention to the importance of the most critically Ranked factor

## CONCLUSION

The Ranking Scoring Scale used in the main text has the advantage compared with the other scales considered, that it does not reduce the significance of the most critically Ranked factor or introduce ambiguity into the Ranking.

## REFERENCES

1. BRAYBROOKE D. and LINDBLOM C.E. A Strategy of Decision, The Free Press, New York, 1963, p.258.
2. WALPOLE R.E. and MYERS R.H. Probability and Statistics

for Engineers and Scientists, Fourth Edition, Macmillan Publishing Company, New York, 1989.

3. LUCE R.D. and KRUMHANSAL C.L. Measurement Scaling and Psychophysics published in Stevens' Handbook of Experimental Psychology, Vol 1, Second Edition, published by John Wiley and Sons, New York, 1988, pp3-4.
4. LUCE R.D. and KRUMHANSAL C.L. Measurement Scaling and Psychophysics, Op Cit, p.7.
5. CHICKEN J.C. and HAYNS M.R. The Risk Ranking Technique in Decision Making, Pergamon Press, Oxford, 1989, p.83.
6. LINDLEY D.V. Making Decisions, Second Edition, John Wiley and Sons, London, 1985, pp21-29.
7. BROWN R.V., KAHR A.S. and PETERSON C. Decision Analysis for the Manager, Holt, Rinehart and Winston, New York, 1974, pp425-437.
8. VAN HORNE J.C. Financial Management and Policy, Eighth Edition, Prentice-Hall International Inc., 1989, pp64-68.
9. KOUTSOYIANNIS A. Non-Price Decisions, The Macmillan Press Ltd, London 1982, pp611-635.

## APPENDIX 5

### Rules for Deriving Data from Expert Opinion

(These rules were given in Ref.12)

The following six rules, if followed, should help to minimize the errors in interpretation of the opinions of experts:- (1) (2)

- 1) The experts consulted should have expertise in the field being studied.
- 2) Experts should also be asked to identify evidence that tends to contradict their opinions.
- 3) The problems on which expert opinion is sought should be kept down to an understandable size.
- 4) Analysis of the views of several experts is better than the view of a single expert.
- 5) Structured elicitation of opinions is better than unstructured questioning.
- 6) Mathematical analysis of opinions is better than some subjective view of opinion.

It must be remembered that no matter how carefully expert opinions are collected and analysed they will still remain qualitative opinions. The analysis will not convert them into quantitative data. It is sometimes difficult to decide how far a problem has to be decomposed to be of understandable size. Certainly a problem should be decomposed to the extent that it matches the expertise of the expert. Such decomposition may reveal parts of the problem for which there is no expert opinion.

Reference:-

- 1) VOGEL R C and WALL I B Some Observations on NUREG - 1150 A paper presented at the Probabilistic Safety Assessment and Risk Management Conference, PSA87, held in Zurich September 1987.

- 2) MOSLEH A et al      The elicitation and use of expert opinion in risk assessment: a critical review A paper presented at the Probabilistic Safety Assessment and Risk Management Conference, PSA87, held in Zurich September 1987.

## APPENDIX 6

### A General Description of Bayesian and Fuzzy Analysis

An analyst trying to assess the acceptability of a complex novel project is faced with the difficult problem of finding a way to measure acceptability even though there are few or no relevant quantitative data. Without quantitative data classical statistical methods of calculating probability are of little direct use. The analyst is faced with three options which are:- resort to qualitative analysis using natural language terms to describe acceptability, to use some form of synthesis of quantitative data or use a codified method of statistical inference such as Bayesian or Fuzzy Analysis.

Simple description of acceptability in natural language can give rise to many problems even if the terms used are codified and used in a consistent manner. Ideally the terms used should be related to some quantitative statement of acceptability, but given that no relevant data are available establishing such a relationship is not easy and certainly not precise. One good example of an attempt to relate qualitative statements of acceptability with satisfying a quantitative criteria of acceptability is given by the Civil Aviation Authority (CAA) requirements a civil aircraft has to satisfy. (1)(see Figure 8 in the main text). These requirements relate qualitative descriptions of accident severity and frequency to quantitative statements of acceptability. The main requirements document specifies that satisfaction of the requirements has to be demonstrated experimentally in a precisely defined way that builds up statistically acceptable evidence that the criteria will be satisfied. In other words the final decision about the acceptability of a design is deferred until the acceptability is proved experimentally. A decision maker does not always have the opportunity of waiting for experimental proof before making a final decision. However, the procedure does suggest that when relevant quantitative data are not available any decision about acceptability should be kept under review until the validity of decision can be justified in

quantitative terms.

An alternative to making a decision purely on a qualitative view is to attempt to synthesize the quantitative characteristics of the feature of interest from data on components similar to those from which the feature is made. The synthesizing process can be applied both to complete systems and the individual components that make up complete systems. Synthesis does not produce error free results. For simple engineering systems it has been suggested that for instrument systems the ratio of observed failures to failures predicted by synthesis there is a 96% chance of the ratio being within a factor of 4 of the median value. (2) The American space agency NASA stated that it was not able to use numerical assessment for its fault analysis as the data base it had was so small it would not produce precise failure rates. (2) The problem was exacerbated by the fact that although the NASA programme is massive the differences in configuration between each space shot make comparison of the data obtained from each shot of little value. In the financial area quantitative data about the significance of the risks involved in novel financial projects is equally difficult to establish and banks and insurance companies tend to adopt either a qualitative or a non-dimensional ordinal way of assessing the acceptability of risks. (3) Such methods can be loosely described as inferring the risk acceptability. So the next step is to examine what the formal methods of statistical inference have to offer as an aid to determining risk acceptability when there is little or no data available.

The starting point for any examination of statistical inference must be the work of the 18th Century English Clergyman Thomas Bayes. (4) Fuzzy Analysis has its origins in the form of analysis that Bayes originated, so there is no excuse needed for giving considerable emphasis in the discussion that follows to Bayes methods. Inference involves extrapolating from the known to the unknown. The following quotation from Sir Ronald Fisher's book "The Design of Experiments" helps to put the arguments that follow into perspective. "We may at once admit that any inference from the particular to the general must be attended with some degree of uncertainty, but this is not the same as to admit that such inference cannot be

absolutely rigorous, for the nature and degree of the uncertainty may itself be capable of rigorous expression." (5).

In mathematical terms Bayes' Rule can be expressed as follows:-

If events  $B_1, B_2, \dots, B_k$  constitute a partition of a sample space  $S$ , where  $P(B_i) \neq 0$  for  $i = 1, 2, \dots, k$ , then for any event  $A$  in sample space  $S$  such that  $P(A) \neq 0$ , is (6)

$$P(B_r | A) = \frac{P(B_r \cap A)}{\sum_{i=1}^k P(B_i \cap A)} = \frac{P(B_r)P(A | B_r)}{\sum_{i=1}^k P(B_i)P(A | B_i)}$$

for  $r = 1, 2, \dots, k$

In other words Bayes' Rule specifies a way of determining the conditional probability of an event given some of the other relevant data.

The Bayesian approach is intended to be applied to the analysis of distributions appropriate to problems for which the data is initially subjective. Subjective data representing belief about what the relevant parameters should be, rather than hard quantitative data such as the results of observation. A typical example of subjective data would be expert opinions about the acceptability of a novel project. Starting from an initial position, or prior position, when there is some subjective view about the data and its distribution it is possible to calculate the prior mean and prior variance. Then with the addition of some objective data it is possible to refine the prior view into a better estimate of the distribution. The refined distribution, known as the posterior distribution, does need a data input to make it any improvement on the prior distribution. Essentially the process involves extrapolation and because it involves extrapolation there must still be some uncertainty about the conclusions. (7). But it is important to remember that the Bayesian process is iterative, that is the results become more certain as more data are obtained.

The Bayesian approach can be applied to determination of: means, correlation, regression, contingency tables and analysis of variance. Essentially in all applications of the Bayesian approach the problem lies with identification of prior conditions and related basic data. This underlines the difficulty of assessing the acceptability of really novel projects for which there really are no data. It is just in this area that classical statistical methods are at their weakest as they make no allowance for the role of subjective data. The decision maker often has to make his decision on the basis of subjective data so what else has Bayesian analysis to offer. In the context of decision making the Bayes estimator and Bayes Risk have to be considered. (8) Assuming that the decision maker is concerned to make the correct decision an attempt must be made to evaluate the benefits resulting from a correct decision and any penalties that may result from making a wrong decision. The criterion that can be used is for the decision function  $\bar{\theta}$  to have the least penalty when the incorrect action is taken. The next step is to introduce a loss function  $L$  whose value depends on the true value of parameter  $\theta$  and action  $A$ .

The functional relationship is  $L(\bar{\theta}; A)$  and for decision making problems a loss function of the form  $L(\theta; A) = |\bar{\theta} - A|$  can be used or if two or more decision functions have to be considered  $L(\bar{\theta}; A) = (\bar{\theta} - A)^2$

Since  $A$  is unknown, the set of all possible values is known as the parameter space. For each possible value of  $A$  the loss function will have different value.

A risk function  $R$  can be defined for the decision function as  $R(\bar{\theta}; A)$  and this in turn defines the expected value  $E$  of the loss function in the following way:

$$R(\bar{\theta}; A) = E[L(\bar{\theta}; A)]$$

If a decision has to be made between two options  $\bar{\theta}_1$  and  $\bar{\theta}_2$  and the minimax criterion is adopted then the decision options  $R(\bar{\theta}; A)$  that is selected is the one that has the lowest maximum risk. Determination of the expected value may be very complicated, a fact belied by the simplicity of the expression  $E[L(\bar{\theta}; A)]$ .

In considering which choice to make between the options available a term called a Bayes' Estimator is sometimes used. The Estimator B is the Bayes Risk x the decision function which gives a minimum value. For example if  $\bar{\theta}_1$  and  $\bar{\theta}_2$  are decision functions then if  $B(\bar{\theta}_1) < B(\bar{\theta}_2)$  then it follows that  $\bar{\theta}_1$ , is the better decision.

Now to consider a practical example of a decision involving a public enquiry. Public Inquiries call for a tremendous amount of detailed information and take a year or more to reach their verdict. In Inquiries there are usually many groups presenting their cases and the chairman of the Inquiry has to make his decision on the basis of the evidence they present. The arrangement is analogous to any decision making process the chairman of the Inquiry could be equated to the chief executive of a company or a government minister. The influence of a particular group on the final decision has been characterised in the following way (9) :-

$$x_1 = a + b_2x_2 + b_3x_3 + b_4x_4 + \dots + b_nx_n + E$$

the	=	constant	+	contribution	+	contribution	+	contribution	+	contribution	+	error
chance of				of groups		of size of		of nature of		of all other		
winning				favoured		group		group		factors		
or losing				argument						considered		

While such a regression equation is attractive as theoretical expression a considerable amount of evidence is required to convert it into a practical tool for estimating influence. Even without the additional evidence the equation can help structure subjective analysis of a groups influence.

The diagram in Fig.A6.1 shows how Bayes Theorem can be used to iteratively refine an estimate of a proposal winning support in a mixed group of decision makers.

Bayes Theorem is expressed as  $P(H_1 | A) = \frac{P(A | H_1) P(H_1)}{P(A)}$

where	$P(A   H_1)$	=	likelihood
	$P(H_1)$	=	prior probability
	$P(A)$	=	sum of products of likelihood and prior probability for relevant calculations

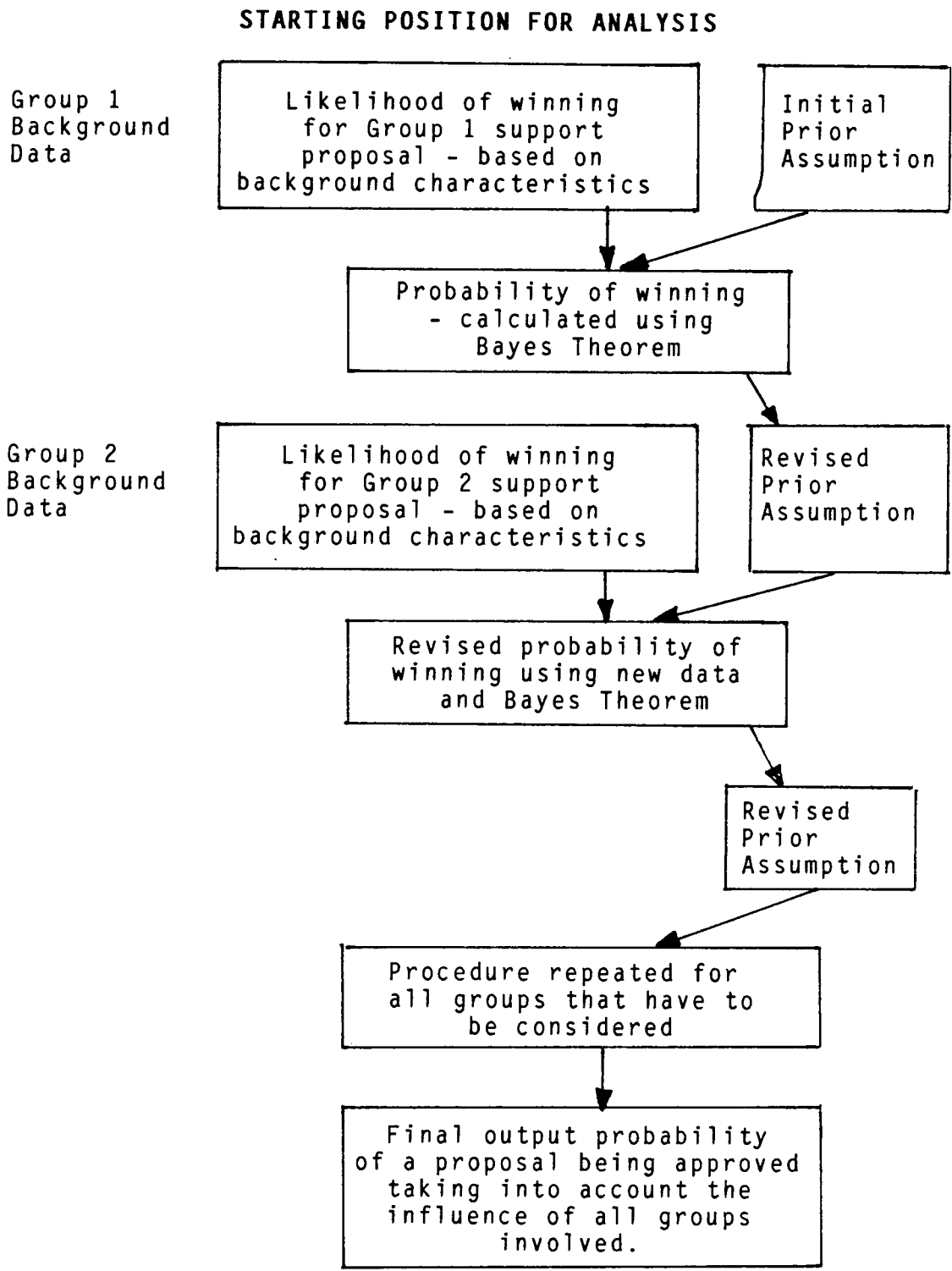


Fig.A6.1 Application of Bayes Theorem to estimating likelihood of a particular proposal winning support in a mixed group of decision makers

$$P(H_1 | A) = \text{standardised likelihood score obtained by aggregating likelihood and prior probability}$$

The result of the calculation is a statement about the probability of a particular proposal winning support from a mixed group of decision makers, the probability being between 0 and 1. Equally the calculation shows the probability of the group losing. As with all Bayesian analysis the more data there is about the performance of the group of interest the more the estimate of success or failure can be improved.

In the context of the discussion in this book the question that has to be answered is whether or not it is possible to have a prior distribution that expresses complete ignorance.

Assuming that the prior distribution can be described as

$$f(\pi) = C' \pi^{a-1} (1-\pi)^{b-1}$$

where:-

$$f(\pi) \text{ is the function governing the unknown population proportion } \pi \text{ and } 0 < \pi < 1$$

$$C' \text{ is a constant} = \frac{(a+b-1)!}{(a-1)!(b-1)!}$$

$$\left. \begin{array}{l} a \text{ is a non negative constant} \\ b \text{ is a non negative constant} \end{array} \right\} \beta \text{ distribution parameters}$$

If there is no prior information it can be argued that  $a = 0$  and  $b = 0$  which gives:-

$$f(\pi) = C' \pi^{0-1} (1-\pi)^{0-1}$$

$$= \frac{1}{C' \pi (1-\pi)}$$

which gives a 'U' shaped distribution curve.(10).

An alternative suggestion is to assume  $a$  and  $b$  are both equal to 1. Such an assumption gives a rectangular

distribution, which implies that every value of  $\pi$  between 0 and 1 is equally likely. In some ways the conclusion that all values of  $\pi$  are equally likely is a fair description of the implications of a state of complete ignorance.

However, a little understanding of the real world would suggest that a uniform distribution is very unlikely and that it would be more reasonable to assume that  $a$  and  $b$  are both greater than 0 but less than 1.

If the prior distribution is derived simply on the basis of a single analyst's opinion the view that the prior distribution is biased may be justified. Structured consultation with several experts with genuine knowledge of the subject being studied may yield a more helpful indication of the likely pattern of distribution. Although knowledge of prior distribution is conceptually indispensable to Bayesian analysis such knowledge is not always important in determining the exact shape of the posterior distributions.

This can be demonstrated as follows:-

If it is assumed the distribution of interest is a beta distribution and the posterior distribution mean

$$\mu = \frac{x + a}{n + a + b}$$

where  $n$  = is the sample size  
 $x$  = is the number of observations with the desired characteristics  
 $a$  and  $b$  are the  $\beta$  distribution constants of the prior distribution and have values between 0 and 1, or at a least small compared to  $n$ .

It can be seen that the characteristics of the prior distribution have little influence on the posterior distribution.

Although the Bayesian approach provides a way of improving prior predictions of the likely posterior distributions, as real evidence becomes available, it does not make prior distributions guessed in ignorance into precise

of a set that makes up the variant of set theory known as fuzzy set theory. It is stated that the originator of fuzzy set theory has described the aim of the theory as being: "The development of a methodology for the formulation and solution of problems which are too complex or ill-defined to be susceptible to analysis by conventional techniques". (11).

In fuzzy analysis for each component of a set it is possible to assign a degree of membership of the set. If for all components the degree of membership is 1 then the problem is not fuzzy. But if the degree of membership is between 0 and 1 then for those components with a membership of less than 1 their membership is fuzzy. This concept of the validity of a particular value belonging to a particular group or set of data has long concerned statisticians. One method of eliminating weak members of a group (outliers) is known as the Dixon test. (12). The method is based on an assessment of the ratio of the difference between the suspect value (outlier) and its nearest value and the difference between the suspect value and the most remote value.

Various methods exist for massaging the fuzzy members of a set. The object being to improve the veracity of the membership as a whole. The main methods are :- 1. To concentrate the fuzzy elements of a set by reducing the membership of the set by eliminating all members that are only partly in the set. 2. To dilute the set by increasing the membership of the set by including those members that are only barely in the set. 3. To normalize membership of the set so that at least one member has a degree of membership of 1. 4. The set can be intensified that is increasing the degree of membership for the members that have a degree of membership greater than 0.5. 5. Membership can be fuzzified this increases the degree of membership of members with a non-zero degree of membership.

Before looking in detail at the application of Fuzzy Analysis attention is drawn to the fact that even supporters of Fuzzy Analysis recognise that what can be explained by fuzzy subsets can also be explained in other ways. (13) One of the important roles seen for Fuzzy Analysis is the quantitative analysis of qualitative

descriptions of the subject being studied.

Moving now to consider the help that Fuzzy Set Theory can give to the art of statistical inference. Starting from the statement of set theory that the characteristic function of a set defines all the elements that make up the set. It is generalization about the degree of membership of a set that makes up the variant of set theory known as fuzzy set theory. It is stated that the originator of fuzzy set theory has described the aim of the theory as being: "The development of a methodology for the formulation and solution of problems which are too complex or ill-defined to be susceptible to analysis by conventional techniques". (11).

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Before looking in detail at the application of Fuzzy Analysis attention is drawn to the fact that even supporters of Fuzzy Analysis recognise that what can be explained by fuzzy subsets can also be explained in other ways. (13) One of the important roles seen for Fuzzy Analysis is the quantitative analysis of qualitative statements such as 'low', 'somewhat low', 'medium' and 'fairly high'. The essential preliminary step in the analysis of systems of comparative statements expressed in natural language is to establish a way of ranking their meaning. Such a step really amounts to giving a qualitative statement a quantitative significance. A simple description of the kind of relationship that can be established is given in Table A6.2. In analysis of real situations the relationship may be more complex and involve several levels of analysis.

Exploitation of Fuzzy Analysis for assessment of complex systems does depend on the use of a computer and for this purpose several programs have been developed including FRA and IPIRISK. (14) Even though in the future it may only be

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Qualitative Expression	Fuzziness or Uncertainty
Certain	1
Quite Probable	0.7 - 1
Probable	0.4 - 0.7
Improbable	0.0 - 0.7
Impossible	0.0

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**Table A6.2 Example of Relationship between Qualitative Expressions and Fuzzy Statements.**

necessary to press a few keys on a computer keyboard to complete a Fuzzy Analysis it is still important to understand the significance of the method. It is appreciated that in the world of consumer products Fuzzy Logic has already been put to use in making TV sets

automatically increase their brightness as the room grows darker and increases the sound volume when the viewer moves further from the set. (15) Also fuzzy-logic video cameras have been made to correct for shake in the arm of the operator so that an unblurred picture is produced. (15) At the heavier industrial level fuzzy control systems have been used to control furnaces for making cement (16), departure of subway trains and banks of elevators. (15).

Several attempts have been made to apply Fuzzy Analysis to assessment of the acceptability of risk, these attempts include references 17, 18, 19 and 20. In reference 17 an assessment of the acceptability of two major plants was made, which was not quite a complete Fuzzy Analysis but used a weighting index of distribution and degree of compliance. This underlines the problem that runs through all applications of Fuzzy Analysis that have to be based on guessed data and patterns. Essentially it is only when the data and patterns can be confirmed that confidence can be established in the conclusions derived from the analysis. In decision making terms this means confidence in the findings of the analysis can only be established post the decision as the project proceeds and real data is generated. This dilemma is always present, to some extent, in decision making.

In reference 18 Preyssl was more specific in his use of "Fuzzy Risk" analysis. In his findings he stresses that Fuzzy Analysis produces a grade of relative compliance with quantitative criteria of acceptability. To illustrate his analysis he presents the results of a study showing how the chance of a major release of radioactivity from a Triga nuclear reactor can be assessed. Complete details of the procedures used were not given.

Reference 19 is a particularly interesting paper as it starts from the problems associated with collecting the data to be analysed. In this case the data described abnormal occurrences recorded during the operation of a sample of 43 of the worlds major nuclear power plants. The aims of the study were to examine the data, to identify the pattern of abnormal occurrences and to examine the data to see what indication they gave of designers and operators learning from experience. The reports of occurrences often

entailed imprecise knowledge and/or incomplete or ambiguous verbal statements. By assigning a membership function to each piece of information, it was possible to make a fuzzy analysis of the data. The analysis produced a possibility of risky operation for each of the reactors in the sample. In the examination of the data for any indication of abnormal occurrences being reduced by learning from experience. Perfect learning was considered to be the situation in which there is no repeat of abnormal occurrences, at the other end of the scale there is zero learning. On this basis each piece of information was allocated a degree of membership of the learning set. From this data, using Fuzzy analysis methods a value for the index of learning was calculated. This index of learning showed that some more recent models of reactor had apparently learnt from the experience from earlier models and showed a reduction in abnormal occurrences.

## REFERENCES

1. JAR-25 Joint Airworthiness Requirements, Large Aeroplanes published by the Civil Aviation Authority Cheltenham, revised 17:3:86.
2. CHICKEN J.C. Risk Assessment for Hazardous Installations, published Pergamon Press, Oxford, 1986, pp 73-75.
3. See Chapter 3 of the main text.
4. IVERSEN G.R. Bayesian Statistical Inference Sage University Paper 43, published Sage Publications, Beverly Hills, 1984.
5. FISHER Sir R.A. The Design of Experiments, published Oliver and Boyd, Edinburgh, Reprint 1953, p.4.
6. WALPOLE R.E. and MYERS R.H. Probability and Statistics for Engineers and Scientists published Maximillan Publishing Co. New York, fourth edition 1989, pp39-40.
7. IVERSEN G.R. Bayesian Statistical Inference, Sage University Paper 43, published by Sage Publications Inc. Beverley Hills, 1984, p8.
8. WALPOLE R.E. and MYERS R.H. Probability and Statistics for Engineers and Scientists. Op Cit pp274-277.

9. BUDGE I. Representations of Political Argument: Applications within Meta-Planning. Political Studies, Volume XXVI Number 4, December 1978, pp439-461.
10. IVERSEN G.R. Bayesian Statistical Inference, Op Cit, pp29-31.
11. SCHMUCKER K.J. Fuzzy Sets, Natural Language Computations and Risk Analysis, published by Computer Science Press, Rockville, 1984, p.6.
12. LOWE C.W. Industrial Statistics Vol. 1. First Edition, published by Business Books Ltd., London, 1969.
13. SCHMUCKER K.J. Fuzzy Sets, Natural Language Computations, and Risk Analysis. Op Cit. p.16.
14. SCHMUCKER K.J. Fuzzy Sets, Natural Language Computations and Risk Analysis, Op Cit. p.43.
15. REID T.R. Fuzz Logic, but Japan puts it to work. International Herald Tribune, 5-6 January 1991, p.1 and p.8.
16. NORMAN P. NAVEED S. A Comparison of expert system and Human Operator performance for Cement Kiln Operation. Journal of the Operational Research Society, Vol. 41. No.11. November 1990., published by the Operational Research Society Birmingham, pp1007-1019.
17. PREYSSL C. CULLINGFORD M.C. SWATON E. Evaluation of compliance of risk-sources when uncertainty and risk-perception aspects are included. Presentation Material, publisher International Atomic Energy Agency, Vienna, 1985.
18. PREYSSL C. "Fuzzy Risk" Analysis Theory and Application, published International Atomic Energy Agency, Vienna, 1986.
19. CATTANEO F. DeSANCTIS S. GARRIBBA S.F. and VOLTA G. Learning from Abnormal Occurances; Results of a Fuzzy Analysis. Paper for the PSA '87 Conference, Zurich, Aug. 30 - Sept. 4 1987.
20. HAYNS M.R. and UNWIN S.D. A method to Incorporate Uncertainty and a Degree of Compliance in Safety Goals, paper for conference, San Francisco 1984.

## APPENDIX 7

### Summary of the World Bank's Guidelines on the use and selection of consultants by borrowers

The World Bank has issued Guidelines to borrowers on what they consider is good practice in the use of consultants. (1) These guidelines give an insight into the way the bank considers technical competence of suppliers should be judged. In the Guidelines the Bank stresses that before any proposals are invited the bank must approve the evaluation criteria it is proposed to use. For evaluation of qualifications and competence the Bank recommends the evaluation is based on three factors which are:- general experience, work plan and key personnel. Each factor is weighted on a scale of 1 to 100. In table A7.1 the weighting given to each factor and the fail and normal rating are summarized.

**TABLE A7.1 Summary of Ratings**

FACTOR	SCORE (SCALE 1-100)	PROPOSED WEIGHTING RANGE AND TYPICAL VALUE	WEIGHTED RATING
Firms general experience	a	0-1 - 0.2 Typical 0.15	a x0.15
Work plan	b	0.25 - 0.4 Typical 0.35	b x0.35
Key personnel	c	0.4 - 0.6 Typical 0.5	c x0.5

Equation for overall rating  $r = a \times 0.15 + b \times 0.35 + c \times 0.5$   
 If  $r$  is less than 60 the company would not be acceptable. The normal range for  $r$  is 60 - 90

The precise weighting factor used is determined by the assessor on the basis of his judgement of the significance of the factor for each proposal.

The extent to which price is used as a selection factor depends on comparability of the options being considered. All options may not be directly comparable. It is recommended that the price and technical evaluations of a proposal are carried out independently. The Bank does not recommend any specific method or procedure for assessing the acceptability of a price. But cautions that consideration of price should not be allowed to undermine quality.

### **Comment**

This method proposed for assessing the acceptability of consultants is suitable for assessing the acceptability of a wide range of suppliers.

### **Reference**

- 1 Guidelines "Use of Consultants by World Bank Borrowers and by the World Bank Executing Agency", published by the World Bank, Washington, 1981.

## APPENDIX 8

### Assessment of Computer System Risks by the Insurance Industry

The way proposals for insurance of the risks associated with computer systems are assessed varies from insurance company to insurance company. With companies with only a small portfolio of computer risks the assessment may be quite simple. But the companies that are specialists in computer and electronic equipment insurance have devised quite comprehensive assessment procedures and detailed guidance on good practice that proposers should follow. The assessment procedures used are based on risk analysis procedures that are used for the analysis of many complex systems such as: aeroplanes, weapon systems, nuclear power plants or chemical plants.

The first stage in assessing the acceptability of the computer system is to review the physical arrangements of the system. Such a review assesses the adequacy of (1)(2):- the general management of the system, fire protection, protection against water, protection against technical faults, protection against criminal acts, protection against environmental hazards and protection against other external effects. In Table A8.1 the essential questions that would be asked under each heading are outlined. Determining the acceptability of the answers to the questions outlined in Table A8.1 involves a systematic analysis of the significance of the evidence. There also has to be collaboration with the proposer so that the proposer has an opportunity to modify his installation to make it acceptable. The iterative adjustment of a proposal may also be associated with discussion about the extent of the cover provided and the premium required.

The adequacy of the arrangements for dealing with emergencies (loss of use of computer system) is an important subject in its own right but has special importance in relation to insurance. This importance stems from the fact that effective emergency arrangements can

**TABLE A8.1 Outline of Computer System Insurance Assessment Questions**

FEATURE	TYPICAL QUESTIONS
General Management	Is the management of the system knowledgeable. Is there an adequate supply of spare parts. Have effective maintenance procedures been adopted. Have effective arrangements been made for dealing with any emergency that may arise.
Fire Protection	<p>Building Provisions - Is the computer centre in a separate building, is fire resistant construction used, are cable runs smoke proof, can air ducts be shut off automatically, provision of emergency lighting.</p> <p>Organizational Conditions - Have fire regulations been established, are fire drills carried out regularly, are there fire proof safes for data.</p> <p>Fire Alarms/Extinguishers - Does fire alarm system conform with national requirements, is a fire extinguisher system installed, are there appropriate portable extinguishers provided.</p>
Protection against ingress of water	Are there water pipes in the vicinity of the computer room, is there a risk of rising water from drains or floods, is the roof water proof, is there a water detection system installed.
Protection against technical faults	Can the air conditioning system give rise to problems such as contamination or excessive humidity. Is the main power system reliable. Is an emergency power system provided. Is the installation protected against lightning, over-voltage and discharges of static electricity.
Protection against criminal acts	Are wall, ceilings, windows and doors of an anti-intruder design. Is access controlled. Are there parts of the building which cannot be monitored by television.
Protection against environmental hazard	Are there external vibrations that can harm the installation, are there intense electric fields that can harm the installation. Are there risks of explosions or release of harmful chemicals in the area.
Protection against other external effects	Is the installation resistant to storm damage, earthquakes. Is the installation on a flight path.

help reduce the losses that arise if an emergency situation occurs.

After a severe accident to a complex installation it may be important to get the system operating again as soon as possible, to prevent losses building up. If standby arrangements are adequate such losses will be minimized. However, there can still be high replacement costs for the insurer to bear. These costs can be reduced if the equipment can be restored. One specialist insurer has established a company to provide a computer system restoration service. The company has branches in Germany, USA, Switzerland, Austria, France, Italy, Spain, Australia and the Netherlands. Experience has shown that restoring rather than replacing damaged equipment can reduce direct losses borne by the insurer by 80%. For the insurance industry to establish a restoration service to reduce the losses associated with a particular activity is unusual, but the benefit in this specific case is clear.

## References

1. Computer Insurance, published Swiss Reinsurance Company, Zurich, Switzerland, 1987.
2. Catastrophes in Computer Centres, published Tela Insurance Company, Munich, Germany, 1985.

## APPENDIX 9

### Analysis of Costs and Benefits

Before any attempt can be made to quantify the costs and benefits of a particular project the nature of the costs and benefits relevant to that project must be determined. The first step in such analysis is determining the point of view from which profitability has to be judged. Clearly the acceptability of a proposal to build a car factory will be judged in different terms to a proposal to increase welfare payments. No matter what type of project is considered some allowance will have to be made for the life of a project. With a project of an engineering nature determination of the appropriate life may be relatively easy to define as it can be related to the wear-out of the various components, but with social projects determination of the appropriate life, if there is one, may be somewhat difficult.

In purely financial terms benefits have to be assessed on the basis of the total of direct and indirect revenues over the life of the project. Sometimes running costs are deducted from revenue to give a figure for total net revenue and total costs are considered as only capital costs. It makes very little difference to the usefulness of the analysis, provided the calculations are performed in a consistent manner and all the costs and all revenues are included. The definition of the costs and revenues that should be included is returned to later. The economic life as opposed to the wear out life of a technical project is quite hard to predict. The rapid developments in technology have shortened the useful life of many complex systems. Organisations have to change their equipment frequently just to keep up with the competition. For example computers, cars, automated systems and communication systems undergo fairly rapid change. Of course the lower the discount rate considered the more sensitive will be the analysis to the length of economic life considered. Discounting is a way of simplifying the analysis of the value of a stream of payments to a common base so that the various options are easier to compare.

The present value  $P_0$  of a stream of payments is equal to:-

$$P_1/(1+r)^1 + P_2/(1+r)^2 + \dots + P_T/(1+r)^T$$

or more briefly 
$$P_0 = \sum_{t=0}^{t=T} P_t / (1+r)^t$$

where  $P_0$  is the present value of a stream of payments  $P_1, P_2, \dots, P_T$  arising in years 1 to  $T$  and  $r$  is the discount rate. In the equation  $r$  is assumed to be constant over the period considered. In the real world  $r$  may vary over time, as the rate used in the private sector is normally the rate at which bank loans are available. In the public sector the discount rate may be set by some central policy body. This variation in the basis for determining discount rates underlines one problem in comparing private sector and public sector projects.

For decision making purposes it is sometimes helpful to consider the Net Present Value (NPV) or Net Present Worth (NPW) as it is sometimes called, as the basis for determining the relative merits of the options available.

NPW or NPV are the sum over the lifetime of a project of the discounted (benefits-costs) a project may be considered acceptable if  $NPV > 0$ . If several options have to be considered the most acceptable one will be the one that has an NPV which is more above 0 than the others.

If there is expected to be inflation during the life of the project the discount rate has to be modified to make allowance for the rate of inflation.

A variation of the NPV that is sometimes used is the Internal Rate of Return (IRR). The IRR is the discount rate required to make the NPV equal to zero. Using the IRR the criterion for minimum acceptability of a project is that the IRR should be greater than the rate used for determining the cost of the capital required. One advantage claimed for using the IRR is that it eliminates the need for choosing a discount rate. (1) However, in practice to make the analysis some knowledge of the discount rate is required. Provided that the proposers or planners have set the discount rate correctly, so that it properly reflects the need to control the distribution of

capital, then the NPV approach is preferred.

Other criteria for assessing the acceptability of competing proposals are: the payback period, output capital ratio and present value over capital ratio. With the payback period criterion the most acceptable project is the one with the shortest period for capital repayment. One criticism of this method is that it ignores the significance of the benefits that may occur after payback is complete. For the present value (PV) over capital (K) ratio approach projects that produce a value of  $PV/K$  greater than 1 are acceptable.

All projects passed by the  $NPV > 0$  criterion would also be passed by the  $PV/K$  criterion.

The figures used in the methods of analysis just mentioned will not be absolute values, there must be some uncertainty associated with them. Provided every cost and every benefit is taken into account. The significance of the uncertainty can be assessed by calculating the parameters using data from the upper and lower ends of the range of uncertainty. If some costs and benefits are omitted from the calculation the range of uncertainty will be greater. The results of such calculation allow two other criterion, which are known as the maximin returns and the minimax-regret to be used to determine the acceptability of a proposal. The maximin return criteria requires the option adopted to be the one with the largest minimum return. In other words the proposal that should be accepted is the one that appears to give the highest return even when the most adverse data is used to calculate the return. The minimax-regret criterion defines the most acceptable project as the one which would involve the greatest loss of gain if it was given up. The assumption implicit in making such assessment being that the data used in making the calculation for each option have equal degrees of uncertainty associated with them.

A more specific method for assessment of public sector investment is known as the social cost-benefit analysis (SCBA), which has been used to assess public sector investment in the third world. (2) The basis of the comparison of investment options would be to calculate the net benefit (NB) on the basis of the resulting exports X, imports M and domestic inputs D.

then  $NB = X - M - D$  where X, M and D are valued in consistent currency

For a proposal to be acceptable NB would have to be greater than 0. If several options have to be considered the option that would be most acceptable would be the one that showed the greatest NB. The problems associated with assessing the acceptability of investment proposals in third world countries are:

1. Doubts about the stability of the exchange rate
2. Reliable assessment of the impact of protective practices such as: tariffs, quota restrictions and subsidies.
3. Availability of labour with appropriate skills.
4. Availability of all the required support services.

The list of associated problems shows how using X, M and D in the simple way shown above may be misleading unless in their calculation the problem factors are effectively dealt with in a consistent way. Alternatively, but not so accurately, weighting factors may be used to take account of each problem factor. Such weighting factors may introduce more problems particularly if they are derived subjectively.

Assuming that the weighting factors can be used with confidence the net benefit equation could be written as follows:-

$$NB = a(bcd X - bM - cdD)$$

Where

- a is the weighting factor for exchange rate stability
- b is the weighting factor for impact of protective practices
- c is the weighting factor for labour availability
- d is the weighting factor for adequacy of support services.

The above equation gives a hint of the significance of the efficiency of pricing which has to be considered in economic cost-benefit analysis (ECBA). But that is not the only feature that has to be considered in assessing the

economic acceptability of projects in the public sector. It is sometimes convenient to consider projects from three aspects which are:-

1. Financial profitability - measured at market prices
2. Economic profitability - measured at efficiency prices
3. Social profitability - measured at social prices

To evaluate a particular project for which the final output cannot be measured directly in market price terms, because the output is in the form of some non-traded good, the composition of the costs involved should as far as possible be broken down into its constituent components such as traded goods, services and labour. Even when the components are identified there may be problems in pricing them as some may have no traded price analogue. Components may be traded, but not on international markets, for example a machine may be made for a very specific local duty that is not found anywhere else and labour may be so unskilled and lacking in education that it cannot be used elsewhere. A method of converting market prices into economic or social prices is sometimes accomplished using 'accounting ratios' (ARs). Various conventions have been proposed for making such conversions: some just consider the conversions for single goods, others adopt an average conversion factors for a group of factors. These variations in conventions together with the variations in exchange rates, prices and taxes all underline the magnitude of uncertainties that have to be allowed for in making an assessment of the acceptability of a project.

Public expenditure can sometimes be measured in terms of social opportunity cost. The rates of return in private industry or weighted average interest rates being used as the basis for comparative evaluation of the social opportunity cost. Where the discount rate used cannot be taken as an equilibrium rate, that is a rate that would lead to the optimum allocation of resources, an alternative measure like  $PV/K$  or  $NPV/K$ , may be used to measure the efficiency of resource use. Where  $NPV$  = net present value,  $PV$  = present value and  $K$  = capital.

In assessing the implications of social pricing

consideration has to be given to the weighting that should be adopted to allow for distribution of benefits that, as a result of the project being considered, would go outside the project country. An egalitarian view that all benefits are equal, no matter where they arise, is not entirely satisfactory when a project is being assessed in terms of the benefit it will give to the country in which it will reside. Weighting of the importance of a project also has to be considered for the time when benefits arise, it is possible more value may be attributed to benefits that arise in the immediate future than those that will arise a long time into the future. When project options aimed at satisfying the same specification, are being compared the time when the benefits will arise should be essentially the same. However, if different types of projects are all competing for the same block of money then the significance of the time distribution of benefits has to be weighted.

The specification of weights has in some way to reflect what is the desired distribution of benefits. The desired distribution may be quite different to the present distribution and it may be skewed in favour of a particular section of the population. Whatever the distribution that is decided upon it must be defensible both in terms of the evidence it is based on and its appropriateness to the people who will be exposed to the project. For example, if it is expected that consumption is to have an optimum value  $N$ . Then following the rules of diminishing marginal utility of extra consumption, if only lower consumption is possible it would have a marginally higher value  $N_1$  and if only higher consumption was possible it would have a marginally lower value  $N_2$ . For such a pattern of benefits a justifiable system of weighting could be for consumption level  $N$  weighting would be 1, for consumption level  $N_1$  weighting would be greater than 1 and for consumption level  $N_2$  weighting would be less than 1. Exactly how much the weightings of  $N_1$  and  $N_2$  would be above and below 1 would depend on the details of each specific case.

If a project is aimed at producing major structural changes in the pattern of a particular country's economy, or a company's structure, then it would be appropriate to weight the various options according to the likelihood that they would produce the required changes. It can be appreciated that for proposals that make a positive contribution to

achieving the required structural change would be given a weighting that would increase their acceptability. Proposals that would make a negative contribution to achieving the required structural change would be given weighting that would reduce their acceptability. Quantifying such weightings would involve a considerable amount of judgement, which would have a large subjective component and involve a considerable amount of policy making.

An interesting example of the application of Cost-Benefit Analysis that illustrates some of the points made above has been given by Brüser. (3) He applied Cost Benefit Analysis to the problem of assessing the acceptability of various proposals for road improvements in Africa-Caribbean-Pacific ACP countries. The criterion adopted was that if the value of the discounted investment costs for a project is lower than the value of the discounted road user savings (RUS), then the acceptance of the project on economic grounds is justified. This criteria can be expressed mathematically as:-

$$\sum_t^{\circ} [I(a_t)][1 + i]^{-t} < \sum_t^{\circ} [RUS(a_t)][1 + i]^{-t}$$

Where  $t$  = period under consideration (typically 15 to 20 years for road projects)

$I(a)$  = investment costs for project 'a'

$RUS(a)$  = road user savings resulting from project 'a',  $RUS =$  (the vehicle operating costs on the present road) - (vehicle operating costs on the road improved buy the proposed project)

$i$  = Discounting (or interest) a discount rate of 12% has been used on some of the projects considered

Brüser stresses that it is important that all potential projects are assessed according to the same economic criteria Ranking of the acceptability of competing options on the basis of profitability in economic terms, the most profitable being the most acceptable. It being accepted

that there may be a minimum level of profitability below which it is considered that the profit level is not sufficient to make it worthwhile going ahead with the project.

A similar approach has been developed for evaluating the merit of road maintenance operations as compared with rebuilding the road. The mathematical expression is slightly different to the one just mentioned and is as follows:-

$${}_tCM_t[1 + i]^{-t} + {}_t[VOC_t - VOCM_t][1 + i]^{-t} - {}_tI_t[1 + i]^{-t}$$

where  
 CM = costs of current and periodic maintenance of project  
 VOC = Vehicle operating costs on road  
 VOCM = Vehicle operating costs on maintained roads  
 I = proposed road rebuilding cost  
 t = period under consideration  
 i = discounting rate

While the methods Brüser used are simple and consistent it can be argued that they do not give a comprehensive evaluation of benefits. For example the equations, as written, do not make allowance for:- increased traffic, improvements in trade, time saved by vehicles being able to complete their journey's faster and extra pollution resulting from increased traffic. These criticisms, in a rather indirect way, indicate the factors that generate the uncertainty that has to be associated with the results of some calculations of cost benefit analysis. The degree of uncertainty may be very large when potential indirect losses and indirect benefits are left out of the calculation.

The general conclusions about cost-benefit methods that must be accepted are: the method does not give absolute results, the measure of uncertainty that has to be allowed for is the product of both the uncertainty in the data used and the accuracy with which the methods of calculation used describes the real world variations they purport to model. Despite the reservations about the degree of uncertainty

associated with the various forms of cost benefit analysis discussed it is accepted the method can still serve a useful purpose in giving an indication of the relative financial merits of competing options.

#### References

- 1 IRVIN G. Modern Cost-Benefit Methods, published by The Macmillan Press Ltd., London. 1978., reprinted 1984, pp15 - 17
- 2 IRVIN G. Modern Cost-Benefit Methods, Op Cit pp 61 - 63.
- 3 BRÜSER A. Economic Aspects of Road Transport Projects, The Courier No. 125, January - February 1991, published by the EEC Belgium, pp64 - 66.

## APPENDIX 10

### MULTI-VARIATE TECHNIQUES

It has been suggested by French that the tremendously increased computational capability resulting from the advent of the computer age in the 1960's allowed more complex models involving multidimensional, non-linear relationships to be explored.(1) This was followed in the 1980's by the view developing that simpler models could be more informative, provided the validity of the model was checked. The role envisaged for complex models being part of the process of checking the adequacy of simple models. The complex model showing whether or not there was any benefit to be gained from making the simple model more complex. These views recognise the fact that unless models are based on accurate information about a proposal and the interactions between all the factors involved misleading conclusions are likely to be indicated. An example of a good model is the representation of the behaviour of an aeroplane for the construction of a flight simulator for training pilots. A model of doubtful value, because of the information it would have to be based on, would be a model of the economy of a third world country with an unstable government.

A survey by Kathawala of quantitative techniques used by large and small organisations in the United States showed of the 226 organisations contacted 36% were unfamiliar with multi-dimensional scaling, 31% made no use of the technique, 19% made a little use of the technique, 10% made moderate use, 2% made frequent use and 2% made extensive use. (2) The five most popular techniques used by the 226 organisations surveyed were: forecasting, breakeven analysis, statistical sampling, computer simulation and regression correlation. With computer simulation being in the top five popular techniques it seems to imply a fairly high interest in multi-variate techniques, higher than suggested by just 14% of users making moderate or greater use of multi-dimensional techniques.

There are several possible approaches to assessing the acceptability of proposals that are made up of several

different independent variables. The basic stages of such assessments are :- (3)

1. Structure the problem.
2. Determine how the various variables are to be rated.
3. Determine the significance of the individual variables for the case being considered and the overall significance of the variables considered. Determining the overall significance requires that the rating of each factor is weighted to put its significance in the correct proportion to the other factors. (This is the procedure adopted in the Risk Ranking Technique).
4. On the basis of rating of significance, determine the acceptability of the proposal.

Structuring the problem is the foundation on which any analysis has to be built. If the structure is not correctly specified, such as by the omission of a variable, the whole validity of the analysis is undermined. In the case of the Risk Ranking Technique the analysis of proposal variables is brought together under the headings: technical, economic and socio-political. The overall view of the acceptability of these three main variables has to be built up from the analysis of the sub-variables from which they are composed.

Determination of how the various variables are to be rated, is essentially setting the criteria for judging acceptability. Many of the possible methods of rating variables have been reviewed by Slovic, Lichtenstein and Fischhoff. (4) Some methods they mention such as Edwards Simple Multiattribute Rating Technique (SMART) and the Multiattribute Utility Models are, because of the calculation steps they involve, more complicated to use than the Risk Ranking Technique. An important point, that Slovic et al make in their review, that must be commented on is that: reference to money aspects of a proposal will focus attention on monetary aspects of acceptability whereas an ordinal rating of acceptability will focus attention on probability. These really represent two quite different stages in an assessment and this point has been

catered for in the Risk Ranking Technique. Evaluation of monetary aspects specified as taking place at the rating of factors stage and ranking of overall acceptability is made in a non-dimensional ordinal form. This ordinal expression of overall acceptability gives a numerical indication of likely acceptability on a consistent basis. The question of weighting the significance of factors relative to one another is of special importance. In the discussion of the Risk Ranking Technique in the main text it proposed the three factors; technical, economic and socio-political, should be given equal weight. As a generalisation, particularly project assessment, this is likely to be the best assumption. However, it has to be recognised that there may be special decision making environments in which one factor has to be considered as having overriding importance and other factors made subsidiary or even disregarded. Examples of such special environments are:- wartime, a state of national emergency and a time of special financial restriction.

In multi-variate analysis like any other form of analysis allowance has to be made for the spread of uncertainty in the data used. Also in the case of major decisions, of the type considered in this study, decisions about acceptability have to be kept under review during the life of the project. The decision making environment may change during the life of a project. The need for a project may disappear, it may be found technical objectives cannot be satisfied, sources of funding may disappear and the project may become unacceptable to the public.

In his survey of the status multiple criteria decision making Stewart drew several conclusions, two of the conclusions he made are particularly apposite to this study, they are:- 1) Any aids to decision making based on multiple criteria decision making should be simple and efficient to use. 2) The problem of how to deal with uncertainty with multiple criteria decision making methods is a problem that still has to be solved.(5) The Risk Ranking Technique appears to satisfy both these requirements. It is simple to use and the presentation of Ranking in the three dimensional form allows it to display the magnitude of uncertainties in the ranking.

## REFERENCES

1. FRENCH S. Editorial - Journal of Multi-criteria Decision Analysis Vol. 1 Issue 1 July 1992 published by John Wiley and Sons Ltd, Chichester.
2. KATHAWALA Y. Applications of Quantitative Techniques in Large and Small Organisations in the United States: an Empirical Analysis. The Journal of the Operational Research Society Vol 39, No.11, pp 981-988, published by Pergamon Press, Oxford 1988.
3. HOGARTH R. Judgement and Choice Second Edition, published John Wiley and Sons, Chichester, 1987 pp 280-285.
4. SLOVIC P., LICHTENSTEIN S., FISCHHOFF B., Decision Making, presented as Chapter 10 in Stevens' Handbook fo Experimental Psychology, Volume 2, Second Edition published by John Wiley and Sons, Chichester 1988.
5. STEWART T. J. A Critical Survey on the Status of Multiple Criteria Decision Making Theory and Practice in OMEGA International Journal of Management Science Vol.20, No.5/6, pp 569-586, 1992. Pergamon Press, Oxford.

