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**UTILIZATION OF PROFESSIONAL ABILITY IN ORGANIZATIONS
- A LISREL MODEL OF THE CANADIAN ENGINEERING PROFESSION**

by

DEREK B. A. CHASE, B.A.Sc. (Honours)

**A thesis submitted to
the Faculty of Graduate Studies and Research
in partial fulfilment of
the requirements for the degree of**

Master of Management Studies

School of Business

Carleton University

Ottawa, Ontario

19 September, 1995

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UTILIZATION OF PROFESSIONAL ABILITY IN ORGANIZATIONS -
A LISREL MODEL OF THE CANADIAN ENGINEERING PROFESSION

submitted by Derek Chase, B.A. Sc. (Hons.)
University of Toronto, 1952

in partial fulfillment of the requirements for
the degree of Master of Management Studies

Thesis Supervisor

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July 18, 1995

ABSTRACT

Research into the antecedents and outcomes of the utilization of professional ability (UPA) in organizations is reported. Utilization is the effective use of professional skills and acquired proficiency.

A theoretically based LISREL structural equation model was tested, using a random survey of professional engineers in Ontario. It established that engineers who are assigned greater professional responsibility by their organizations experience more effective utilization than those who are not, and that those who work in an organic organizational structure, with professionally oriented human resource practices, and with a supervisor who demonstrates competence in managing professionals, also experience more effective utilization. A hypothesis regarding the effect on utilization of having strong career aspirations was partly supported, but a hypothesis regarding the effect on utilization of remaining current with professional developments was not supported. Job satisfaction, and organizational commitment were confirmed as positive outcomes of utilization.

TABLE OF CONTENTS

Acceptance Form.....	ii
Abstract.....	iii
Table of Contents.....	iv
List of Tables	vii
List of Figures	viii
List of Appendices	ix
 CHAPTER ONE: INTRODUCTION	1
1.1 Managerial and Research Objectives.....	1
1.2 Professional Engineers and the Economy.....	3
1.3 Why Study the Utilization of Engineers' Professional Ability in Organizations?	5
1.4 Growth of the Canadian Engineering Profession.....	7
1.5 Financial Benefits of Increased Utilization ...	12
1.6 Organization of the Thesis	17
 CHAPTER TWO: THE UTILIZATION OF PROFESSIONAL ABILITY.....	20
2.1 The Utilization of Professional Ability Defined.....	20
2.2 Professional Utilization - A National View ...	21
2.3 Utilization - The Professional's View	26
2.4 Management's Views.....	35
2.5 The 1986 Utilization Survey	35
2.6 Summary	38
 CHAPTER THREE: PROFILE OF THE ENGINEERING PROFESSION	40
3.1 Engineering Professionalism	41
3.2 Canadian Professional Practice	47
3.3 Professionalization	53
3.4 Professionals in Organizations	56
3.5 Summary	63
 CHAPTER FOUR: THE PROFESSIONAL AND THE ORGANIZATION	65
4.1 The Motivation of Professionals.....	65
4.2 Management of Professionals.....	77
4.3 Antecedents of Utilization	81
4.3.1 Professional Competence	81
4.3.2 Career Aspirations	87
4.3.3 Professional Responsibility	90
4.3.4 Organization Structure	94
4.3.4.1 Organic vs. Mechanistic Structures..	94
4.3.4.2 Mintzberg's Design Configurations ..	98

TABLE OF CONTENTS - Cont'd

4.3.4.3	The Matrix Structure	99	
4.3.4.4	Dual Career Ladder Management	100	
4.3.5	Organizational Practices	102	
4.3.5.1	Support Personnel	102	
4.3.5.2	Training and Development Programs ..	105	
4.3.5.3	Performance Evaluation & Rewards ...	108	
4.3.6	Supervisory Competence	110	
4.4	Outcomes of Utilization	115	
4.4.1	Job Satisfaction	116	
4.4.2	Organizational Commitment	120	
4.4.3	Other Outcomes	122	
4.4.3.1	Obsolescence	122	
4.4.3.2	Job Mobility	124	
4.5	Biographic Characteristics	125	
4.6	Summary	126	
CHAPTER FIVE: A THEORETICAL MODEL OF PROFESSIONAL ABILITY			
	UTILIZATION	130	
5.1	The Utilization of Professional Ability	131	
5.2	Antecedents of Utilization	131	
5.2.1	Professional Competence	132	
5.2.2	Career Aspirations	135	
5.2.3	Professional Responsibility	136	
5.2.4	Organizational Structure	137	
5.2.5	Organizational Practices	139	
5.2.6	Supervisory Competence	140	
5.3	Outcomes of Utilization.....	141	
5.3.1	Job Satisfaction	142	
5.3.2	Organizational Commitment	143	
5.4	Summary	144	
CHAPTER SIX: PROCEDURES AND MEASURES.			145
6.1	Overview of the Research Design	145	
6.2	Procedures	146	
6.3	Measures	148	
6.3.1	Utilization of Professional Ability ...	149	
6.3.2	Professional Competence	151	
6.3.3	Career Aspirations	152	
6.3.4	Professional Responsibility	153	
6.3.5	Organizational Structure	154	
6.3.6	Organizational Practices.....	155	
6.3.7	Supervisory Competence.....	157	
6.3.8	Job Satisfaction	157	
6.3.9	Organizational Commitment	158	
6.3.10	Demographic Descriptors	159	
6.4	Summary	159	

TABLE OF CONTENTS - Cont'd

CHAPTER SEVEN: RESULTS	161
7.1 The Data	161
7.2 The Measures	166
7.2.1 Utilization of Professional Ability ...	166
7.2.2 Professional Competence	174
7.2.3 Career Aspirations	177
7.2.4 Professional Responsibility	178
7.2.5 Organizational Structure	179
7.2.6 Organizational Practices.....	184
7.2.7 Supervisory Competence.....	188
7.2.8 Job Satisfaction	190
7.2.9 Organizational Commitment	191
7.2.10 Summary of the Measures	191
7.3 Bivariate Correlations Between the Measures...	193
7.3.1 Between Measures of Same Concept	193
7.3.2 Between Endogenous and Exogenous Measures	198
7.4 The PRELIS Program - Preparation for LISREL...	207
7.5 The LISREL Model of Utilization	208
7.6 A Multiple Measure Model of Utilization	227
7.7 Summary	229
CHAPTER EIGHT: DISCUSSION AND CONCLUSIONS	233
8.1 The Utilization of Professional Ability Construct	233
8.2 The Causes of Utilization of Professional Ability	236
8.3 The Consequences of Utilization of Professional Ability	238
8.4 The LISREL Models of the Utilization of Professional Ability	239
8.5 Implications of the Research	241
8.6 Contributions and Limitations of the Thesis ..	244
8.7 Suggestions for Future Research	246
REFERENCES	248

LIST OF TABLES

Table 1	Importance of Utilization of Engineers and How Characteristic it is of their Jobs	30
Table 2	Indicators of Utilization Problems Among Engineers.....	31
Table 3	Portion of the Average of 31% of Time Spent on Non-Engineering Tasks that can be Delegated to Others.....	33
Table 4	Characteristics of Respondents	163
Table 5	Comparison by Bachelor Year.....	165
Table 6	Utilization of Professional Ability	167
Table 7	Importance of Utilization of Engineers and How Characteristic it is of their Jobs - With Canadian Results	170
Table 8	Indicators of Utilization Problems Among Engineers, Including Results of Study	172
Table 9	Extent of Organic Management Scale - Characteristics of the Subscales	181
Table 10	Comparison of Mintzberg's & Organic Structure Sub-Measures	183
Table 11	Characteristics of the Original Concept Measures	192
Table 12	Correlation Coefficients Between the Measures of the Same Concept	194
Table 13	Correlation Coefficients With Dependent Measures	199
Table 14	Error Measures for the Indicators in the Utilization Model	213
Table 15	Utilization Model Fit Assessment with Various Free Linkages	216
Table 16	Two Basic Structural Equation Models of Utilization - Maximum Likelihood Coefficients - Standardized Solution	218
Table 17	A Parsimonious Structural Equation Model of Utilization - Standardized Solution	224
Table 18	Sensitivity of Error Measures in the Utilization Model	226
Table 19	Effect of Different Measures on the Parsimonious Fit Model	226

LIST OF FIGURES

Figure 1	Antecedents of the Utilization of Professional Ability in Organizations	127
Figure 2	Direct Outcomes of the Utilization of Professional Ability in Organizations and of its Antecedents.....	128
Figure 3	Model of the Utilization of Professional Ability in Organizations	133
Figure 4	LISREL Model of the Utilization of Professional Ability	209
Figure 5	Basic Structural Equation Model of Utilization Showing Structural and Measurement Relationships	211
Figure 6	Two Basic Structural Equation Models of Utilization with Maximum Likelihood Estimation Coefficients	216A
Figure 7	Two Parsimonious Structural Equation Models of Utilization	222
Figure 8	A Multiple Measures Model of Utilization	228

LIST OF APPENDICES

APPENDIX 1	Research Propositions	267
APPENDIX 2	Letter of Transmittal	268
APPENDIX 3	Scales for the Study	269
APPENDIX 4	Questionnaire	282
APPENDIX 5	Engineering Utilization Index	292
APPENDIX 6	Responses to the Questionnaire	293
APPENDIX 7	Dictionary of Questionnaire Items	302
APPENDIX 8	Dictionary of Derived Items	307
APPENDIX 9	Brief Introduction to LISREL	310

CHAPTER ONE

INTRODUCTION

The purpose of this chapter is, first, to describe the managerial problems being addressed in this thesis and the associated research objectives adopted. The role of professional engineers in the national economy is introduced, and reasons for studying professional ability utilization in organizations are described. Forecasts of the anticipated reduction in the rate of increase of new engineers, and the expected limitations in government funding are reviewed to show that future shortages are likely in some disciplines. The potential financial benefits of increased utilization of the existing cadre of professional engineers are calculated. The chapter concludes with an overview of the organization of the thesis.

1.1 Managerial and Research Objectives

The major managerial problem being addressed in this thesis is *How can more effective utilization of professional ability be achieved?* An additional question is: *Does greater utilization of professional ability lead to greater job satisfaction and organizational commitment?* Satisfaction is defined as the complete fulfilment of the personal needs associated with professional work, while organizational commitment is the strength of an individual's involvement

with a particular organization.

The first problem is of interest to organizational decision makers who employ and manage professionals, and to government decision makers who are responsible for labour and industrial policy and its implementation. Both of these groups have an interest in the economic benefits of greater utilization of human resources. The second problem is also of interest to these groups, and job satisfaction is of particular interest to individual professionals.

To address these managerial problems, this research had two specific objectives. The first was to provide a comprehensive description of the current state of utilization of professional ability among professional engineers. Chapters Two, Three and Four of this thesis review the relevant literature on the utilization of professional ability, on the engineering profession, and on the professional and the organization.

The second objective was to develop a model of the major antecedents and outcomes of the utilization of professional ability (UPA) based on prior theoretical and empirical studies, and to test it by surveying the engineering profession. Antecedent factors studied included the currency of professional competence, the degree of career aspiration, the extent of professional responsibility, the influence of the organizational structure, the effectiveness of professionally oriented organizational practices, and the degree of supervis-

ory competence. The two outcomes studied were job satisfaction and organizational commitment. A finding of strong association between the antecedents and outcomes of utilization would provide a strong incentive for individual engineers and the organizations in which they are employed to improve present practices where these were found wanting.

1.2 Professional Engineers and the Economy

Porter (1991: 73), in his study for the Government of Canada, suggested that "innovation in its broadest sense is the critical requirement for economic upgrading and increased prosperity". However he cautioned that:

the underpinning of competitiveness, and thus of a country's standard of living, is productivity. Productivity is the value of output produced by a day of work or a dollar of capital invested...To achieve sustained productivity growth, an economy must continually upgrade itself ...The capacity of an economy to upgrade its competitive potential depends on...its workforce, its infrastructure, its post-secondary educational institutions, and its public policies (p. 5) ...[but] compared to other countries examined in our research, Canada has few scientists, engineers and technical workers in its labour force [p. 90].

While Canada awards about the same number of baccalaureates in engineering per capita as does the U.S.A. (2.5 and 2.9 degrees per 10,000 of population, respectively), Japan awarded two and a half times as many (6.2 degrees per 10,000) as does Canada (CCPE 1988). In Germany, the number of engineering degrees as a percentage of population is as much as three times higher than that in Canada (Mascolo et al.

1985: 11). Concerns similar to Porter's were expressed in the report of the Ontario Premier's Council entitled "Competing in the New Global Economy" (Ontario, 1988: 222) and in Johnston's (1991) study of the global workforce.

During the last two decades there has been a decline in commercial manufacturing in North America and with it a corresponding decline in manufacturing engineering jobs. A number of authors (Glover 1992; Rajan 1987; Cohen and Zysman 1987) believe that the post industrial thesis described by Harvard sociologist Daniel Bell (1973) is inaccurate in its stress on a non-manufacturing service economy. In their view, a manufacturing economy based on professionally developed new technology remains the critical activity around which others revolve, and is essential for enhancing the quality of life for a growing global population. Glover (1992) argued that "while in major industrial countries employment in services has come to include about two-thirds of the labor force, with manufacturing only accounting for around a fifth, the decline of manufacturing as a source of employment and wealth...mean[s] that the significance and weight of manufacturing is growing" (p. 33). He supported the case for manufacturing with the view that "technically more sophisticated people will usually be more prosperous and powerful than technically less sophisticated ones" (p. 40). Abernathy, Clark and Kantrow (1983) and Dertouzos, Lester and Solow (1989) have urged the U.S.A. to regain its competitive

edge in manufacturing technology, and Hayes and Abernathy (1980) has argued for greater technical competence in the management of manufacturing technology. In recent years, lower inflation and interest rates, and a rise in the value of the Japanese yen relative to U.S. and Canadian dollars, has corrected financial factors that contributed significantly to the transfer of manufacturing to South-East Asia. Engineers have a critical role to play in re-establishing the manufacturing sectors of the North American economy, but the number of manufacturing engineers declined significantly with the transfer. Effective utilization of the existing pool of experienced engineers is thus essential.

1.3 Why Study the Utilization of Engineers' Professional Ability in Organizations?

Ability utilization, in simple terms, is the extent to which a person's special skills are being used. According to Gove (1986: 1811) professions require "a high level of training and proficiency". These skills are expensive to acquire both for the individual and for society, and thus the effective use of professional skills is important.

The utilization of professional ability is worth studying because of the potential benefits to individual organizations employing or retaining professionals, to the nation and to individual professionals. Organizations benefit from an improvement in productivity and competitiveness of the

professional workforce. The nation gains through greater domestic output from the existing pool of professionals and through a reduced need to increase the capacity of engineering schools during financially strained times. Individual professionals also gain through a better understanding of the desirability of influencing their own work scope and job performance measures and managing their careers in organizations.

Many professionals practice within an organizational setting, especially nurses, technologists and doctors in hospitals, and professors and teachers in educational institutions. Professional engineers also can be found in a wide range of organizations (including private industry, government and education) in a large variety of occupations, and at all levels of responsibility. Effective utilization of the talents of the profession paid to be "ingenious", and which represents almost one percent of the total Canadian labour force, will be shown in this Chapter to have far-reaching benefits.

A strong interest in research on the utilization of professional engineers started in the mid-1950s, and lasted about ten years. (These studies are reviewed in Chapter Two). Since the end of this period not as much directly relevant work has been done. However, two significant, empirical studies were those by Ritti (1971b) and, more recently, by the American Association of Engineering Societies (AAES:

1986). The latter study, surveyed a large number of American engineers and developed an Engineering Utilization Index (EUI), using factor analysis of the data, which was used for subsequent correlation studies. Ritti's work and the AAES study, which will be reviewed in detail, draw conclusions but did not attempt to develop overall theories of utilization. The present research presents and tests a model of the utilization of professional ability in organizations.

1.4 Growth of the Canadian Engineering Population

CCPE's Canadian Engineering Human Resources Board (CEHRB 1992) forecast that while there is a surplus of 7,000 engineers at present (mainly as a result of the present economic climate), Canada could experience a shortage starting in the middle of this decade, reaching a total of about 12,000 by the year 2002 even with increased immigration.

Fechter (1991), commenting on a U.S. forecast of the anticipated shortfall in engineering graduates, which was based on a model similar to that used by CEHRB, suggested that such forecasts, based on past trends, were not very useful for policy formulation. A deeper understanding of future demand would be more useful, he argued, and would address such questions as: "How should we define demand? How much growth do we want to see in our pool of engineering talent? What constraints exist as barriers to such growth? How can we accommodate those barriers?" (p. 12).

A U.S. break with past patterns of rapid growth, starting in the 1980s, has also been borne out by Canadian experience. In 1956, for example, the National Conference on Engineering, Scientific and Technical Manpower (NCESTM 1956) recommended that "by 1980, to remain competitive with other industrial nations ... Canada will need to at least triple and probably quadruple [the] currently employed total of some 40,000 engineers" and to do so "we will have to increase our university enrolment by 1980 by as much as 3 - 4 times to satisfy our indicated requirements" (1956: v). In 1970, the Ring of Iron study (Lapp, Hodgins and Mackay 1970) reported that the engineering undergraduate enrolment in Ontario had increased from 3,200 in 1955 to 8,400, and projected an enrolment of 13,000 by 1980. (In fact, the Ontario enrolment was to reach 13,800 by 1980, more than quadrupling the 1955 figure.) During the same period, the total Canadian full-time engineering student enrolment tripled to 35,700 between 1955 and 1980, having grown at a compound rate of 4.5 percent per annum, and thus achieving the size recommended 25 years earlier by the NCESTM. Engineering student enrolment, however, was to flatten out during the decade of the 1980s (the rate of increase declining steadily between 1982 and 1989) to reach a total enrollment of 36,700, and thus recording a total increase for the decade of less than 3 per cent (i.e. only 0.3% per annum!). The significant increase of 11 per cent in enrollment that took place between 1989 and 1991

has not continued and there are strong indications that the pool of engineering graduates will shrink during the next few years (NSERC 1989: 170).

The reasons for the significantly reduced rate of growth in engineering enrolment are to be found partly in the decrease in Canada's population in the 18 to 24 year old age group, the pool of potential students (NSERC 1989: 165). The participation rate (defined to be the ratio of the total number of full-time Canadian and permanent resident students attending Canadian universities divided by the total 18 to 24 year age group population) was 15.7 percent in 1989. If the participation rate remains constant, the number of full-time students is expected to decrease by about 13 percent by 1997. Even by the year 2003, the total number of full-time students would only be about 89 percent of the current number. In order to maintain the number of full-time students at 1989 levels, the proportion of the population attending universities as full time students would have to be 18 percent larger (p. 170). While there has been an increase in the proportion choosing a university education, there has been a downward trend in the proportion of students who choose engineering, such that the absolute numbers are decreasing (p. 165). The same trend down has been taking place in engineering technology courses at Ontario's Colleges of Applied Arts and Technology (Clarke and Reavley 1990) so that no easing in the demand for professional engineers through an

increase in engineering technology graduates is likely.

Canada, traditionally, has relied heavily on immigrants for its professional engineering labour force. Over the 10 year period from 1970 to 1980, 16,000 engineers immigrated to Canada and 46,000 received degrees in Canada, a ratio of more than one to three (Mascolo et al 1985: 7). Recent immigration practices, however, have favoured family reunification, thus reducing the number of qualified professional engineering immigrants compared to those in the post-war decades. In the future, the global competition for qualified engineers may continue to restrain the level of immigration. At the same time, a provision in the North American Free Trade Agreement (NAFTA) will make it easier for Canadian professional engineers to find work in the U.S.A. and thus to consider emigration. These factors will tend to reduce the proportion of Canadian engineers in the total labour force and thus aggravate anticipated shortages.

Women have been increasing their participation rate but at present they still only represent 16% of the total full-time undergraduate engineering enrolment, whereas they represent 45% of the business and commerce enrolment (Baignée 1990, 1991). Greater participation is a very promising avenue for increasing the number of engineering graduates if past traditions of employment can be changed.

The University of Toronto Career Centre has reported that starting salaries in recent years have been higher for

engineering than for either business, arts, or science graduates. If even greater financial rewards were reflected in engineering enrollment, it would take up to eight years after such salary increases became apparent before the shift in career choices showed up as registered engineers (i.e. 4 years university plus 4 years of post Bachelor degree experience).

By way of contrast, the full-time commerce enrolment, which was about one third of the full-time engineering enrolment in 1955/56, was equal by the early 1970s, and was 50% larger in 1990/91 (StatCan 1991). The large pool of business and commerce graduates, academically trained in general management skills, are now competing for middle management positions which in an earlier period have been available to engineers trained on-the-job. A study of high school students in Britain (Smithers and Robinson, 1986), showed that, there too, there has been a significant increase in the number of students choosing business and accounting, and a drop in applications for physics and maths. Students felt that "they were more likely to do well with a business education than specific scientific or technological training which could compartmentalise them", or as one student said: "Why be a scientist when I can be his boss?" (p. 69). In Chapter Four there is a discussion of the importance of professional engineers becoming more competent in the management of their professional work, and of the work of other

engineers and technicians whom they direct, as a means of improving the overall utilization of professional ability. Greater stress on the management role of engineering may also redirect some students presently enrolling in commerce courses toward engineering schools.

1.5 Financial Benefits of Increased Utilization

A Past President of the Canadian Council of Professional Engineers (CCPE), which represents all engineers, has warned that "there is abundant evidence that many Canadian firms do not use engineering and innovation as sources of strategic advantage [and] this under-utilization of engineers in Canada concerns CCPE's constituent associations" (Bouchard 1993). An alternative to increasing the supply of new engineers is to make better use of the engineering capability of the present pool of engineers. Increasing the utilization of professional engineering ability of the experienced population could provide immediate benefits to the nation equivalent to training new engineers and at a significant cost saving.

There are two ways to estimate the macroeconomic benefit to the nation of an improvement in the utilization of engineers. The first is through the cost savings resulting from the need for fewer engineers to do a given amount of work. The second is through a reduction in the cost of graduating an increasing number of engineering students.

There are about 145,000 professional engineers in Canada and they represent 0.9% of the total labour force (CEHRB 1989: 1,2). The total cost of their salaries based on the reported median of \$65,000 per annum (PEO 1995: 7) and employment fringe benefits, of say 25% of salary, is equal to almost \$12 billion. Each 1% improvement in utilization would be equivalent to a national, or macroeconomic, "saving" of \$120 million per annum. To the extent that an engineer's contribution to the output of the economy is greater than his or her cost input, the true benefit is correspondingly greater. Evidence will be provided in Chapter Four that greater job satisfaction and organizational commitment are linked to lower job turnover. If a strong association can be shown to exist between the utilization of professional ability, on the one hand, and job satisfaction and organizational commitment, on the other, then further cost savings, associated with training and inefficiency as a result of personnel turnover and the introduction of new employees, can result from greater utilization of ability. A similar, microeconomic benefit, argument can be made at the individual organizational level.

Macroeconomic benefits of improved utilization can also be obtained through the cost saving of not having to educate the corresponding number of additional engineers which would otherwise be required. These incremental costs would be incurred for additional staff, new engineering facilities and

their operating and maintenance costs. The anticipated financial budget pressures on Canadian provincial governments, responsible for higher education, over the next few years, however, will make it difficult for them to finance the human and material resources needed to increase enrollment.

Based on the number of engineers who are reaching retirement age (CEHRB 1989:3), retirements are expected to average about 1,800 per year. If the annual immigration continues at the historical rate of about 1,200 (p. 15), and Canadian engineering graduates continue to register as professional engineers at the historical rate of about 70% of the graduating classes (i.e. 5,000 out of 7,000 per year), the net annual growth in membership will be 4,400 (i.e. $5,000 + 1,200 - 1,800 = 4,400$). This is a rate of increase of 3 per cent per annum, and, if maintained, would result in a total of over 170,000 members in the year 2000. Since average annual increases in engineering membership over the decade ending in 1988 averaged 3.5 per cent, or about 5,000 (p. 2), the expected increases of 4,400 are equivalent to an annual shortfall of 600 relative to the past trend. A reduction in enrollment and immigration would, of course, increase this shortfall. Greater utilization of the ability of the existing pool of professional engineers thus deserves the increased attention of all the parties directly concerned.

While enrolment in undergraduate engineering programs during the 1980s was essentially flat, the significant increase of 15 per cent between 1989 and 1991, already noted, encouraged a joint committee of CCPE and the National Committee of Deans of Engineering and Applied Science, in a report on engineering education (CCPE/NCDEAS 1992), to recommend that the capacity of undergraduate engineering programs be expanded to meet the anticipated increased demand. The CCPE/NCDEAS report indicated (p. 27) that it costs governments an average of \$6,800 per full-time student (based on the total operating budget of all engineering schools). In 1991 there were approximately 40,000 undergraduate engineering students in Canada (p. 8), and 7,000 degrees were awarded (p. 9), that is a ratio of one degree per 5.71 enrolled undergraduate students. Thus, the cost to governments per engineering Bachelor degree awarded in 1991 was 5.71 times \$6,800, or \$38,800. The report recommended an increase in enrollment of 20% by the year 2000 to 46,000 students (p. 38). If this were done progressively, starting from the 1990 and 1991 average of about 38,000 students, it would be equivalent to an increase of about 1.9 per cent per annum. Assuming the degree-to-enrollment ratio remains the same, an additional 7,700 bachelor degrees would be awarded between 1990 and 2000 (i.e. an average of 770 per annum). Of this average number of 770 bachelor graduates, 70 per cent, or 540, could be expected to register as professional engineers.

The additional cost to governments of the expanded enrolment would be \$55,000 per additional professional engineer, or \$30 million per annum. (The cost is greater if the net cost of student loans to engineering students is included.) It seems unlikely, as already stated, that with the present large Federal and Provincial deficits, that these funds will be forthcoming to expand engineering school capacity. In fact, a decrease in university, and thus engineering faculty, budgets appears imminent.

If each one per cent increase in total utilization of professional ability of were to result in requiring one per cent fewer engineers (i.e. 1,450) to do their present work, then an increase in utilization of professional ability of only 0.4 per cent per annum would be equivalent to the total annual increase in enrollment proposed by the CCPE/NCDEAS (1992) report, at a saving of at least \$30 million per annum.

If a significant increase in engineering enrollment is unlikely and a capacity increase is similarly unlikely, must we accept the economic consequences of having fewer engineers? An alternative solution to an impending engineer shortage is to increase the utilization of the present cadre of 145,000 Canadian engineers. Because of the significant benefits it is important to understand how to foster such an increase in the utilization of professional ability. The present research contributes to this understanding by developing and testing a theoretical model of the factors which

affect the utilization of professional ability in organizations. The chapters that follow describe the prior work leading to the development of the theoretical model, the methods and procedures used to test the model, and the conclusions that can be drawn.

This section has demonstrated the significant financial savings associated with not having to increase university engineering enrollments in order to meet the anticipated future shortages at a time of financial constraints, through the alternative of increasing the utilization of the professional ability. In section 1.4 it was shown that engineering enrollment is not rising as a result of demographic changes and student preferences. The need for greater utilization is thus urgent.

1.6 Organization of the Thesis

The objectives of this thesis are to review the literature on the utilization of professionals in organizations, and thus to develop propositions and an overall model which links utilization and its antecedents and outcomes, and to test them, using a survey of professional engineers. Based on the results, conclusions are drawn which may assist organizations in industry and government, the engineering profession, and individual professional engineers to take necessary steps to increase the utilization of professional ability in organizations.

Chapter Two presents a description of the utilization of professional ability. Efforts in North America to mobilize interest in the concept are presented. A description from the professional's point of view is followed by a description of a recent major study on the utilization of U.S. engineers.

Chapter Three profiles the engineering profession, which is used as the basis for the present research on professionals in organizations. It includes a description of professionalism and, particularly, of professional engineering practice in Canada. The process of becoming professionalised, starting with the educational process and subsequent membership in professional organizations, is reviewed.

Chapter Four consists of a review of previous studies dealing with the causes and effects of the utilization of professional ability. Relevant theories of organizational management and of professionally-related organization structures are described, as are job satisfaction and organization commitment theories.

Chapter Five presents the proposed model of utilization of professional ability derived from the review of the literature in Chapter Four. The model includes six antecedent factors affecting the utilization of professional ability, and two outcome factors. Each of the concepts is described and a number of propositions presented which relate the antecedent and outcome concepts to the utilization of

professional ability.

Chapter Six presents the procedures and measures used to test the model of the utilization of professional ability in organizations. Each of the measures proposed is described in detail, and a questionnaire which incorporates these measures is presented.

Chapter Seven describes the results of the study. The data is first evaluated. This is followed by a detailed examination of each of the measures. Then the correlations between the measures are explored. The hypotheses about the antecedents of the utilization of professional ability, and the consequences of utilization on job satisfaction and on organizational commitment, are tested in a LISREL model of utilization. In addition, the antecedents of utilization are also tested in the model as direct antecedents of job satisfaction and organizational commitment.

Chapter Eight presents a discussion of the empirical results. Interpretations of the findings regarding the utilization of professional ability construct, its causes and consequences are offered. The implications of the findings for individuals, organizations and researchers are also discussed. Contributions and limitations of the thesis are described. A discussion of the directions for future research concludes the thesis.

CHAPTER TWO

THE UTILIZATION OF PROFESSIONAL ABILITY

The purpose of this chapter is to define the concept of utilization of professional ability (UPA), and to explore the research that has been done on utilization to date. The development of the North American interest in professional human resource utilization at a national or macroeconomic level is also reviewed. The concept of utilization is then looked at from both individual professional and management viewpoints. The chapter concludes with a description of a major utilization study carried out by the American Association of Engineering Societies in 1986.

2.1 The Utilization of Professional Ability Defined

The concept of engineering utilization has been described in terms of the work activities that engineers carry out in their jobs, but has rarely been explicitly defined (Kaufman, 1986: 89). Stanic and Pym (1968: 8) in a study of engineers in England defined utilization as "the adequacy of the fit between the demands of the job and the abilities and skills of the incumbent". Ritti (1968, 1971a, 1971b) looked at the person-job fit in his major study of over 4500 engineers in a large U.S. corporation and referred to poor fit problems as underutilization and misutilization. He identified intellectual demands and time demands as import-

ant factors, and found that underutilization occurs when both time and intellectual demands on the job are light, while misutilization results when heavy time demands on the job are combined with light intellectual demands.

Ability is a competence or proficiency and is therefore a variable related to individuals. Ability utilization is a measure of the relative extent of utilization of a given ability. A person's ability can be increased through experience and study, or decreased through under-use or misuse. Ability utilization involves the efficient use of a person's talent in the time available. It is affected by the work environment and by the extent of support available to the individual. The main concern of this study is the extent to which professional ability is being utilized and the extent to which it can be improved.

2.2 Professional Utilization - A National View

The purpose of this section is to review the post-war national studies of utilization and to show that they were focussed on the adequacy of the supply of new engineers to meet anticipated national demands. With the supply continuing to increase until the mid 1980s there was little interest in exploring ways of increasing individual utilization of professional ability.

Early post World War II work carried out specifically on professional utilization in the U.S. was almost entirely from

the national human resources viewpoint. It was motivated, in the main, by attempts by the western nations to keep up with the Soviet Union during the Cold War. This defence-oriented activity had the limited effect of sensitizing senior industrial managers to the fact that the pool of trained persons is not infinite, and that responsibility for efficiently using this resource lies within each industrial organization.

Immediately after World War II, and before the Cold War started, there was little evidence of any North American organizational interest in overall professional staff planning. With the large number of returning veterans graduating in engineering there was a general feeling that human resources were more than adequate to fulfil the peacetime requirements. A U.S. survey in the year 1949, in fact, forecast an oversupply of engineers for the next few years. This was also the view in Canada. However, only one year later with the outbreak of hostilities in Korea, the "utilization" of existing human resources suddenly assumed national importance with the staff shortages encountered.

Not surprisingly, with the end of the Korean war in 1953, the U.S. National Manpower Council (NMC) published "A Policy for Scientific and Professional Manpower" (NMC 1953) which "encouraged the search for new and more effective ways of utilizing available trained personnel" (p. 27). The NMC authors based the Policy on "the definition of 'utilize' that seems to apply best to engineers [that] is 'to turn to profit-

able account'" (p. 67), but, significantly, recognized that "'utilization' cannot be defined with any precision at all in comparing the accomplishments of intellectual workers" (p. 75). Measuring the ratios of technicians to engineers, for example, was deemed to be useless as a criterion of efficient utilization (p. 83). The Council recommended that "management balance among the different types of manpower it employs (including professional and technical); and that business and government intensify their efforts to develop executives who understand the importance of insuring [sic] that each highly trained person has the opportunity to utilize his capacities as fully as possible" (p. 28). They also recommended that the most important means of improving utilization is "to employ engineers only in positions which make full use of their technical training and experience", since they found that a large number "perform administrative and managerial functions" and that there was a shortage of technical workers (p. 173). These views failed to recognize the importance of the managerial and decision-making role of professional engineers, and failed to stress the need for training and development of technologists and technicians. They did not take note of the situation in Europe where industry, particularly in Germany, is directly involved in technician training, with its attendant commercial benefits.

A major conference of U.S. industrialists on "The Utilization of Scientific and Professional Manpower" to discuss the

1953 Policy followed the same year (NMC 1954). It was devoted mainly to persuading industry to address the problem of how to make better use of their existing trained people. The conference agreed that engineering university training should avoid specialization because of rapid technological change, that more humanities and social sciences would help graduates understand human problems, that intensive and well-planned on-the-job training should include judicious assignment of duties and be complemented by continuing education, that better use of assistants should be encouraged, that effective communication of management goals and upward communication are essential, that neither over-organization nor too loose a structure are helpful, and, that top management must be willing to exert pressure on the whole organization to improve the utilization of technical manpower (p. 96, 97). This was a period of major change in management thinking (Drucker 1952) and the conclusions began to be reflected in major changes made in the structure and organization by large U.S. and their Canadian subsidiaries. Large firms like General Electric delegated a great deal of technical freedom to their professional staff.

President Eisenhower established a committee of scientists and engineers in 1956, chaired by James R. Killian Jr., who had urged that the U.S. "concentrate more on the quality of our own science and technology and less on ... an academic numbers race with the Russians" (Killian 1955). The National

Academy of Science Committee on Utilization of Scientific and Engineering Manpower's report "Toward Better Utilization of Scientific and Engineering Talent" (NAS/CUSEM 1960) confirmed that the Soviet Union was quickly catching up to the U.S.A in both quantity and quality of engineers and urged action to provide "a climate for creativity and productivity", and research funding to provide "increased knowledge for dealing more effectively with utilization issues". It also recommended a focus on the development of the men and women in science and engineering ("the nation which holds the lead in [science and engineering] holds the initiative in world affairs").

More recently the U.S. National Research Council (USNRC) established a Committee on the Education and Utilization of the Engineer (CEUE) to assess "the efficiency of utilization of engineers - the extent to which their technical abilities are being used" (USNRC/CEUE 1985b: 24). However, the CEUE's analysis of utilization was very limited and was mainly concerned with a review of employment sectors and primary activities (USNRC/CEUE 1985a). No far-reaching changes appear to have been implemented.

While these U.S. Presidential commissions and national committees highlighted the importance of utilization of engineers, and involved senior management of organizations, they did not embrace current, nor encourage subsequent, academic research effort which would expose the underlying

issues. This lack of senior level support may have been partly due to the fact that while in 1985 the federal government was employing, directly and indirectly, some 30 percent of the engineering pool (and another 8 percent via subcontractors), the number of engineers had doubled between 1960 and 1982 (USNRC/CEUE 1985a: 87), so that supply had kept up with demand.

It thus can be said that, in spite of the significant cost and effort devoted to these national commissions during the early post war period, they contributed little to an understanding, let alone an improvement, in the utilization of individual professionals. It appears that their goals were focussed mainly on national supply-demand issues related to U.S. defense needs rather than to industrial competitiveness. The continuing supply of young engineers during this period meant that the issue did not attract the attention of industrial management.

2.3 Utilization - The Professional's View

An alternative to national studies is to gain an understanding of the utilization of professional ability at an individual level with the persons directly involved. This section reviews research done from the individual professional's perspective.

An early major study of engineers by Danielson (1960) recognized the seriousness of utilization problems and the

characteristics of engineers which link their utilization and motivation. Hirsch, Milwitti and Oakes (1958) defined utilization as "the performance of productive work for which the scientist [and engineer] has had unique training and experience" that is "taking scientists [and engineers] as they are, and considering how to get the best use of their time" (p. 67). Based on a statistical analysis of the work of (mainly) engineers, they found that "there is a loss of from 20 per cent to 50 per cent of potential output due to time spent on activity beneath a scientist's abilities" (p. 70). They went on to conclude, optimistically and based on some general assumptions, that if losses due to activities beneath abilities, assignments of negligible value, effort on unassigned projects, duplication of effort, turnover and inadequate physical facilities, are corrected, "improved utilization of scientific manpower available could result in a tenfold increase in useful output" (p. 71). A subsequent study of engineers by Kornhauser (1963) confirmed that "engineers in industry indicate that they think their special competence is not adequately utilized" (p. 139).

At the same time, Raudsepp (1963e: 102), in one of a series of studies of the views of about 1000 engineers, found that 34% of non-supervisory engineers felt that their job did not utilize their "training, skills and abilities"; and that 71% felt that they "spend more time on details and routine tasks than should be required" in their position. Nearly one

in three engineers (31%) declared "a need for competent technical and nonprofessional supporting help and for better utilization" (Raudsepp 1964a: 83). Ritti, who carried out a similar survey of engineers in industry several years later, found that 65 percent agreed with these views (Ritti 1971b: 140).

The American Society for Engineering Education (ASEE), in their major study of Goals of Engineering Education (LeBold et al. 1966), surveyed over 3,000 engineering graduates. An important finding was that "engineers ascribe the highest importance to values that concern their work opportunities" (p. 252). LeBold continued his studies and in 1981 obtained similar results (LeBold et al. 1983). In his engineer-centred review of the work of Eisenhower's President's Committee, Torpey (1970) pointed to an individual focus for future studies. He recognized that much more effective utilization was required if an optimum was to be achieved (1970: 3), but the nature of the duties and the actions of engineers, "such as evolving new ideas, devising new methods, combining known concepts, and applying new information, cannot be satisfactorily measured against existing or projected standards". A major contribution was his conclusion that "the concept of utilization is distinct from manpower shortage" (1970: 4), that is, that it concerns the utilization of the professional ability of individual engineers rather than the supply-demand balance of engineers in the nation, thus giving support to

further engineer-centred research. The route to a solution to the problem of better utilization of professional ability was beginning to be identified.

Table 1 presents comparable data from U.S. surveys carried out over a period of 20 years. All of these surveys are consistent in demonstrating that the opportunity to use their skills and abilities is ranked first or second in importance in the work goals of engineers. Only about half of the same respondents, however, reported that it was characteristic of their job. There is a significant and relatively consistent difference of from 31 to 39 percentage points between the average of those who indicated that the utilization indicator is "extremely" or "very" important and those who indicated that it is "extremely" or "very" characteristic of the job. In the most recent major survey (AAES 1986), carried out in 1984, the importance assigned to challenging work assignments and to use of overall technical competence increased significantly (to 95% and 94% respectively). At the same time these indicators of utilization became more characteristic of the job for a larger percentage of respondents (56% and 59% respectively), such that the percentage point differences (at 39% and 35% respectively) have remained relatively unchanged compared to the previous studies.

Other researchers were also busy studying individual performance and utilization. Hall and Lawler III (1971) were able to establish that job pressure enhances performance and

TABLE 1

IMPORTANCE OF UTILIZATION OF ENGINEERS AND HOW CHARACTERISTIC
IT IS OF THEIR JOBS

UTILIZATION INDICATOR & SOURCE	SAMPLE & YEAR	IMPORTANCE		CHARACTER.		DIFFER. OF 1
		1*	RANK	1*	RANK	
Opportunity to use special abilities (Case, et al., 1967)	953 B.S. Berkeley & UCLA alumni, 1961	71	1	39	6	32
To use skills and abilities in challenging work (Perrucci & LeBold, 1967)	1926 B.S. Purdue alumni 1964	89	1	54	1	35
To use skills and abilities in challenging work (LeBold, et al., 1966)	3234 industry engineers, 1965	85	1	48	2	37
Opportunity to use skills and abilities in challenging work (LeBold, et al., 1983)	2300 technical society members, 1981	81 (77)	2 (2)	44 (46)	5 (4)	37 (31)
Challenging work assignments	3868 members of U.S.	95	1	56	5	39
Use of overall technical competence (AAES, 1986)	engineering societies, 1984	94	2	59	4	35

Secondary source of incl. first four items: Kaufman, 1986: 90

* percent responding "extremely" or "very" important or characteristic
() indicates weighted percentage

is not always undesirable: pressures for high quality work
seem to enhance a researcher's attitudes and performance.

Ritti (1971b: 38) found that utilization of skills is a major
dimension of engineers' work descriptions. As already noted,
he distinguished between under-utilization, involving light
time and intellectual demands, and misutilization, the result

of heavy time pressure and light intellectual demands (p. 141). He concluded that "when heavy time demands are combined with intellectual interest, motivation or willingness to do the task increases and makes the task seem less onerous" (p. 103), while light time demands combined with light intellectual demands makes it appear more so. He was led to believe that engineers saying they 'prefer to do more' corresponds to a condition of skill utilization that has its basis in fact, that is, "It is a response to career anxiety generated by the lack of opportunity to perform, together with a self-concept held by most engineers in which performance is central" (p. 91). Table 2 lists details of these results and

TABLE 2

INDICATORS OF UTILIZATION PROBLEMS AMONG ENGINEERS

<u>PROBLEM AND INDICATOR</u>	<u>PERCENT</u>
<u>Underutilization</u>	
1. Light intellectual demands and light time demands	17
2. Prefer to do more work	29 (15*)
<u>Misutilization</u>	
3. Light intellectual demands and heavy time demands	7
4. Too much work	10
<u>Overall</u>	
5. Light intellectual demands	36 (29*)
6. Under + misutilization	
(1 + 3)	24
(2 + 4)	39 (25**)

Secondary source of table: Kaufman, 1986: 90

Primary sources: Ritti, 1971a: 136 & 142

* Landis 1971: 386, 387

** Landis' 15% plus Ritti's 10%

other indicators of utilization problems.

Ritti (1971a: 136,142) found severe problems of utilization among the 17% who were highly underutilized (with light intellectual and light demands), and among the 7% who were highly misutilized (with light intellectual and heavy time demands), giving a total of 24% of the engineers with utilization problems. His survey also reported that 29% preferred to do more work, an indication of underutilization, and that 10% had too much work, an indication of misutilization, giving a total of 39% of engineers indicating utilization problems. Landis' study (1971) of over 1000 engineers in U.S. industry, carried out at the same time, found that fewer engineers (15%) considered their work load on the light side, and that fewer (29%) reported light intellectual demands (p. 387). If the 15% who reported they "prefer to do more work" in Landis' study is added to Ritti's 10% who reported having "too much work" the total becomes 25% (shown in Table 2 with a double asterisk). Thus at least one quarter of all engineers' surveyed reported being underutilized or misutilized. If these results were true of the overall engineering profession in 1971, the need to take corrective action was evident.

In seeking the causes of low utilization, Landis (1971: 388) found that over 40% of the engineers surveyed reported devoting an average of 31% of their time to non-engineering work. The reported portion of this time that

could be undertaken by others is shown in Table 3. Somewhat surprisingly, Landis found that time spent on non-engineering tasks was justified, according to 64% of the Landis' engineering sample, either because it could be delegated, was part of the job, or it was inefficient and too time-consuming to

TABLE 3

PORTION OF THE AVERAGE OF 31% OF TIME SPENT ON NON-ENGINEERING TASKS
THAT CAN BE DELEGATED TO OTHERS

<u>SUPPORT PERSONNEL</u>	<u>PERCENT</u>
Engineering Aides	40
Technicians and Draftspersons	27
Clerical Personnel	12
None [Not designated]	21

Source: Landis, 1971: 388

delegate. Only 24% felt that time spent on non-engineering tasks was not justified because this work could be done by clerical or sub-professional personnel (p. 388). Landis suggested that a discussion of the utilization of engineers in organizations should start with two questions: "What is an engineer really expected to do, and how does his individual activity fit into the company pattern?". He suggested that an engineer "will only be utilized effectively if he [or she] can be matched with the demands of the job, if he [or she] remains challenged at a rate which is commensurate with his [or her] own growth and development, and if his [or her] time is well spent" (p. 384). Unlike Ritti, Landis did not stress

the need for engineers to move into management (and learn how to delegate some of their non-professional duties to others). Landis' survey showed, however, that achievement needs and challenging work overshadow all other factors in motivating engineers to do a good job, a finding that agreed with McClelland's theory of needs (1961). (This is discussed further in Chapter Four.)

Kaufman (1974: 93), like Ritti and Landis, recognized that "utilization of knowledge and skills is an important aspect of work challenge", and also identified misutilization and underutilization as two relatively independent dimensions of utilization. He confirmed Ritti's conclusion that misutilization was greatest "when professionals experience light intellectual demands on their jobs together with heavy time pressure" and that underutilization occurred with light intellectual and light time demands on the job (p. 95). Kaufman suggested that "the effects of both misutilization and underutilization can be avoided by providing professionals with intellectually demanding job assignments combined with time pressure" (p. 96).

Unlike the nationally oriented supply-demand studies which considered engineers as a human resource, the individually oriented studies carried out during the quarter century between 1970 and 1985, provided valuable insights into ways of increasing the effectiveness of the existing pool of engineers through greater utilization of their ability.

2.4 Management's Views

Senior management's views on engineering utilization are not well represented in the literature. However, a survey of their views on engineering utilization was carried out by a Panel on Engineering Employment Characteristics of the National Research Council's Committee on Education and Utilization of the Engineer (USNRC 1985b: 25). Like the national studies described in section 2.2, this survey was narrowly focussed on human resource needs at that time. The results showed that in senior management's opinion, computer hardware engineers, computer software engineers, and civil engineers were the most fully utilized (70% and higher), electrical and mechanical were somewhat lower at 55 to 60 percent, while electronic, industrial, aeronautical and chemical were somewhat underutilized (46% and lower). These percentages taken together with the Panel's more general conclusion that senior managements tends to estimate utilization as higher than do individual engineers, indicated that severe utilization problems existed, even for the most fully utilized engineers. However, no recommendations to improve utilization were provided by the management Panel.

2.5 The 1986 Utilization Survey

The first in-depth research study of the utilization of professional engineers is the National Engineering Utilization Survey (hereafter referred to as the "1986 Survey").

It was commissioned by the Engineering Manpower Commission of the American Association of Engineering Societies, representing over one-half million engineers (AAES 1986). The objectives were, "to reduce the requirement of increased capacity for engineering schools, to assist in the improvement of productivity and competitiveness of the technical workforce in the United States, and to assist in the retention of mature, experienced engineers in the profession". The authors argued that if current engineers were utilized more effectively throughout their careers, then the needed additional engineering output might be provided in an effective way without further pressure on the engineering schools.

In the 1986 Survey report (AAES 1986) utilization was defined as:

the effective use of a graduate engineer's time on professional tasks. It implies the use of the engineer on professional tasks such as design, synthesis, and analysis for the preponderance of the workweek. It also implies that the time spent by the engineer should challenge the technical capacity of that individual at a high level for significant portions of the time spent in such professional activities [p. 3].

The major finding of the 1986 Survey was that "American engineers are highly under-utilized". When asked whether excellent utilization of engineering personnel was "important personally", an overwhelming 90 per cent of the engineers surveyed answered in the affirmative. On the parallel question of whether such excellent utilization was "characteristic of that engineer's employer", only 33% of the respon-

dents indicated that it was. The 1986 Survey found that several factors were major contributors to utilization, namely, management interactions, management policies and practices, availability of support services, the extent that continuing development is facilitated, and the availability of information sources. Ninety-two percent of the engineers surveyed indicated that good management policies including effective technical personnel communications was a key element in the workplace, but only 43% indicated that such communications were characteristic of their current employment situation. Management policies and practices which impact directly on the engineer were also found to affect the level of utilization, for example, companies which encouraged innovation and new ideas received higher utilization ratings. The authors identified several consequences of poor utilization, including obsolescence, poor performance, job dissatisfaction and job turnover (p. 5).

The support of practicing engineers by technicians and other personnel, and the availability of equipment and facilities also was found to be a significant factor in higher utilization. The 1986 Survey authors noted that computer-aided design and word-processing equipment may replace much of the drafting function and the need for secretarial help, respectively. This appears to have largely come about in the ensuing decade, but a reduction in personal assistance may be resulting in engineers being used less effectively than if

they are supported by suitably trained personnel.

A third major factor affecting the degree of utilization is the way in which engineers can continue to develop throughout their careers. "Challenging work assignments" was ranked as extremely important by respondents. While there was a high degree of satisfaction expressed with the technical education provided at university (88%), only 62% were satisfied with the written communication skills, 55% with the oral communication skills, and only 52% with the preparation in "human relations skills" provided at university. The authors concluded that there is considerable scope to improve the education in these fields.

The 1986 Survey is particularly valuable in its orientation towards engineers in the engineer-organization interface. The study narrowly focussed on engineers who devote most of their time to design or development, thus excluding those engineers who manage those doing this work. While Canadian professional engineers include engineers who manage engineering work, the results of this relatively recent survey have significance for Canadian engineers, and thus were used as a basis for a model of utilization of ability in organizations, and associated hypotheses.

2.6 Summary

The utilization of professional ability is the degree to which the work of professionals requires them to use their

knowledge, skills and abilities. Under-utilization occurs when both time and intellectual demands are light, while misutilization results when heavy time demands of the work are combined with light intellectual demands. Significant problems of utilization were reported to affect at least one in every four engineers, with under-utilization more widespread than misutilization.

The post World War II studies, concerned with U.S. national interests, were too general to provide much insight into the problems and possible solutions to the utilization of professional ability in organizations. The 1960s saw a start to a focussing on individual engineers in industry, with a number of major U.S. studies being carried out in the 1970s. These studies provided a much clearer understanding of utilization of individual engineers. There is little evidence that senior managements of organizations employing professional engineers recognized that an individual utilization problem exists. The engineer-centred 1986 Survey found that utilization of professional ability continues to be a problem for a significant percentage of U.S. engineers a quarter of a century after it was first identified as a problem. The major factors reported as contributing to utilization were management policies and practices, including communications, the extent of support services, and the extent to which individuals can develop their careers.

CHAPTER THREE

PROFILE OF THE ENGINEERING PROFESSION

The purpose of this chapter is to present a description of professional engineering in Canada. The main reasons for selecting the engineering profession as the basis for a study of the utilization of professional ability have been presented in Chapter One. A more detailed review of the profession of engineering, and particularly of the manner in which engineers practice and are regulated in their profession in Canada, and of how they do so in an organizational setting, is warranted to provide the basis for understanding how to effect the individual and organizational changes need to bring about greater utilization of professional ability. A review is also warranted to distinguish the Canadian engineering profession from other professions and, particularly, from American and other national engineering professions. These distinctions may influence the generalizability of the results to engineers in other countries and to other professional groups.

The description of engineering professionalism is followed by a definition of professional practice as it applies to Canadian engineers. Next is a description of the professionalization, or formation, of professional engineers in Canada. Finally, the practice of professional engineering within an organizational context is described.

3.1 Engineering Professionalism

Greenwood (1957) suggested that ideal professions are distinguishable by possessing: a systematic body of theory, professional authority, sanction of the community, a regulative code of ethics, and a professional culture. Some professions such as medicine, law and the clergy meet all of these requirements and do so, in the main, by providing their personal services to a large number of individuals in the community. While doctors do practice in an organizational setting, hospitals and clinics provide an independently administered supporting function, allowing doctors to provide their personal services directly to patients. Lawyers and accountants are employed by large organizations, generally, for their specialized knowledge of finance, and of the laws and regulations, respectively, rather than for their skills in an organizational setting. The same focus on a body of knowledge but applied to a select group of clients is true for teaching and nursing, although some of these practitioners do undertake full-time administrative responsibilities.

While much of technical engineering practice falls into the specialist category, engineers appear to be unique in the extent of their involvement as a profession in all aspects of their organizations. Young engineers usually start their careers in a technical specialty. Some continue along this path to become highly skilled technical practitioners in

their chosen field of expertise, maintain close contact with colleagues in their field, and generally act as technical consultants. A majority of graduate engineers, however, go on, with experience, to become technical generalists. They may work as group leaders, supervisors, or managers of design or production operations, or in aspects of the organization where they may not make as much use of their technical knowledge. Engineers are effective in many areas, particularly if the organization's work has a technical content, acquiring the non-technical and managerial skills necessary on the job.

Allen (1988) suggested that few would contest the statement that "engineers are not scientists" and yet the social science literature "is replete with studies of 'scientists' who upon closer examination turn out to be engineers" (p. 3). Engineers, he argued, "differ from scientists in their professional activity, their attitudes [and] their orientations". In particular, they communicate about their work in very different ways. Thus, while both start with verbally encoded information (papers) as input, their outputs are different: the scientists output is verbally encoded information, but the engineer's is physically encoded, making it difficult to decode for subsequent use. The engineer must rely upon direct personal contact with other engineers to obtain his or her information. Allen summarized that whereas "the scientist's principal goal is a published paper, the technologists's goal is to produce some physical change in

the world" (p. 8).

Kerr et al. (1977: 332) looked at U.S. engineers as quasi-professionals and used six functional characteristics to differentiate them from pure professional scientists. His comments indicate that there are significant differences between U.S. and Canadian engineers. First, he pointed out that few U.S. engineers are licensed. Second, Kerr et al. found that whereas scientists seek freedom to select the problems they will study, engineers are typically given the problem and even the procedural guidelines for solving them. This conclusion could have been based on the large number of U.S. engineers working in very large organizations, such as those in the aerospace industry, where many perform technologist or technician work. Kerr et al. did not include engineering managers in their definition of engineers, and argued that the transition to management is much more accepted among engineers, whereas scientists have a tendency to stay in their technical specialty, thus demonstrating that engineer's commitment to, and identification with, their profession is weaker than that of scientists. They appeared to take the view that when engineers become managers they cease to be professional. This view is disputed, and other views will be presented later. Kerr et al. also found that U.S. engineers do not have as strong a foundation in ethical values of professionalism as scientists and that their standards of certification, review of competence and censure are beyond

the power and interest of U.S. engineering associations.

Registered Canadian professional engineers, in fact, are engaged in a broad spectrum of work activity ranging from that which is highly technical to that which has little technical content. A trend away from the purely technical is often the result of a closer allegiance with the aims and needs of the organization and, in time, may result in some loss of technical competence. Engineering has historically embraced a strong management element. The early engineering of bridges or railway lines, for example, involved not only its design but also supervision of its construction, with associated management, cost control, and attendant financial and human resource responsibilities.

Canadian self-governing engineering associations have been established under provincial laws to protect the public's, rather than the practitioners', interests. Engineering practice is governed by legally enforceable codes of ethics. Other self-governing professions, including the medical and legal professions, have also established separate non-licensing organizations to serve their narrower interests and particularly to negotiate wages or fees. Canadian engineers appear to be satisfied with the present indirect role played by their provincial associations of advancing the position of engineers without compromising the aims of provincial laws. While the engineering associations do not regulate or negotiate the salaries and working conditions of

employee engineers, they do carry out two comprehensive salary surveys annually. This provides both engineers and their employers with valuable comparative salary information based on professional responsibility level (technical and/or supervisory) with which to negotiate individual salaries.

In some other nations, the focus of the engineering associations is technical. The resulting "balkanization" of the profession by technical field in the U.S.A. (Zussman 1985 and Layton 1971) and in Great Britain (Whalley 1986), and the lack of common standards of admission, have hindered their professional engineering societies in enforcing ethical standards (Evan 1969: 126), or of performing an economic function for the members (p. 122). Through their active support, large U.S. corporations have discouraged any political professionalism within the technical institutes. Newell, writing of American engineering in 1922, stated that while "in its ideals the engineering profession is not surpassed by those of any other group of public servants ... in practice ... it has been found difficult to reduce them to a brief statement and to secure general agreement upon such statement" (Newell 1922: 133). The chief difficulty, he wrote, was due to the fact that there is little agreement in the U.S.A. about the meaning and limitations of the word "engineer" and of the word "professional" as applied to engineering; the engineer may be a mechanic, a tradesperson or a professional. Without legal protection for the terms

engineer or professional engineer, this situation remains unchanged today, 70 years later. Evan (1969) stated that American professional engineering associations have not done a very good job of regulating their members' conduct: "Only in the most general terms do canons of ethics touch upon the relation of the engineer to the public or to society as a whole" (p. 124).

Perrucci (1973: 121) also argued that for American engineers there is a "decline in the possibilities for the development of engineering as a genuine profession committed to the service of man [and woman]... as a result of increasing specialization and fragmentation of the profession". In his view, this limited "the chances for the emergence of a professional organization with sufficient power to shape its own activities" (p. 122). Further, the fragmentation of the American engineering profession meant that it lacked the power to influence legislation regarding licensing and protective laws, to influence university-based curricula, and to judge the performance of practitioners, and meant that non-graduates and graduates from a number of physical science fields could be employed and designated as engineers. Perrucci expressed concern that this situation was not conducive to the development of "a service ethic ... to serve the human welfare of the American people" (p. 125) since "it encourages the dependence upon, and authority of, employing organizations" (p. 132). With the continuation of this

fragmentation in the U.S.A., however, it appears that the present situation is unlikely to change.

While American and British engineers continue to be thus technically balkanized, French engineers, like their Canadian counterparts, remain professionally united. This is particularly true of graduates of the prestigious French engineering schools, where technical management is the logical career progression (Crawford 1989, Boltanski 1987, Barsoux and Lawrence 1991). Canadian engineers in the province of Quebec, in particular, appear to be following the French model, with senior engineers moving readily between private industry, consulting, government administration and government agencies.

3.2 Canadian Professional Practice

Lapp, Hodgins and Mackay (1970: 32) proposed the following simple definition of engineering: "Engineering is a profession, responsible and accountable for man's physical environment, its management and control". The practice of professional engineering in Canada, is defined by Canadian Council of Professional Engineers' (CCPE) guidelines as "any act of planning, designing, composing, evaluating, advising, reporting, directing or supervising, or managing any of these acts, that requires the application of engineering principles, and that concerns the safeguarding of life, health, property, economic interests, the public welfare or

the environment" (CEQB 1992: 16, *italics added*). Canadian provincial legislatures, which legally control the practice of professional engineering and delegate it to their provincial engineering associations based on comparable legal definitions, are in the process of adopting the CCPE definition as their statutes are revised. By way of warning to the self-governing professions, the Ontario Royal Commission Inquiry into Civil Rights cautioned that "the granting of self-government is a delegation of legislative and judicial functions and can only be justified as a safeguard to the public interest. The power is not conferred to give or reinforce a professional or occupational status" (Ontario 1968). This guidance is foremost in the minds of professional engineers as they undertake major reviews of the missions of their professional associations.

The formation of the Canadian Society of Civil Engineers (CSCE) in 1887 can be said to signal the beginning of a Canadian tradition of engineering as a profession (Millard 1988). In that year, five Canadian universities were already offering engineering courses and by 1921 almost 90% of the CSCE members were engineering graduates. While American engineers were considering unionization for the profession as a means of control and power (Layton 1971), Canadian engineers sought and, in 1922, obtained the right to self-government and licensing from their provincial governments (Millard 1988).

Since universities are self-governing institutions, a rapid increase in the number of engineering schools in Ontario, from two in the mid 1950s to fourteen in the next fifteen years, posed problems of overcapacity and of access to limited financial resources from the provincial governments which provided such support. The 1970 "Ring of Iron" report on Ontario engineering education (Lapp et al. 1970) was commissioned as a result. The recommendations in favour of limiting or reducing enrolments in both undergraduate and graduate programs (1970: 88, 89) were accepted after careful review by the Council of Universities (C.O.U. 1971). The report's Recommendation 7:2 for "periodic requalification (perhaps every five years ... requiring a course of study in either control or management, together with a structured program in applied humanities" was reviewed by Association of Professional Engineers of Ontario (APEO, now PEO) and found to be difficult to implement (C.O.U. 1971: 81, 82). (Belated recognition, a quarter of a century later, that the governing professional associations cannot avoid addressing this public interest issue is shown by recent deliberations to this effect by the PEO's Professional Development Committee.) Based on the data provided in the Ring of Iron report, Shemilt (1976) observed that there was a rapid flow of engineers into managerial and supervisory positions: almost half the engineers surveyed were filling management roles within ten years from graduation, with about one-quarter in oper-

ations and the balance in research, design and development. He also identified, from the data for over 4,000 graduates, that upon graduation less than 60% worked in the same field as that of their undergraduate studies. He concluded that "this picture of considerable mobility implies at the very least that caution must be used in supporting extension of highly-specialized courses" (Shemilt 1976: 1-21). There is little evidence that his advice has been heeded to date, with undergraduate engineering specialties doubling over the past 20 years (CCPE/NCDEAS 1992:10).

Common implementation of the self-governing legislation by the provincial engineering associations has resulted in a homogeneous professional population, composed almost entirely of university graduates with comparable training (CEHRB 1989:5, CEAB 1993), largely through the effort of CCPE's Canadian Engineering Accreditation Board (CEAB) which controls the curricula of engineering schools through its accreditation of engineering programs. The Canadian curriculum has been influenced by the deliberations of the American Society for Engineering Education (ASEE) which has produced two major reports: the Goals of Engineering Education Study (ASEE 1968) which recommended a 5-year program leading to the Master's degree as the first professional degree in the U.S., and A National Action Agenda for Engineering Education (ASEE 1987). Strong opposition to the 5-year program from engineering deans resulted in a final report which backed off this

recommendation. CEAB's role also extends to mutual recognition agreements between Canada and other nations, and has recently entered into such agreements with Australia, Ireland, New Zealand, South Africa, the United Kingdom and the U.S.A., allowing registered engineers in Canada to practice in the others.

The Canadian engineering profession was responsible in the early 1960s for the formal recognition of engineering technologists and technicians and the author was a member of the original Certification Board for several years. With the establishment of Colleges of Applied Arts and Technology in the mid-1970s, engineering technicians and technologists were encouraged to establish their own provincial associations (in Ontario this is the Ontario Association of Certified Technicians and Technologists, OACETT). These associations have been very active in lobbying their provincial governments for professional self-governing status on the basis that their work is the same as that of professional engineers. Many engineering technologists are, in fact, performing work side-by-side with engineers who are registered and licensed as professional engineers. The difference lies not so much in the content of the work as in the extent to which professional engineers maintain their technical competence and accept responsibility for their work as defined in the code of ethics. As long as engineers working in industry are not legally subject to the code of ethics,

the pressure is likely to remain. Evidence of a similar conflict between engineers and technologists is apparent in the U.S. While Canadian Colleges of Applied Arts and Technology award three year diplomas, which are not accredited by Canada's CCPE, several U.S. universities award a Bachelor degree in engineering technology, which the U.S. Engineering Council for Professional Development (equivalent to CCPE) began to accredit in 1967 (ASME 1986: 15).

CCPE's Canadian Engineering Qualifications Board (CEQB 1993) provides common guidelines to CCPE's constituent provincial engineering associations with respect to the licensing of foreign-trained practitioners or graduates of non-CEAB accredited institutions (p. 4), the engineering experience requirements for entry into the profession, national guidelines for admission to the practice of professional engineering, the code of ethics, continuing competence, and the definition of the practice of professional engineering. An environmental practice code is being developed.

The codes of ethics of the provincial engineering associations are enforced through legally constituted panels, which are empowered to apply disciplinary measures, including the imposition of fines and withdrawal of licenses. While the legal reach of the codes is presently effective mainly with respect to engineers working as consulting engineers directly for the public, Canadian engineers who work in industry maintain high ethical standards through peer pressure. There

is increasing support in the profession, however. for regulations which would require professional engineers in industrial organizations to certify products and be responsible for practices which affect the public wellbeing and safety, and which would permit formal disciplining of such engineers in cases of malpractice

3.3 Professionalization

For Freidson (1973), professionalization:

represents a basis for organizing jobs and work in a division of labor which is entirely different from the administrative principle ... management can control the resources connected with work, but cannot control most of what the workers do and how they do it ... and the work itself is the key to production . . . While an administrative structure does exist, it is largely restricted to authority over supportive economic, clerical and maintenance services [p. 32].

Professionalization of an engineer typically begins during her or his four year period of education at a school of engineering, usually located within a university, and leads to a Bachelor degree in one of the technical branches of engineering (Moore 1970). The intellectual and time demands are very significant while at university, and leave little time for outside socialization. The engineering curriculum, approved by the Canadian Engineering Accreditation Board (CEAB 1993), is very full. It is mainly composed of technical subjects, but presently allows eight elective courses in non-technical subjects. In general, organizationally-

related courses, such as the basic courses in undergraduate Commerce degree programs (organizational behaviour, financial management, economics and marketing) which provide a useful introduction to work in organizations, have not been successfully offered to engineering students, and where offered are seldom chosen, possibly because the technically-oriented students do not perceive the nature of organizational work. The ASME conference on education (ASME 1986: 120) recognized that engineers, when they graduate, function, or are supposed to function, in a business environment, however, "we do not at the present time ensure in the curriculum that they have any appreciation for, or understanding of, what the business environment is". Engineering graduates continue to graduate deficient in important aspects of organizational knowledge.

Graduation is followed, in Canada, by a further period of apprenticeship in an engineering field under the guidance of a professional engineer for two (now changing to four) years. By the end of this period, the engineer-in-training must pass an exam in professional practice, and provide evidence of satisfactory engineering work experience, before being admitted to full membership in the profession of engineering. These years provide a significant opportunity for the profession to influence the young engineer, and some of the engineering associations have embarked on "mentoring" programs to match recent and experienced engineers.

Professionalization continues after registration. While

the focus in Canada on general professional associations, rather than on technical societies, avoids the problems of technical balkanization, it might suggest that Canadians are less focussed on technical competence, the foundation of professional engineering. Canadian engineers wishing to keep up-to-date technically, however, have a choice of joining several technical society branches of the Engineering Institute of Canada (EIC), including the Canadian Society of Mechanical Engineers (CSME) and the Canadian Society of Civil Engineers (CSCE). The parent EIC has a long history, with the original society, the Canadian Society of Civil Engineers being founded in 1887, two years after the completion of the Canadian Pacific transcontinental railway. Canadian engineers are encouraged to join U.S. and U.K. technical institutes, many of which have established Canadian branches in the large cities, providing additional access to recent developments through their journals and meetings. These include: the U.K. Institute of Civil Engineers (previously the Society of Civil Engineers) operating since 1771 (Skempton 1981: 23), the American Society of Civil Engineers (ASCE) founded in 1852, the American Society of Mechanical Engineers (ASME), founded in 1880 (Sinclair 1980, Calvert 1967), and the Institute of Electrical and Electronics Engineers (IEEE) founded in 1884 (McMahon 1984). The Society of Engineering Education, now the American Society for Engineering Education (ASEE) (ASME 1979: vii), was formed in 1893 and

has assumed a leadership position in American and Canadian engineering education. The value of these technical societies would be greatly enhanced if the regulating associations were to require engineers to remain current after the original certification based on graduation with a Bachelor degree, particularly if governments were to permit professional engineers a tax deduction for the cost of attending seminars and conferences, as is presently the case for medical practitioners

3.4 Professionals in Organizations

While the *esprit de corps* developed as engineering students remains high when graduate engineers join organizations, which the large majority do, the technical product or service focus of the work of graduate engineers makes it difficult for them to remain aloof from active involvement in the management aspects of the work of the organization, even among those doing applied research work. Engineers are unlike scientists, who tend to remain more deeply involved in a scientific quest for knowledge and thus continue to maintain closer relations with colleagues in their scientific field and outside their organization than to those within their organization. This distinction is not always recognized. For example, Scott (1966: 266) included engineers with scientists when he argued that "professionals participate in two systems - the profession and the organization -

and their dual membership places important restrictions on the organization's attempt to deploy them in a rational manner with respect to their own goals". Second, he suggested that "the profession and the bureaucracy rest on fundamentally different principles of organization" which generate conflicts between them. Kornhauser (1962: 8), also writing about engineers and scientists in a research setting, insisted that to examine professionals in bureaucracies is to examine the "relation between two institutions, not merely between organizations and individuals". He argued that there is a need for both sides to make adjustments to accommodate each other. Ritti (1971b), however, pointed out that both these authors conducted their work in organizations with large numbers of both engineers and scientists, but failed to recognize the significant differences between the engineers and the scientists.

The concept of a clash between business and professional goals has been applied to the work motivations of engineers and scientists by Kornhauser (1962). The label *local* has been applied to those whose loyalty is primarily to their employing organization, while *cosmopolitan* was applied to those whose loyalty is to their profession (Shepard 1956, Gouldner 1958, Glazer 1964). Ritti (1971b), in his survey of engineers in a large U.S. engineering company, found, however, that "the goals of engineers are generally in harmony with the aims of the business". Scientific goals, correspon-

ding to a *cosmopolitan* orientation, are "least frequently indicated as 'very important'", whereas "the business goals dimension - or local orientation - is frequently chosen" (p. 50). Ritti concluded that professionalism implies a loss of role influence:

the professional who has been emancipated from business concerns is also rendered powerless to pursue the supposedly professional concerns . . . for I am firmly convinced that management is where the power is, and those with power will come also to have the responsibility for making the decisions [p. 213].

In a nationwide survey of engineers LeBold, Perrucci and Howland (1966) also found that their professional or *cosmopolitan* orientation is very weak. The discrepancy between their findings and those of Kornhauser, which stressed the tensions between organizations and their professionals, may be due to the fact that Kornhauser's samples included both engineers and scientists in a research laboratory environment, where greater importance tends to be placed on self-generated technical work.

Engel and Hall (1973: 80) saw significant advantages for professionals working in organizations. They suggested that work in bureaucratic organizations can provide the professional with the opportunity to be more faithful to the ideals of professionalism. In their view, this takes place in several ways: (1) as salaried employees they are freed from the economic pressures of individual practitioners, allowing them to participate in intrinsic rewards "based on

work achievement as an end in itself" (following Barber 1963), (2) greater peer and public evaluation is possible so that "incompetence can more readily be discovered", (3) an increasing interdependence between and within professions allows each professional to make her or his unique contribution. Engel and Hall concluded that:

some of the attributes of professions have not been eliminated, as claimed by those holding an anti-bureaucratic view, but rather experienced a change in character which, in some instances, permits a more faithful adherence to the professional ideal ... [thus] it would appear that some earlier writers overemphasized the negative aspects of the industrialization of the profession [p. 84, 86].

Galbraith (1967) reviewing the large number of skills brought to bear in decision making in a modern organization, which he called a technostructure, maintained that:

nearly all powers - initiation, character of development, rejection or acceptance - are exercised deep in the company. It is not the managers who decide. Effective power of decisions is lodged deeply in the technical, planning and other specialized staff [p. 69].

The most important aspect of power is that it is a function of dependence. To create dependency, "the thing[s] you control must be perceived as being important. Since an organization seeks to avoid uncertainty, individuals or groups who are able to deal with the uncertainty will be perceived as having more power" (Cyert and March 1963). Engineers, in particular, tend to be heavily involved in the technostructure and, to the extent that they can absorb the

organization's uncertainty, can have a significant influence.

As organizations employing engineers in Canada grew larger during the 1960s, engineers trained "to question and challenge the accepted norms" found their technical influence waning "in the ever expanding national and supernational industrial complexes" (Barnes 1975: 4). Barnes found that unorganized professional engineers were only able to increase their wages by 78 percent between 1962 and 1972, while 'big labour' industry wage rates rose 92 percent (p. 5). As a result engineers in the public service joined unions, and some engineers in industry went on strike to improve their wages (p. 23).

The study by Perrucci LeBold and Howland (1966: 246) of 3200 American engineering graduates, showed that the proportion of engineers whose activities are primarily technical drops from 65 to 33 percent over a period of 20 years after the Bachelor degree, and that twenty years or more after graduation, two-thirds of their work is administrative. A review by Rothstein (1969) of various studies also showed that "the proportion of engineers in management positions increases markedly with years since graduation" (p. 92). Using a very narrow definition of engineering, Rothstein (1969: 95) concluded that "engineering is not, and was not, a terminal profession for most engineers ... [therefore] engineering does not fit the functionalist model of professions" (p. 95). Evan (1969: 120) concluded that the knowledge and

skills of engineers obsolesce so quickly that engineers "find it necessary to shift into management work or non-engineering occupations in the middle of their careers".

The narrow view that engineering does not include management functions, or that management is a separate profession had been advanced by a number of authors starting in the early 1950s (e.g. Drucker 1952, 1954), promoted by the growing number of schools of management and supported by large engineering companies such as General Electric. (The author recalls that during this period, Canadian engineers were asked to choose whether they wished to remain professional engineers, doing strictly technical work, or become professional managers.) However, twenty years after the Perrucci, LeBold and Howland study, the 1986 Survey found that 50 percent of the work of engineering respondents involved managerial and communication skills. They concluded that engineers were continuing to manage and that "the profession of engineering can no longer be thought of as strictly technical in nature (if it ever was)". In Canada, Baignée found that approximately 33 percent of registered professional engineers defined themselves as "managers" (CEHRB 1991:11).

Koplow (1967: 88) suggested that "an engineer's inability or unwillingness to master management's skills and field of knowledge leads to his [or her] almost certain failure as a manager". The concept of "people versus things" troubles

many engineering managers whose orderly thinking may inhibit the intuitive abilities he or she may have. Similarly, Koplow's "soft versus hard skills" describes the difficulty many engineers have with what cannot be measured. He argued that a serious and sustained effort to recognize and value soft skills is essential for success in engineering management. Dewhurst (1991) urged organizations to help specialists to cope with the transition to management through a series of experiences.

A popular solution to acquiring management skills is through graduate MBA programs. Raelin (1990: 26), however, argued that it does not teach what managers need to know in confronting day-to-day interpersonal problems. While the MBA is good at teaching problem-solving it does not do an adequate job in problem-finding, and cannot train students in effecting social change. His conclusion was that managers need to learn behavioral, organizational and industry-specific skills.

Solomon and LaPorte (1987) argued that "separating management education from technical education produces corporate leaders who lack familiarity with the whole organization (p. 61)...[since] the normal career path for the majority of scientists and engineers is to move into management positions after a certain period of time" (p. 65). Thus their training should recognize that "some basic understanding of business principles, accounting principles, and personnel relations

might be valuable skills". Engineering management is a rapidly growing new discipline with the number of world-wide institutions offering such programs having increased from 84 to 121 between 1984 and 1990, graduating a cumulative total of 30,000 by 1990. Six of these programs in 1990 were in Canada and 94 in the U.S.A. (Kocaoglu 1990: 176). Wyrick (1991) offered an alternative view that engineering management topics should be incorporated into traditional engineering undergraduate programs. Mascolo, Wright and Slemon (1985) suggested that the undergraduate engineering curriculum should devote more time to understanding "internal and external markets, and the political, social, economic and human environment" (p. 19).

The extent to which engineering managers practice professional engineering and provide technological leadership has received little attention in Canada and deserves careful study. The foregoing review provides some insight into this important aspect of professional engineering

3.5 Summary

The history of the engineering profession in Canada, the U.S. and Western Europe has been well documented. The engineering profession in Canada, which is structured to embrace all the technical specialties, differs from those in the U.S. and the U.K. which are structured into technical divisions. Further, the Canadian engineering profession has legal stand-

ing which permits it to control its own practice. While engineers have a strong allegiance to their profession, their work in an organizational setting tends to be one of deep involvement in the mission of the organization. They do so as specialized, supervisory and managerial decision makers, particularly when technical matters are involved. In doing so engineers are part of the management of the organization. Only a few, mainly government organizations, are unionized.

The Canadian engineering Associations licence professional engineers two (now changing to four) years after graduation from an engineering school upon evidence of satisfactory experience. However, there is no requirement at present to demonstrate continuing competence. Further, the Associations have only prosecuted cases of faulty engineering by professional engineers in, so called, private practice working directly for the public; they have not ensured that professional engineering carried out in industry meets the code of ethics and public safety standards.

The Canadian Engineering Accreditation Board, acting on behalf of the Associations, has not required that management subjects be included in the engineering school curricula even though the management of engineering work is included in the definition of professional engineering work in the CCPE guidelines. The engineering profession has not yet grasped that the management of professional engineering work is also engineering and, in fact, always has been.

CHAPTER FOUR

THE PROFESSIONAL AND THE ORGANIZATION

The purpose of this chapter is to review previous studies related to the utilization of professional ability in organizations. This literature includes the parallel fields of organizational behaviour and career development. The review begins with the elements which motivate professional work, and those relating to the management of professionals. This is followed by a discussion of the factors which affect the utilization of professional ability. Such antecedent factors include professional competence, career aspirations, professional responsibility, organization structure, organizational practices, and supervisory competence. The next section deals with outcomes of the utilization of professional ability, including job satisfaction and organizational commitment. This information will be used to develop a number of propositions relating the antecedents and outcomes with utilization, and to develop an integrated theoretical model of utilization in Chapter Five. The final section describes the effect of biographical characteristics on utilization.

4.1. The Motivation of Professionals

Jones defined motivation theory as the attempt to explain "how behaviour gets started, is energized, is sus-

tained, is directed, is stopped and what kind of subjective reaction is present in the organism" (quoted in Lawler 1969: 426). More specifically for our purposes, Robbins (1993: 205) defined motivation as "the willingness to exert high levels of effort toward organizational goals, conditioned by the effort's ability to satisfy some individual need".

Maehr and Baskamp (1986) argued that to understand the nature of motivation one should "look first at the behavior that is to be explained" (p. 2). They suggested that most motivational talk arises from observations about variations in five behavioral patterns which they labelled direction, persistence, continuing motivation, intensity and performance. Performance, they claimed, is a product of acquired skills, ability and a combination of the other four behavioral patterns. While performance is "a very crude measure of motivation", performance levels often lead to motivational inferences and are thus important (p. 5).

Based on their research Steers and Porter (1991: 20) argued that "if managers truly want to improve performance and work attitudes, they must take an active role in managing motivational processes at work...[providing employees] with jobs that offer greater challenge, diversity, and opportunity for personal need satisfaction" (p. 580).

The motivational theories which are described in this section are still current and provide a background to understand the basis for the top-down management of professionals

by organizations. Four theories focus on needs. These are Maslow's hierarchy, Herzberg's motivation-hygiene, Aldorfer's ERG, and McClelland's needs, theories. They have been found useful in explaining productivity and job satisfaction. The job characteristics model also does this for individuals with a high growth need, such as professional engineers. The sixth motivation theory, Vroom's expectancy theory, focusses on performance and offers a strong explanation of employee productivity and turnover, especially for those professionals with few limitations imposed by work methods, supervisors and company policies.

One of the best known theories of motivation is Maslow's (1943, 1954) "hierarchy of needs". He argued that his higher order needs, including internal self-esteem factors, self-respect, autonomy and achievement, and his self-actualization factors, growth, achieving one's potential and self-fulfilment, are satisfied internally (within the person). Research has not, however, validated the theory (Robbins 1993: 207).

In Herzberg's (1966) alternative motivation-hygiene theory, the factors leading to job satisfaction are separate and distinct from those leading to job dissatisfaction. To motivate people, Herzberg suggested emphasizing achievement, recognition, greater responsibility, advancement, and the doing of the work itself. According to Robbins (1993: 211), the trend toward allowing workers greater responsibility in

planning and controlling their work can probably be largely attributed to Herzberg's findings and recommendations.

Alderfer (1969), in a reworking Maslow's (1943) need hierarchy to correspond more closely with subsequent research, argued that there are three groups of needs: existence, relatedness, and growth, hence the label ERG theory. Existence is concerned with providing basic material requirements including salary and working conditions; it includes Maslow's physiological and safety needs. Relatedness is the desire to maintain important interpersonal relationships; it aligns with Maslow's social need and the external component of his esteem classification. Growth is concerned with the intrinsic desire for personal development, and includes the intrinsic component from Maslow's esteem category with the characteristics included under self-actualization (Robbins 1993: 211). In an organizational environment, the first two needs are controlled by the individual's supervisor and by organizational practices, which can act to enhance or limit personal growth needs.

The motivation theories of Herzberg, Mausner and Snyderman (1959) were based on a survey of accountants and engineers, applied specifically to knowledge workers. Their concept of positive "motivators" (achievement, recognition, work itself, responsibility, advancement and growth) and negative "hygiene" factors (company policies, salary and supervisory style), led to the idea of enriching jobs for

white-collar workers, including engineers. Gomersall (1971), based on his research, argued that "factors affecting motivation of engineers show that work itself has the greatest impact". Ritti (1971b: 89) also found that the work goals of engineers are achieved through performance of tasks that allow them to demonstrate their capabilities. ERG theory addressed the rewards-goal relationship, with motivation being high if the rewards satisfy needs that are connected with personal goals. Jobs that have high complexity score high in motivating potential and increase the linkage between effort and performance. Finally, jobs that offer autonomy and feedback tend to satisfy those employees who want greater control over their work (Robbins 1993: 232).

The Great Depression had seen an interest in attempts to improve job performance. The Hawthorne studies (Mayo, 1933, and Roethlisberger and Dickson 1939), in particular, had led people to believe that job performance could be improved through better employee attitudes. However, Brayfield and Crockett (1955) in their review of subsequent investigations concluded that "there is little evidence in the available literature that employee attitudes...bear any simple...or appreciable relationship to performance on the job".

Herzberg et al. (1957) in their review confirmed that prior research did not show strong relationships between employee attitudes and productivity. Productivity is a quantitative measure of outputs and inputs, and while appropriate for

blue-collar and clerical workers, is not a suitable measure of the intellectual work of professionals. Job performance is a preferred measure of professional work, and is usually based on the extent to which the professional accomplishes her or his tasks, often as defined in a job description. However; performance, according to Von Glinow (1990: 41), is difficult to define: "There may be numerous aspects of a professional's performance that should be evaluated, but if these aspects are not measured properly, they will be difficult to evaluate...a considerable part of the creative, innovative role that a professional plays is highly subjective...both objective and subjective measurements are filled with difficulties".

While job performance is based on defined job expectations of the organization or the professional's supervisor, the utilization of professional ability is a measure of the extent to which the work of the professional utilizes his or her full abilities and skills. It can be judged by both the individual and the organization. To the extent that the organization focusses on job requirements these two judgments are likely to differ. For, example, unless the organization utilizes the full ability of the professional, utilization may tend to be directed toward work which does not coincide with the organization's objectives.

Writing at the same time as Herzberg, McGregor (1957) summarized Taylor's earlier (1947) scientific theory of work

motivation (which he called "Theory X") as management by getting things done through people who are by nature indolent. He concluded that management by direction and control fails to provide motivation towards organizational objectives (1957: 27). McGregor's alternative, "Theory Y", advocated that management's task is "to arrange organizational conditions . . . so that people can achieve their own goals best by directing their own efforts toward organizational objectives". Decentralization, delegation, job enlargement, participation and consultative management, and self-evaluation of performance based on self-set targets are all ideas, still current, resulting from his theory. Argyris (1957) also wrote a criticism of scientific management based on the clash between the common characteristics of personality development, in which humans go from a state of dependence to independence. In the classical organization concept of division of labour, the individual sells skills rather than total abilities, while chain of command tends to make individuals dependent and passive. This lack of congruency, Argyris argued, generates frustration, a short term perspective and conflict.

Drucker (1952, 1954) had arrived at a conclusion similar to McClelland's, but called his theory "management by objectives", in contrast with management by control. Drucker was very influential in the 1950s in persuading companies employing large numbers of engineers, such as the General Electric

Company, to introduce his management concepts. These firms exported the concepts to their Canadian subsidiaries, including Canadian General Electric, at a time when the author was an employee. The objectives chosen had to meet return on investment (ROI) criteria. As high inflation and high interest rates became prevalent, the high required ROI made it very difficult to justify R & D and new investment, leading to a significant loss of control by engineering decision-makers, particularly in manufacturing enterprises. Thus McGregor's and Drucker's attempts to delegate were frustrated.

Likert (1961), expanding on McGregor's theory, argued that participative management is the most effective way of achieving high performance. Vroom and Deci (1970:17) inferred that the principles of participative management are most useful in managing persons with strong needs for, what Maslow (1954) called, self-actualization. Expanding this view, Deci (1975:223) suggested that under participative management, the organization "minimizes the differences in authority between the supervisor and subordinates; the supervisor becomes more of a consultant than a boss". Schein (1981: 382) based on his study of the Japanese management style, argued that participatory methods also can work in the U.S. They must, however, be based on the different premise that teamwork and participation lead to better problem solving and more efficient performance since knowledge, informa-

tion and skills are distributed among a number of people, and not because teamwork, consensus or involvement are goals *per se*. Recent studies (Graham and Verma, 1991), however, find that management is often reluctant to share its decision-making power, and that participation typically has only a modest influence on employee productivity and motivation.

McClelland's (1961) theory of needs focused on three needs: achievement, power and affiliation. He defined his need for achievement (nAch) as "the drive to excel, to achieve in relation to a set of standards, to strive to succeed". McClelland found that high achievers differentiated themselves from others by their desire to do things better, to seek situations where they can obtain personal responsibility for finding better solutions and where there is the challenge of working on problems.

Task characteristic theories sought to identify the task characteristics of jobs, how these characteristics are combined, and their relationship to employee motivation, satisfaction and performance. Hackman and Oldham's job characteristics model (JCM) identified five core job characteristics and their relationship to personal and work outcomes (Hackman, 1977: 129). These five characteristics are skill variety, task identity, task significance, autonomy, and feedback. The first three combine to create meaningful work, leading the employee to view the job as being important and valuable. Jobs that possess autonomy give the incumbent a

feeling of freedom and personal responsibility, while feedback permits the employee to obtain clear evidence of his or her effectiveness and performance. Individuals who work on activities with high core job dimensions are generally more motivated, satisfied and productive than those who do not. Individuals with a high growth need are more likely to respond to job enrichment than those with low growth need.

Vroom's (1964) expectancy theory is one of the most widely accepted explanations of motivation and continues to find support, serving as a base for integrating the theories described. Expectancy theory predicts that an employee will exert a high level of effort if she or he perceives a strong relationship between effort and performance, performance and rewards, and rewards and satisfaction of personal goals. According to this theory "the individual must receive meaningful feedback about his [sic] performance, the job just be perceived by the individual as requiring him to use abilities that he values in order for him to perform the job effectively...[and] the individual must feel he has a high degree of self-control over setting his own goals and over defining the paths to these goals' (Lawler 1969: 429). Based on this theory, Porter and Lawler (1968) proposed a model which integrated the concepts of reward, expectance, effort, performance and satisfaction. In the model the value of reward and the expectance of the reward affect effort, which moderated by ability results in performance. Performance results

in rewards, which if perceived as equitable, results in satisfaction. Satisfaction, in turn, contributes to greater effort, thus continuing the loop. Porter and Lawler described two types of rewards: intrinsic and extrinsic. Extrinsic rewards depend upon others to recognize the performance and to administer the rewards. High performance can be an immediate cause of intrinsic satisfaction assuming that the job provides sufficient challenge to appeal to growth needs. Deci (1985) suggested that the need for competence leads people to seek and conquer challenges that are optimal for their capacities, and that competence acquisition results from interacting with stimuli that are challenging. The reward for competency-motivated behaviour is the inherent feeling of competence which seems to result only when there is some continual stretching of one's capacities. Deci offered an operational definition of such intrinsic motivation as "an activity when a person does the activity in the absence of a reward contingency or control" (p. 51).

According to Von Glinow (1990):

Overall, the most important sources of attraction, motivation, and retention of professional employees derive from the professional rewards associated with the work itself, from the career development process, and from the organizational processes (including how the work is evaluated, how autonomous the workers are, and how well people work with one another). Important sources do not include financial or economic rewards, of either a short-term or long-term nature [p. 79].

Robbins (1993: 230) suggested that a popular, although

arguably simplistic, way of thinking about employee performance was a function of the interaction of ability and motivation; that is, $\text{performance} = f(A \times M)$. If either A or M is inadequate, performance will be negatively affected. Intelligence and skills (subsumed under the label "ability") must be considered in order to be able to accurately explain and predict employee performance. However, Robbins added, the opportunity to perform must be added to the equation, thus $\text{performance} = f(A \times M \times O)$.

According to Anderson and Kleingartner (1987):

Professionals are socialized by their educational backgrounds to expect to work independently,...and to work under conditions of challenge and autonomy. Performance is a response to internalized motives, which dictate goals as well as standards [p. 12].

This section has reviewed four theories that focus on needs in explaining the relationship between achievement and productivity, and McGregor's and Drucker's theories of management. Also reviewed was the job characteristics model, which predicts that individuals with a high growth need, such as engineers, will be both high performers and satisfied when their jobs offer skill variety, task identity and significance, autonomy and significance, autonomy, and feedback. Vroom's expectancy theory continues to be effective in explaining performance increases where the jobs performed are more complex and where the individual has greater responsibility and discretion in the organization's structure.

In summary, the literature reviewed provides evidence of links between motivation and achievement, on the one hand, and job performance, productivity and job satisfaction, on the other.

4.2 Management of Professionals

Individuals join organizations to further their own careers and to obtain personal satisfaction. In so doing they must come to terms with the interests of the organization which employs them. There is evidence, however, that organizations have not taken a serious look at the interests of their professional employees.

Ritti (1971a) found that in pursuing its aim of improving the effectiveness of resource allocation and eliminating errors caused by faulty judgement, "management has created a climate of over-control which is the source of underutilization; ... over-management and inflexible personnel policies are at fault" (p. 155). Ritti (1971b) also found that "the mode of organization appropriate to the business of big systems development implies an individual problem of underutilization of skills ... and lack of influence inherent in the productive process" (p. 68). Thus, he argued, "engineers seeking ways to meet their personal goals are blocked by the typical work organization" (p. 70). He found that:

differences in supervisory behaviour that do exist are the product, not the source, of the management environment ... the outcomes observed at the lowest (engineer) level of the organization are in many respects beyond the control of local people, are in fact the long-range outcomes of division and corporate level policy decisions [p. 160].

Ritti (1971b) also recognized that "it is the [organization's] mission and the environment that establish the character of individual tasks generally and determine the probability of underutilization" (p. 137). He concluded that "the low role influence that is associated with underutilization stems not from endemic technological constraints but from management policies - top management policies" (p. 173). He reasoned that if "important systems decisions involve business and economic considerations, as well as intelligence about the activities of competitors [and] these kinds of information are seldom entirely within the grasp of non-supervisory engineers" then, under these conditions, there is a clear attraction to progressing up the supervisory ladder where the engineer is able to become more involved in making decisions that affect his or her work (p. 178). True job enrichment in engineering organizations, he concluded, calls for "upgrading the role of the technician and changing the role of the engineer to that of technical manager (p. 240).

Based on his own extensive survey, Landis (1971) expressed a similar view:

management must pay greater attention to allowing its engineers freedom of ideas and action together with personal growth while at the same time the scope and overall responsibility of the individual remain defined. More recognition should also be given to the manager as a technical leader in addition to his [or her] function as a "manager of men [and women] [p. 393].

Thompson and Dalton (1976) also found that high organizational positions are attractive to the technically oriented because they give them the power to be autonomous in their technical functioning. They also found evidence that necessary technical updating will be achieved by mid-career engineers on their own, if they are given challenging assignments that require new knowledge or skills.

Schein (1978: 312), however, was critical of managerial psychologists who focus primarily on the selection of managers. He believed that this emphasis was misplaced since "more and more companies [will] acknowledge their dependence on key technical or functional people who may be individual contributors". Raelin (1985: 265) suggested that "it is entirely possible to merge the professional staff's dedication to technical performance in their discipline with a genuine commitment to organizational performance". He described a number of polarized values and suggested mediation strategies to deal with them. First was the dual problem of overspecialization, on the one hand, and overprofessionalization, on the other, for which he suggested the use of linkage devices to promote access to the corporate culture, Autonomy was another major problem, for which he

suggested the dual ladder and the control of the means, but not the ends, as mediation strategies. A distaste by professionals for close supervision can be mediated, he suggested, by self-management and peer control through a focus on objectives. Finally, lack of respect for organizational procedures could be mediated by decentralization and use of matrix structures.

The literature reviewed in this section has described research on the views of professionals in U.S. organizations: those whose loyalty is to their profession and those whose loyalty is to their organizations. The U.S. literature tends to draw a clear distinction between engineers and managers, perhaps influenced by schools of management promoting management as a separate profession, and by the greater U.S. focus on technical versus managerial qualifications in their classification of engineers. The evidence indicates that what is at issue is control of the decision making process. Since engineering in organizations tends to be a team effort, coordination, i.e. the management of that effort, is a basic need. Engineers who become managers do not cease to be engineers. Although they might find it harder to maintain their purely technical competence, the job of coordinating the technical effort, at least in the first levels of supervision, requires that technical knowledge be integrated with other knowledge needed to accomplish the task. Canadian professional engineers include a large percentage who class

themselves as managers and yet remain members of the engineering profession as they progress up the management ladder. As noted in Chapter Three, the Canadian Council of Professional Engineers' definition of professional engineering includes the management (as well as the doing) of professional engineering work. If Canadian engineering licensing associations become active in requiring that engineers take updating courses to maintain their licences, organization-related courses would be logical candidates for inclusion in such studies since so many engineers become managers after a few years of practice, and are in a position to influence the utilization of engineers assigned to them.

4.3 Antecedents of Utilization

Several factors may affect the utilization of professional ability: professional competence, career aspirations, professional responsibility, organization structure, organizational practices, and supervisory competence. The literature linking each of these factors to utilization is described in the subsections that follow.

4.3.1 Professional Competence

While all Canadian professional engineers, in order to be registered, must show evidence of academic competence, usually in the form of a Bachelor degree in engineering, and professional experience (two years, changing to four). There

is, at present, no requirement to maintain professional competence, and to provide evidence of such competence, in order to remain registered. The maintenance of competence thus falls upon on-the-job training. Where the work is not challenging or is repetitive, there is a strong possibility that the professional engineer's knowledge will become out of date. However, there is evidence that the Canadian Provincial Governments are exerting pressure on the self-governing associations to implement appropriate reforms.

While stressing the importance of professional technical work for engineers, Kornhauser (1962) was one of the first to recognize engineering administration as a "valued activity", which "may lead in the future to the development of special training programs for the administration of science, paralleling the formation of graduate schools of business administration" (p. 205). Similarly, Dougherty (1968) in a review of engineering education suggested that since the "formal education dealt almost exclusively with mathematical expressions of things of the biophysical world [and] ... social sciences were largely omitted, along with any sincere treatment of the humanities ... we might well predict that the technologist would find difficulty in transition from lone researcher to supervisor, manager or administrator" (p. 12). Babcock (1974: 103), in his review of engineering management education in university degree programs appealed for a definition of engineering management and a differentiation from business

management. His preference was that it be thought of as Management by Engineers (where both technical and management knowledge are needed), rather than Engineering of Management (relying heavily on quantitative mathematical analysis) or Management of Engineering (limited to the management of engineering or research activities). However, in spite of the urging, little progress in taking action on any of these suggestions has taken place in the ensuing quarter century.

Part of the problem, according to Armstrong (1992: 45) lies in the usage of the term management which has changed over time so that it now signifies "a controlling and directing activity separable from expertise in the process being managed". The end result has been "a conception of management as an activity quite distinct from engineering and other operational expertise". Thus, according to Koontz and O'Donnell (1968: 54) "managers perform the same function regardless of their place in the organizational structure ... [thus] managerial knowledge and experiences are transferable from department to department and from enterprise to enterprise". Drucker (1954: 344) said much the same thing: "Every manager does many things that are not managing ... All are necessary and have to be done well. But they are apart from that work which every manager does whatever his [or her] function or activity ... work which is common to all managers and which is peculiar to them".

Armstrong (1992) was highly critical of these views, and

particularly of Mintzberg's (1973) empirical study, which found that "managers jobs are remarkably similar", since "in observing managerial behaviour ... Mintzberg did not observe roles, as he claimed, but inferred them" (p. 47). The danger with Mintzberg's research, according to Armstrong, "is that a reader inclined toward the half-truth that management is essentially about 'handling people' rather than knowledge processes ... can easily read Mintzberg's study as empirical confirmation. In reality, a crucial component of 'handling people' may be the offer of expert advice or guidance" (p. 48). Armstrong concluded that "the conception of 'management' behind current management education implicitly denies the managerial relevance of engineering itself". Yet, in the real world, management, as Taylor [1947] conceived it, is integral to engineering. Technological work means precisely nothing until the engineer has also organized the labour force to put it into practice" (p. 52).

A call for action to improve the management training of engineering students was made by Mascolo, Wright and Slemon (1985) in a discussion paper for the Science Council of Canada. They argued that "in order to integrate the exploitation of technology into society, engineering curricula will need to devote more time to the understanding of areas such as interactions between production units, internal and external markets, and the political, social, economic, and human environments of our society" (p. 19). Similarly, Clarke and

Reavley (1990: 54,55) recommended that "courses in technological innovation or technical entrepreneurship should be customized to meet the specific needs of science and engineering students, especially in the areas of interpersonal relations, communication, and high technology marketing", and that "professors should be encouraged to develop undergraduate versions of their MBA-level courses on technological innovation or technical entrepreneurship that meet the specific needs of science and engineering students". The 1986 Survey indicated that engineers appear to agree. An overwhelming 88 per cent of the respondents expressed satisfaction with their technical education at university, however, only 52-62 percent were satisfied with the written communication, the oral communication, and the human relations skills developed, prior to beginning engineering practice. The need is apparent, with engineers spending 47 percent of their time with duties such as administration, teaching, writing, marketing and consulting which involve managerial and communication skills (AAES 1986:20). The authors of the 1986 Survey concluded that these skills are critical to the engineer's ability to function effectively, and recommended that engineering schools review their curricula to incorporate courses which enhance graduates' preparation in these areas (p. 2). Doing so, need not mean extending the present undergraduate period; writing and communication skills, for example, could be fostered within existing courses, and certain School of

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Business core courses could be included among the options available. Until engineering schools find a way to incorporate this knowledge in their basic undergraduate curricula, newly graduating engineers will continue to be deficient in these areas.

In a survey of engineers and scientists in R & D to determine activities seen as most important for professional growth, Margulies and Raia (1967) found that on-the-job problem solving elicited the highest proportion of responses (42 per cent), followed by on-the-job colleague interaction (20 per cent). On the other hand, they found that publishing and independent reading, formal courses and programs, and outside professional activities elicited relatively small percentages of replies. They concluded that:

professional growth and development ... is related to such variables as openness of communications, the organization's responsiveness to individual needs for development, the individual's ability to seek and find help, the nature of colleague interactions, the extent to which flexible team effort is employed, and the autonomy of the individual scientist or engineer [p. 46] ... continuing education programs, if they are to be effective, must be an integral part of organizational life, must be related to the organization mission, and must be in response to the needs of the individual [p. 48].

The degree to which an engineer needs to stay technically current appears to influence how she or he keeps up to date. Among those who state that professional development is essential, technical publications, job assignment, conferences and meetings, and self-study are important, while those

who state that it is of moderate help place more importance on general continuing-education courses. Engineers with advanced degrees, in particular, according to Kornhauser (1962:141), are "more likely to be given more challenging assignments [and] to be encouraged to participate in professional meetings, publish their research findings and continue their graduate training at company expense".

Randle's (1959) investigation found that 85 percent of professional development was attributable to on-the-job experiences. Similarly, Adam's (1984) later survey of over 1100 electrical engineers to determine how they stay current found that work assignments were the most important factor, especially among older engineers. If on-the-job experience is to result in professional growth, however, the work itself must be challenging; repetitive assignments are hardly conducive to growth. Pressure from legislators in Canada is growing to establish that professionals remain competent as a condition of licence renewal. Professional engineering associations are just beginning to look at means for ensuring that engineers remain competent.

4.3.2 Career Aspirations

Hall (1976) suggested that four basic definitions for the term career had been advanced. The first considers a career as advancement through a sequence of promotions, and lateral moves with enhanced responsibility, during a person's

work life. Second, careers are viewed as tied to a profession, such as engineering. Third, a career is viewed as a lifelong sequence of jobs with no value judgement made. Finally, careers are lifelong sequences of role-related personal experiences.

Schein (1971: 402) recognized the need for two concepts of career: a) the career seen as a "set of attributes and experiences of the *individual* who joins, moves through and finally leaves an organization" and b) the career as defined by the *organization*. There is an interplay between the organization and the individual, with the organization influencing the individual through acculturation or adult socialization, while the individual influences the organization through a process of innovation. Schein suggested that the process of socialization tends to be more prevalent in the early stages of a career and innovation in the later stages. Schein's (1978: 5) career development perspective focussed on the active interaction and involvement of the individual and the organization through activities and jobs. He argued that if the matching processes work optimally, both parties will benefit, with increased productivity levels, creativity and long range effectiveness for the organization, and job satisfaction, security and personal development for the individual.

Morrison and Hock (1986) emphasized a continuous growth process, centred around experiential learning, in their

definition of career: "a sequence of work roles that are related to each other in a rational way so that some of the knowledge and experience acquired in one role is used in the next" (p. 237). Like Schein they suggested that two major processes contribute to career development, where career management represents the organizational perspective, [and] career planning, or self-management, the individual perspective, in which individuals exert personal control over their careers" (p. 238). This personal process involves "seeking information, establishing career goals, and planning the routes one will follow to such goals through occupational, geographical, and organizational choices, job assignments, work activities, self-development programs, and making and acting upon career decisions" (p. 238).

Hall (1976) suggested that the process by which work goals and job challenge lead to good performance result in a self-reinforcing sequence of personal changes, including psychological success, heightened self-esteem, greater job involvement, personal motivation and higher future goals. Thus, he argued, an early career task is to become established by demonstrating strong performance and experiencing psychological success. In a later examination of work in careers, Hall (1986) recommended that employees "assume responsibility for his or her own career development (or at least 80 percent of it) ...[by acquiring] new career competencies, not just job skills. These career competencies might

be called 'metaskills', because they are skills in acquiring new skills. The most important metaskills are adaptability (routine busting), tolerance of ambiguity and uncertainty, and identity change" (p. 248). Johnston (1989) proposed a "T-shaped" model of engineering career development. The engineer starts as a technical specialist, getting to know more and more knowledge in depth, but less and less of the wide spectrum of organizational knowledge (i.e. the "T" has a long vertical portion). As her or his career develops, activities broaden to encompass other knowledge, such as project management or marketing (i.e. the T-shape becomes flattened).

4.3.3 Professional Responsibility

Raudsepp (1964b: 133) found a serious interest in decision making by engineers who believe that "recognition should be reflected in increased responsibility and more freedom in making engineering decisions". Kornhauser (1962: 63), prior to this time, had reached a similar conclusion in his study of engineers in major industrial firms and also found that those with higher degrees "are much more likely to participate in determining their own work assignments". This is understandable since engineers with advanced degrees tend to work as skilled technical specialists in organizational units where they are, possibly, the only person in their specific field of work.

Ritti (1971b: 121) in his survey of utilization found that the extent to which engineers are able to influence decisions is negatively correlated (-0.83) with underutilization. There was a direct relationship between engineers who said they prefer to do more work, an indicator of underutilization, and the those who reported that they are seldom or never allowed to make necessary technical decisions. This lead him to conclude that there is a strong relationship between role influence or involvement in the management of the work, and the overall level of underutilization. Subsequently, Bailyn (1982: 82) confirmed Ritti's (1991b) finding, concluding that high organizational positions "are satisfactory to the technically oriented because they give them the power to be autonomous in their technical functioning. It is the autonomy ... not the prestige or status associated with the management of people".

Organizational decisions are not made by a single individual and are non-rational according to Daft (1989). Summarizing the present state of knowledge he wrote that:

most organizational decisions are not made in a logical, rational manner . . . on the contrary, they are characterized by conflict, coalition building, trial and error, and mistakes. Intuition and hunch are often the criteria for choice. The decision process is disorderly, and may seem random [p. 385].

Simon (1957) in his classic Administrative Behaviour stated that while rational decision-making processes represent the ideal, the organizational context is predominantly

nonrational. Engineers trained in the rational process of decision making under uncertainty have an advantage over those workers who are not so trained where this process is used. However, nonrational decision making conflicts with this training and, being difficult to learn effectively in an academic environment, must be learned on the job. Finding the opportunity to do so is thus important for engineers seeking greater professional responsibility.

The American Society for Engineering Education (ASEE) survey (1965: 254-256) asked over 4,000 engineers with over 10 years of professional experience to select subjects in which additional training would be helpful. The results showed that technical subjects were dramatically less often chosen as compared to the management skill group. (The top ten subjects chosen were all deemed essential for management). The survey report concluded that for much of engineering work, there is only a need for a few "technical superstars". They found that the average engineer is motivated to improve his or her chances of performing some directive, coordinative function, which requires a blend of managerial skills and technical experience. They concluded that this is the only road toward broader, more interesting, and higher status activities, that is, to a greater utilization of professional ability. If the opportunity to pursue highly technical work is, in fact, limited, then it is logical that many engineers will perceive that further technical specializ-

ation will not help them to advance in their careers as much as training in management skills.

The ASEE survey (1965: 256) also found that "technical obsolescence" results from the organization's attempts to apply a structure that is incompatible with the required function. The answer lies, the authors concluded, in redefining the role of engineer from worker to manager. This echoed Ritti's (1971b: 62) earlier conclusion that "an engineer's emphasis of getting into management is not so much a desire to manage people - to supervise others - as it is to achieve organizational status that permits him [or her] a wider latitude of technical involvement" and hence greater utilization of professional ability.

The 1986 Survey found that the primary difference between the time expenditures of engineers at different levels of utilization is the increasing amount of management and administration (observed with higher levels of utilization) with a corresponding decrease in routine technical functions. The 1986 Survey concluded that given the desire to be well utilized by many engineers, there is "a driving force toward managerial and administrative positions and away from the purely technical" (AAES 1986:26). In spite of the evidence that engineers gravitate into technical supervision and higher management, the engineering profession, as already noted, has not taken steps to ensure that adequate training is provided. There is thus a danger that engineers are not

being adequately trained to take greater professional responsibility and are thus less effective in directing engineering work.

4.3.4 Organization Structure

Researching time and work activities in British industry, Stanic and Pym (1968) in their study of the nature and causes of poor utilization among engineers in Britain found that utilization is affected by organizational structure and communications. Organizations can be structured in a number of ways; organic and mechanistic structures are two divergent ways. These structures, the design configurations proposed by Mintzberg, the matrix structure, and dual career ladders are described in the subsections that follow.

4.3.4.1 Organic versus Mechanistic Structures

Three elements of organization structure which affect the utilization of professional ability are: specialization, or the extent to which work activities are broken down, formalization, the extent to which written rules, procedures and standards are used, and centralization of decision-making authority (Robbins, 1993: 487). Where formalization is low, employees have considerable freedom to use their discretion in their work. Formalized standards, for example, eliminate the possibility of employees engaging in alternative behaviour. In decentralized organizations action can be taken

more quickly to deal with problems, and employees are less likely to feel left out of decisions that affect their careers.

An organization's structure reduces ambiguity for employees and thus facilitates higher levels of performance. Organizations structured around limited specialization, low formalization, and wide spans of control provide employees with greater freedom and the opportunity for behavioral diversity than those that are not so structured. These conditions are amenable to greater utilization of professional ability.

A mechanistic structure is characterized by high specialization, particularly through horizontal differentiation, high formalization, and high centralization. It is, typically, a rigid pyramid-shaped structure. An organic structure, on the other hand, is low in specialization, formalization, and centralization. Coordination is obtained through upward, as well as lateral and downward, communication, and through a high degree of participation in decision-making. Highly innovative organizations tend to have organic structures, while firms following a cost-minimization strategy need a mechanistic structure. An organization pursuing an imitation strategy tries to minimize risk while maximizing profit, and tends to adopt a combination of mechanistic and organic structures. Engineers are found working in all three types of organization.

Burns and Stalker (1961), followed by Lawrence and Lorsch (1967) and Galbraith (1967), showed that organizations with organic structures were more successful under conditions of uncertainty or when innovation is required; these are conditions which favour the participation of engineers. Organic structures are characterized by more upward and horizontal communication. Kaufman (1974:122) found that to a large extent management policies determine the communications climate in the organization. A climate of open communication is a prerequisite if professionals are to influence decisions in the organization. Poor colleague communication results in the misuse of engineering personnel.

Raudsepp's (1963b,c,d) surveys of engineers in industry also found a serious problem in communications, for example, 74 percent of the engineers claimed that top management failed to inform them about their decisions and the reasons for the decisions, 53 percent did not know how their work fit in with company policies, and 63 per cent felt that management made decisions based on limited information. In addition, 45 percent felt that management reacted unfavourably to engineers' suggestions, while only 33 percent felt that they reacted favourably (1963b:122). When broken down between non-supervisory and supervisory engineers, the results were significantly different. While only 46 percent of the non-supervisors felt they are given as much information as they needed about the company's operations, 82 percent of the

supervisors felt satisfied with the extent of information received. On the other hand, when asked about being left out of things which affect them, 79 percent of non-supervisors and 52 percent of the supervisors felt they were left out (1963c:124). These data indicate that serious organizational problems in communication affect both engineering levels of responsibility, but particularly non-supervising engineers.

Harrison (1975: 138), in his empirical studies of research scientists, showed that "professionals in formal organizations perceive themselves at higher levels of role performance in the presence of the organic system of management". However, Pelz and Andrews (1976), based on their study of over 1300 scientists and engineers, found that the more productive groups were neither too loosely nor too rigidly structured. They gave members a strong influence on decision making although that influence was shared with their supervisors, colleagues and clients.

While the advantages of organic structures have been argued for uncertain technological and environmental circumstances, scholars such as Bailyn (1982), focusing on the structural impact of technological changes, have argued that both mechanistic and organic structures are inappropriate for high-tech firms facing rapidly changing technological environments. These firms require clear, stable organizational structures, maintaining their flexibility through frequent reorganizations and the use of temporary teams.

4.3.4.2 Mintzberg's Design Configurations

Mintzberg (1983), a Canadian graduate engineer and professor of management proposed that there are five basic parts to any organization: the operating core, the strategic apex, the middle line, the technostructure, and the support staff. A key feature of his proposal was that any one of these five parts can dominate an organization.

In the operating core, employees perform the basic work related to the production of products and services. The strategic apex includes the top-level managers, who have overall responsibility for the organization. The middle line includes the managers who connect the operating core to the strategic apex. The technostructure includes the analysts who have responsibility for establishing the procedures and practices in the organization. Finally, the support staff includes personnel in staff positions, who provide indirect services for the organization. If the operating core is dominant, decisions are decentralized, creating the *professional bureaucracy*. If the strategic apex is dominant, control is centralized creating a *simple structure*. Where the middle management is dominant, the basically autonomous units create a *divisional structure*. A *machine bureaucracy* results where the technostructure is in control, via standardization. Finally, an *adhocracy* results where the support staff is dominant, with control through mutual adjustment. Each structure has its strengths and weaknesses, and

behavioral implications. Professional engineers can be found in all five forms of organization structure. Where the operating core or support staff are dominant, the organization structure is organic, but where the strategic apex, middle line, or technostructure are dominant, the structure is mechanistic.

4.3.4.3 The Matrix Structure

A matrix structure is another organizational design, which attempts to link the advantages of functional departmentalization, through the pooling and sharing of specialists across products or services, with the advantages of product or service departmentalization, through the coordination among specialties related to a given product or service. In a matrix structure, employees work as a team in a group that has two bosses, their functional department managers, and their project, product or service manager.

The matrix organization improves the utilization of engineering specialists, on the one hand, and provides a means of developing management skills among engineering product leaders and managers. It can lead to increased motivation among professional employees. According to Anderson and Kleingartner (1987) increased utilization of the matrix organization of work was, arguably, the most significant organizational response to professional bureaucratic conflict: "the temporary nature of the project leads itself

especially to the suspension of hierarchical authority and replacement with more flexible problem-solving, task oriented work, organization and responsibilities" (p. 15). Work in a matrix structure, however, can result in greater time and intellectual demands, leading to stress (Knight, 1976).

4.3.4.4 Dual Career Ladder Management

Dual career ladder management was proposed in 1958 as a way of freeing-up technical professionals to concentrate on the technical decisions for which they had been trained, with general supervisory management taking care of their routine personnel, administrative, and budgeting matters. Thus, parallel "management" positions were created to accommodate these professionals (Shepard 1958). Under this system nearly every engineer eventually becomes a "manager". The system assumes that the technical and administrative responsibilities can be separated. It was not long before weaknesses became apparent. Goldner and Ritti (1967), in their empirical study of engineers, found that the dual career ladder concept, had not been successful. Ritti (1971b: 227) pointed out that "the group with formal responsibility for technical decisions ... must eventually have responsibility as well for manpower and other resources". Thus, he argued, "dual management actually serves to formalize the powerlessness of the staff professional by creating a second-class management without management influence ... the actual function of dual

management is to create an alternative definition of success legitimated by notions of professionalism" (p. 233). Ritti concluded that "dual management is fated from the start because it is based on misplaced ideas and is overlaid on an existing system of role definitions with which it is incompatible" (p. 234).

More recently, Roth (1982) suggested that a critical examination shows that the shortcomings of dual career ladders can be overcome if the technical jobs have formal accountability and performance standards, if the highest levels of the professional ladder are attainable, if the rewards are evenly distributed between the two paths, and if the highest level of the professional track is involved in top-management decision making. Morrison and Vosburgh (1987: 116) cautioned, however, that the dual career ladder "can be alluringly simple in concept but deceptively difficult in design and execution". The 1986 Survey (AAES 1986: 20) found that "most of the companies visited during the study had a dual career ladder, but it did not go as high as the management ladder".

In a survey of nearly 1500 engineers and scientists in nine U.S. organizations, Allen and Katz (1986) asked respondents to indicate their career preferences in terms of increasing managerial responsibility, technical ladder advancement, or more interesting technical work. They found that while young engineers generally seek managerial advance-

ment, a substantial proportion report a preference for "technical ladder" advancement in the organization. Further, that "both of these more career-oriented motivations decline with age and are replaced with a desire for more interesting work content without regard to organizational standing" (p. 528).

A longitudinal study of the dynamics of dual career ladders by Katz, Tushman and Allen (1990) showed that the relationships and contacts within an organization affect the dynamics of the dual ladder, with first level supervisors playing a strong role in the shaping of the professional's outlook toward, and the effectiveness of, the dual ladder. They concluded that the management side has power, while the technical side does not. thus confirming the position taken by Ritti almost 20 years earlier.

4.3.5 Organizational Practices

The human resource policies and practices of an organization are important factors influencing employee behaviour and attitudes. The sub-sections that follow review the literature discussing the influence of support personnel, training and development programs, and performance evaluation and reward systems.

4.3.5.1 Support Personnel

Ritti's analysis (1971b) of engineering work in a major

corporation showed that development engineers with the highest ratio of technical support are the most likely to need additional technical support, and where engineers need the greatest amount of technical support, they were least likely to feel underutilized (light time and intellectual demands) but most likely to report misutilization (heavy time, light intellectual demands). Ritti's explanation was that engineers "with more need for support get more -- but less than they could use. The result is increasing misutilization" (p. 117). Thus while a lack of technical support does not appear to cause underutilization, it seems to result in misutilization. The ratio of technical support did not account for underutilization, it is the technical mission or the organization that "determines the need for technical support" (p. 117).

The 1986 Survey found that an important factor in the utilization of engineers is the extent of support of practicing engineers by technicians and other support personnel, together with the availability of necessary equipment and facilities (AAES 1986:1). Among respondents, 86 percent stated that it was important personally to have sufficient technical support personnel, and 70 percent stated that it was important personally to have sufficient non-technical personnel available. The authors noted that:

most engineers do not know how to use technicians ... Since the development of supervising skills has been absent from engineering training, they may feel more

comfortable doing their own technician work. Most of all, engineers need to be trained to exercise their role as leader of the technical team [AAES 1986: 17].

Over 80 percent of all respondents stated that it is important personally to have up-to-date equipment and adequate computer facilities. In the nine years since the 1986 Survey there has been an huge increase in the availability of personal computers, to the point where most engineers that need them are now likely to have them available. The 1986 Survey authors commented that:

computers reduce the need for secretarial help because the word processing capability is used by engineers to generate reports. Whether this makes for effective utilization of engineers is a matter of debate [AAES 1986: 17].

A more recent need for up-to-date communications hardware and software, such as E-mail, seems to be well on the way to being addressed.

The relevance of the organization's support staff to utilization of their professional staff should not be underestimated. The quality of suitable technical and non-technical support staff to support and complement the work of professionals can have an important influence on the utilization of professional engineers. Thus, careful hiring and training of such staff should be given attention and involve the participation of the professionals to be assisted.

4.3.5.2 Training and Development Programs

Formal and job rotation training programs directly improve an employee's ability to carry out the job effectively and to perform at a greater level of responsibility. They also reduce the possibility of obsolescence and of job frustration, and of subsequent job dissatisfaction. Training can be particularly valuable during a period of cutbacks when valuable employees may feel there are few opportunities for growth (Granrose and Portwood, 1987).

For professional development and growth, according to Kaufman (1974: 130), organizations must "examine the effects of their policies and control systems on individual competence and organizational effectiveness". Thus organizations should "design professional jobs to make them more challenging ... by improving the utilization of professional knowledge and skills and by increasing individual responsibility and influence" (p. 161). Organizations also should "provide for changes in job assignments to avoid narrow specialization" including, for non-supervisory engineers, the "possibility of a career change to an administrative career [with] appropriate management training". Kaufman also noted that "work which is more challenging requires engineers to utilize as well as update their knowledge, resulting in greater enrollment in graduate courses" (Kaufman 1975: 407).

Miller (1986) claimed that progressive firms begin career development programs as part of a larger effort to

improve productivity and reduce turnover. Three types of support are fundamental to this process: top-management support, support for training of both managers and professionals in the methods of career management, and procedures that allow the manager and professional to have a career discussion at least once a year.

The U.S. National Academy of Engineering, through its meetings and forums, recognized that flexibility and adaptability are important qualities for engineers (USNRC 1990: v). Since shortages tend to occur in individual disciplines, especially those linked with high growth, flexibility can help resolve the shortfalls. They recommended that a "basic education, particularly limited to only the first professional degree level, ... [cannot be] relied on to meet the greater challenge of the future ... [thus] career-long education [and] professional development" will be needed. While large organizations offer in-house programs and promote reimbursable off-site courses, "for the small company, the governing rule is that the individual is on his/her own" (p. v). An opportunity thus exists for governments to help these professionals by allowing approved part-time and short courses to be subject to income tax deduction, as is the case for full time courses.

The 1986 Survey (AAES 1986: 33) found that engineers are not unanimous in valuing continuing development activities. Only 68 per cent of the respondents stated that it is import-

ant personally to have comprehensive on-the-job training available for engineers. However, 96 percent stated that it is important personally to be assigned challenging work assignments by their supervisors and their organization in order to broaden their experience. Morrison and Hock (1986: 266), based on their organization studies, concluded that "the contribution of work experience to career development is significantly greater than the contribution of education and training. While these may provide an intellectual knowledge base, they seldom provide skill development and do not include effective social skills or personality development". Morrison and Hock's experience-based development model considers both intellectual and personal development. However, organizational and personal goals are likely to clash, since it is not always possible for organizations to create continually challenging work (i.e. someone has to do routine work).

Challenging work is more likely to be obtained where engineers are able to influence the organization. This decision making influence is usually secured at a management level, since it usually requires a knowledge of a number of factors, many of which are not strictly technical, to influence organizational decisions. This can mean that, unless the personnel administration function ensures fairness, managers can obtain a greater share of the personal development budget and the attendant benefits.

4.3.5.3 Performance Evaluation and Reward Systems

Performance evaluation represents an assessment of the employee's work. The work of engineers can seldom be determined objectively, and subjective measures are usually assessed by the engineer's direct supervisor. Since performance evaluation is often the basis of promotions, pay raises and even of continuation in employment, it is an important factor from the viewpoint of the engineer being evaluated. If the supervisor focuses on visible and easy-to-measure criteria, such as punctuality or promptness, this focus may override quality measures and discourage individuals from taking on important problems (Huber, 1980: 215). The way the individual perceives the performance evaluation, the competence of the supervisor who carries it out and the organization's policies, are more important than any independent assessment that might be made. The views of the individual are essential in trying to understand the individual's behaviour, but they are often not sought.

The content of the performance evaluation has been found to influence employee performance and satisfaction (Nathan, Mohrman, and Milliman, 1991). Performance and satisfaction increase when the evaluation is based on behavioral, results-oriented criteria, when the employee's career is discussed as well as the performance, and when the employee has an opportunity to participate in the evaluation. These conditions lead to a minimum of dissatisfaction, reduce

job turnover, and increase organizational commitment. The 1986 Survey, however, found limited interest in career guidance among engineering respondents (only 54 percent felt that "high quality career guidance" was important personally). This relatively low response could be the result of having had very limited previous exposure to the benefits of good career guidance, since career guidance is not always part of annual engineering performance evaluations. Von Glinow (1990: 171) suggested that when performance assessment fails for professionals, "it is typically because of a breakdown in the organizational systems that define, measure, reward, and give feedback on performance".

Remuneration that is fair and equitable was found by Locke (1976) to be a determinant of job satisfaction. Canadian professional engineering associations, as already noted, conduct two annual salary surveys: one of their memberships and the other of companies employing large numbers of engineers. In each case, the results are grouped by level of professional responsibility and by year of graduation. Thus an engineer can compare himself or herself with his or her peers and make a determination of whether their pay is equitable, and take whatever action he or she feels is appropriate.

Rewards also are likely to lead to high employee performance and satisfaction when they are tied to performance, and are tailored to the needs of the individual (Robbins, 1993:

587). Employee benefits, including flexible hours, maternity and paternity leaves and day-care centres, also may increase job satisfaction and organizational commitment.

4.3.6 Supervisory Competence

Badawy (1982: 162) argued that managerial competency has three interrelated components: knowledge, skills and attitudes. Knowledge in the principles and elements of administration is a prerequisite. The professional skills are technical, personal (ability to motivate, influence and communicate with others), and administrative (ability to organize, plan, direct and control). The importance of the latter increases with increasing management responsibility. In Badawy's view, the major cause of managerial failure among engineers is poor interpersonal skills.

Given (1955: 50) provided a list of 15 qualities of a good engineer evaluated as management qualities. Many of these, such as imagination, temperament, productivity, knowledge, leadership, courage and integrity serve the executive well. However, analytical power, mathematical ability, and ability to think with symbols, often lead engineers to overlook the human, illogical needs of subordinates. Ability to communicate is frequently missing among engineers but is a very useful ability for the executive.

The evidence indicates that the engineer's immediate supervisor plays an important role in the utilization of

professional ability, through the distribution of work assignments and the type of supervision of the work itself.

Kaufman (1974:119), based on his research on engineering supervisors, concluded that "the manager's style, combined with his expertise, can be a powerful influence in creating a climate of utilization and challenge". Utilization is a problem when supervisors are not technically up-to-date and thus cannot properly evaluate the work of their staff; it can occur when engineers are supervised by non-engineers.

Scissons (1979) carried out a survey of 196 Canadian engineers and concluded that there is a need to pay attention to the role of the engineer as a potential administrator and people handler, and argued that the supervisor of engineers should be an engineer. Kaufman (1974) found that human relations skills were not related to the productivity of scientific groups. McCall (1983) suggested that professionals will accept the decisions of a supervisor who is technically competent in spite of deficiencies in human relations or administrative skills. Andrews and Farris (1972) found that effective leaders apply, and high performance professionals want, relatively high pressure. Their study of twenty one research teams showed that differences in supervisory practices did not have much effect on team performance. McCall (1983) pointed out that leader behaviour may have additional subtle or indirect effects on professionals, with supervisory leadership "more orchestra-

tion that direct application of authority" (p. 152). To make a difference, McCall suggested that leaders must create controlled freedom, though collegial give-and-take in decision making (p. 153). Morse (1953) also found that very close supervision of highly skilled work, sometimes a fault of engineering supervisors, does not result in higher productivity.

Raudsepp (1963a) in his survey of 500 working-level engineers and 500 engineering managers in industry found that while 94 per cent of all engineers stated that it is important to know how they stand with their supervisor, 47 percent of the engineers claimed that their supervisor seldom let them know where they stand. Similarly, 82 percent claimed that it is important to have a full discussion with their supervisor about future progress with the company, but only a minority (48 percent) of engineers surveyed claimed that their immediate supervisor kept them informed of objectives, policies, and plans affecting their work more than half the time. A significant majority of 84 percent of engineers agreed with the reverse statement that "engineers often have to work in the dark; nothing comes from management, and supervision does not seem to know what is happening; there is no discussion of mutual problems". When asked where the problem lay, 55 percent stated that ideas go no further than their immediate supervisor.

The 1986 Survey found that 60 percent of highly utilized

engineers indicated that "engineers participate in decisions" is characteristic of their jobs, compared with only 7 percent of poorly utilized engineers so reporting (AAES 1986:41). This indicated that the utilization of engineers could be improved by increasing the extent to which they participate in the decision making processes of their organizations. The 1986 Survey also found that 76 percent of highly utilized engineers reported that their firm is "generally well managed and progressive", while only 15 percent of those in the lowest quartile group did so (p. 41). Similarly, ninety-two per cent of the engineers surveyed indicated that good management and technical personnel communications were a key element in the workplace, but only 43 percent indicated that such communications were characteristic of their work place. The authors concluded that "the most important constraint on the effective utilization of engineers is the quality and effectiveness of interactions between practising engineers and managers" (AAES 1986:1). They recommended greater participation by engineers in the senior management decision-making process, and in the setting of management policies and practices which impact directly on the engineer.

Sorge's (1979) review of British, French and German engineers in management showed that there is a strong tradition for such a career progression in Germany and France, but less so in Britain. In North America, in the post World War II period and especially in large technically-oriented organ-

izations, the need for strong financial management during a period of rising labour costs and high interest rates, and the introduction of management disciplines reduced the relative value of traditional technical engineering skills.

Recent approaches to understanding leadership include the attribution theory of leadership, and transactional versus transformational leadership (Bass and Avolio, 1990). Attribution theory proposes that leadership is merely an attribution that people make about other individuals. Thus, positive or negative performance by an organization or a sub-unit is ascribed to the leader. Most leadership theories concern transactional leaders. They focus on motivating their followers toward the organization's goals. Transformational leaders, on the other hand, pay attention to the development concerns of individual followers, help them see problems in new ways, and inspire followers to put out extra effort to achieve group goals. Bass (1990: 22) identified the characteristics that differentiate the two types of leadership. The transactional leader contracts exchange of rewards for effort, promises rewards for good performance, and recognizes accomplishments. But, while the transactional leader abdicates responsibilities and avoids making decisions, the transformational leader provides vision and a sense of mission, instills pride, and gains respect and trust. Bass and Avolio (1990: 23) found that transformational leadership is more strongly correlated than

transactional leadership with lower turnover rates, higher productivity, and higher employee satisfaction. Thus those engineers, whose direct supervisors can be described as transformational leaders, are more likely to find greater utilization than those who have transactional leaders.

4.4 Outcomes of Utilization

Attitudes are evaluative statements, either favourable or unfavourable, concerning people, events or objects. Gould and Kolb (1964: 40) in their dictionary of the social sciences provide the following definition: "An attitude is a mental and neural state of readiness, organized through experience, exerting a directive or dynamic influence upon the individual's response to all objects and situations with which it is related". Much of the research in organizational behaviour focuses on two attitudes: job satisfaction and organizational commitment. Job satisfaction refers to an individual's general attitude toward her or his job. Organizational commitment is a state in which an employee identifies with a particular organization and its goals, and wishes to maintain membership in the organization (Mowday, Steers and Porter, 1979).

Job satisfaction, organizational commitment, obsolescence and job mobility are possible outcomes of the utilization of professional ability and are discussed in the sections that follow.

4.4.1 Job Satisfaction

Job satisfaction, or an individual's general attitude toward her or his job, has been the subject of studies for over 50 years, with Hoppock (1935) writing the first intensive classic work. After World War II, Morse (1953) and then Morse and Weiss (1955) studied job satisfaction. They found that "for most men [and women], having a job serves other functions than the one of earning a living ... working gives them a feeling of ... having a purpose in life" (p. 42). Herzberg, Mausner and Snyderman (1959) studied the motivation to work by knowledge workers and identified some determinants of job satisfaction and its effects. In an examination of more than 50 studies they found that "a minimum of 13 percent of the working population expresses a generalized negative attitude to their jobs"; they added, however, that "the intensity of these attitudes is not known". Their industrial field studies indicated that task success is an important determinant of work satisfaction. Their main contribution was to refocus attention on the work itself, and to suggest that job satisfaction can only be provided by giving individuals more responsibility in their work. A 1974 U.S. Department of Labor study found that "there has not been any significant decrease in overall levels of job satisfaction over the last decade", a conclusion supported by a Gallup study, which found a rela-

tively consistent level from 1963 to 1973, averaging 88.8 per cent (Fein 1976:469).

Seeking to establish a relationship between satisfaction and productivity several reviews of the literature have been carried out (Brayfield and Crockett 1955; Herzberg, Mausner, Peterson and Capwell 1957; and Vroom 1964); these reviews found no consistent relationship. A recent careful search of the literature indicates that while there is a positive relationship, the correlations between job satisfaction and productivity are consistently low, in the vicinity of 0.14 (Iaffaldano and Muchinsky, 1985). When moderating variables are accounted for, a strong relationship was indicated between job satisfaction and performance, with the satisfaction performance correlations being stronger for professional, supervisory and managerial positions than for clerical and blue-collar workers (Petty, McGee, and Cavender 1984). A further important finding (Bagozzi 1980) was that studies that have controlled for cause and effect confirmed the hypothesis stated several years before by Lawler and Porter (1967) "rather than being the cause of performance, satisfaction is caused by it" (p. 28).

Locke (1969) defined job satisfaction as "a function of the perceived relationship between what one wants from one's job and what one perceives it as offering or entailing" (p. 316). In his view there are three elements to this definition: "1) the perception of some aspect of the job ... 2) an

implicit or explicit value standard, and 3) a conscious or subconscious judgement of the relationship between (e.g. discrepancy between) one's perception(s) and one's value(s)" (p. 316). Thus, Locke argued, the causes of job satisfaction are not in the job nor solely in the person, but in the interaction between them (p. 319). In Locke's (1976) extensive review of the literature he defined job satisfaction as "a pleasurable or positive emotional state resulting from the appraisal of one's job or job experiences" (p. 1300). He indicated that the more important factors conducive to job satisfaction are mentally challenging work, equitable rewards, supportive working conditions, and supportive colleagues. Professional employees, in particular, tend to prefer jobs that offer them the opportunity to use their skills and abilities, and give them variety, freedom and an indication of their accomplishments. They also want a remuneration and promotion system that they perceive to be fair and equitable. Promotions should provide opportunities for greater responsibility and personal growth. Supportive working conditions include having adequate tools and equipment, and administrative assistance. Locke also concluded that the behaviour of the employee's colleagues and supervisor are major determinants of job satisfaction.

Two early studies of engineering utilization linked it with job satisfaction. Danielson (1960: 42) identified "poor utilization of abilities and skills", "unable to prove

oneself", "lesser trained person could do job", and "boredom or monotony" as important reasons for job dissatisfaction. Kornhauser (1962: 140) argued that as a consequence of poor utilization of their professional skills, engineers tend to be relatively dissatisfied with professional work, and may come to view administrative work as offering greater challenge, as well as larger extrinsic rewards.

A decade later, Ritti (1971b), in a company-wide survey of professional and non-professional personnel, found that a significant percentage of the engineers were less satisfied with their work than any other work group except those directly involved in production, the blue-collar workers. Likewise the percentage of engineers who expressed a desire to do more work than they were expected to do was significantly higher (at 29%) than that for any of the other groups, indicating "a close correspondence between satisfaction with work and feelings of underutilization" (p. 6). Based on a factor analysis of his survey results which related goal satisfaction with work characteristics, Ritti found that six of the forty characteristics provided a 70 percent association, with utilization alone accounting for two-thirds of this prediction. Wood and LeBold (1970: 185) in a study of job satisfaction among 3,000 engineer, found that 76 percent were either "very satisfied" or "satisfied". Professional challenge was most related to overall job satisfaction. The study by Porter (1961) showed that job level

was a major factor determining managers' perceptions of needs and need satisfaction. Replication of Porter's studies has generally confirmed his findings (Cummings and ElSalmi 1968: 140).

Subsequent studies based on Holland's personality-job fit theory support the view that people with personalities that are congruent with their chosen profession, and have the right talents and abilities for their jobs, are more likely to succeed in their tasks, and thus to achieve high satisfaction from their work (Feldman and Arnold, 1985). The result is not consistent with Ritti's (1971b), reported above, if it is assumed that engineers fit Holland's description. Nevertheless, the objective of this research is not to determine the level of satisfaction, but whether greater utilization results in greater job satisfaction, and the 1986 Survey found a strong correlation between high utilization and high satisfaction with the engineer's career and present job situation (AAES 1986: 40).

4.4.2 Organizational Commitment

Mowday, Steers and Porter (1979: 226) described commitment in terms of attitude, rather than commitment-based behaviour, such as when individuals forgo alternative courses of action to link themselves to the organization. In their view, attitudinal commitment represents a state in which an individual identifies with a particular organization and its

goals and wishes to maintain membership in order to facilitate these goals. Organizational commitment can be characterized by at least three factors: a strong belief in, and acceptance of, the organization's goals and values, a willingness to exert considerable effort on behalf of the organization, and a strong desire to maintain membership in the organization. Organizational commitment, as an attitude, differs from job satisfaction. It emphasizes attachment to the employing organization, including its goals and values, while satisfaction emphasizes the specific task environment where an employee performs his or her duties. More recently, Hulin (1990: 489) described organizational commitment as "an attitude-like attraction to an organization rather than specific work role characteristics. The utility and value associated with role or organizational membership is contingent on remaining in an organization; it is not contingent on any specific work role behaviors other than not quitting or retiring".

Based on evidence provided by Smith, Kendall, and Hulin (1969), Mowday, Steers and Porter (1979: 226) noted that job satisfaction "has been found to be a less stable measure over time, reflecting more immediate reactions to specific and tangible aspects" than organizational commitment.

Steers' (1977) study of 119 scientists and engineers found that need for achievement is significantly associated with commitment. He concluded that:

individuals come to organizations with certain needs, desires, skills, and so forth, and expect a work environment where they can utilize their abilities and satisfy many of their basic needs. When the organization provides such a vehicle (for example, when it makes effective use of its employees, ... the likelihood of increasing commitment is apparently enhanced. When the organization ... fails to provide employees with challenging and meaningful tasks, commitment levels tend to diminish [p. 53].

If challenging work is considered as a measure of utilization, greater utilization appears to result in greater organizational commitment.

4.4.3 Other Outcomes

Obsolescence and job mobility have been found to be other effects of utilization, and are discussed in the next two subsections. Three obvious biographic characteristics which might affect professional ability utilization are the person's age, gender and length of service with the organization. A significant amount of research has been done to analyze these individual biographical characteristics and these are discussed in the third subsection.

4.4.3.1 Obsolescence

There is evidence that poor utilization of professional ability is a major contributor to obsolescence. Kaufman (1979a) defined obsolescence as "the degree to which engineers lack the up-to-date knowledge or skills necessary to maintain effective performance in either their current or

future work roles" (p. 826). He differentiated between "job obsolescence - pertaining to an engineer's current job assignment - from professional obsolescence - the capacity to perform in new and different jobs in an engineer's field". The major factors linked to the development of obsolescence, in his view, are "the organizational climate in which engineers work, which is determined largely by management policies and practices [and] the nature of the work that engineers are assigned, particularly the use of their technical knowledge and skills". In his study, Kaufman found that 75 percent of engineers who reported a high degree of misutilization had a problem keeping up with new developments, while less than 50 percent of those who felt that misutilization is not a problem reported having trouble keeping up-to-date.

Dalton and Thompson's (1971) study also indicated that obsolescence has more to do with the use of existing skills, and the need to learn and use emerging technologies on the job, than does formal course work. In fact, they found that coursework generally did not help performance, and may well be associated with continuing performance decline. They concluded that obsolescence is more a result of organizational incentive systems and lack of job challenge than it is of individuals. Thus, they concluded that it is organizations, not people, who become obsolete. Recent research by Felscher et al. (1985) confirms this view. They found that failure of management to provide challenging work

and to emphasize the need for technical currency is the likely cause of obsolescence.

Ritti (1971b), however, believed that obsolescence should be dealt with differently:

the responsibility for obsolescence lies not with engineers as individuals; it follows directly from .. management's definition of what 'engineer' means, [thus] the solution must be found in the organization of work roles rather than in individual updating, [that is] the answer lies in redefining the role of engineer from worker to manager [p. 219].

4.4.3.2 Job Mobility

Satisfaction has been shown to be negatively related to job turnover (Brayfield and Crockett 1955; Vroom 1964; Mobley, 1982). We have already noted that job satisfaction is significantly related to utilization of professional ability. It appears, therefore, that utilization acts through job satisfaction to affect job turnover. Other factors, including unstable labour market conditions, a factor that is particularly relevant at the present time, and length of employment with the organization are also important, and act to reduce voluntary job turnover (Farris 1971; Gerstenfeld and Rosica 1970; Raudsepp 1963a). There is evidence, however, that job mobility, when it occurs, results in a significant increase in the utilization of ability (Dunnette, Arvey and Banas 1973). Job involvement also seems to be a good predictor of job turnover, accounting for as much as 16% of the variance (Farris 1971).

The research evidence also shows negative relationships between organizational commitment and job turnover. However, organizational commitment has been found to be a better indicator of job turnover than job satisfaction (Mowday, Porter and Steers 1982; Arnold and Feldman 1982).

4.5 Biographical Characteristics

A recent meta-analysis has found that age and job performance are unrelated, and that this seems to be true for all types of jobs, professional and nonprofessional (McEvoy and Cascio, 1989). Similarly, the seniority-productivity relationship has been extensively studied and the conclusions show that seniority is not a good predictor of productivity (McDaniel, Schmidt and Hunter, 1988). By the time professional engineers are registered they will have had at least two (soon four) years of engineering experience in addition to their four year undergraduate education. Thereafter, their job performance is more likely to depend on the other factors described in this Chapter than on their age. A positive association between age and job satisfaction, particularly for professionals, however, has been established (Lee and Wilbur, 1985), perhaps due to increased opportunity to influence decisions.

The evidence in the literature also suggests that there are few, if any, important differences between males and females that affect their job performance (Hyde, 1981).

Similarly, there is no evidence that an employee's gender affects their job satisfaction (Quinn, Staines and McCullough, 1974).

4.6 Summary

The literatures on organizational behaviour and career development describe some of the factors which affect the utilization of professional ability. The motivation of professionals has been found to affect, and be affected by, both personal and organizational characteristics. Its effect appears to be indirect in affecting the utilization of professional ability.

Factors which have been identified as contributing directly to the utilization of professional ability include professional competence, career aspirations, professional responsibility, organization structure, organizational practices, and supervisory competence. Figure 1 summarizes these antecedent relationships and provides a convenient listing of the associated references covered in this Chapter.

Outcomes of the utilization of professional ability identified in the literature, and discussed in this chapter, include job satisfaction, organizational commitment, obsolescence, job mobility, and job performance. Figure 2 summarizes these relationships and provides a listing of the associated references; the antecedents of utilization, already shown in Figure 1, are repeated but with their associations

Figure 1

**ANTECEDENTS OF THE UTILIZATION OF
PROFESSIONAL ABILITY IN ORGANIZATIONS**

Figure 2
OUTCOMES OF THE UTILIZATION OF
 PROFESSIONAL ABILITY IN ORGANIZATIONS

with the outcome factors shown. Job satisfaction and organizational commitment are highlighted since only these two factors are addressed in more detail in this research and included in the model of utilization.

The findings summarized in Figures 1 and 2 provide an attractive basis on which to develop a theoretical model of the antecedents and outcomes of the utilization of professional ability in organizations. This model described in Chapter Five.

CHAPTER FIVE
A THEORETICAL MODEL OF THE UTILIZATION
OF PROFESSIONAL ABILITY

The purpose of this chapter is to present a theoretical model based on the factors, presented in Chapter Four, which seem most relevant to an understanding of the utilization of professional ability in organizations. A basic model of utilization, with six antecedent factors, is merged into a complete model which includes job satisfaction and organizational commitment as outcomes.

This chapter begins with a discussion of the utilization concept, already introduced in Chapter Two. This is followed by a discussion of six concepts which are hypothesized to be causes of the utilization. Two of these six concepts reflect the personal characteristics of the individual professional concerned: professional competence and career aspirations. The four organization related concepts are professional responsibility, organization structure, organizational practices, and supervisory competence. In the final two sections, the modelled outcomes of utilization, job satisfaction and organizational commitment, are described.

The sections that follow review the evidence presented in Chapter Four to select six antecedent concepts and link them with utilization through six propositions. Also based on the evidence, the utilization concept itself is linked to

two outcome concepts by a further two propositions. Overall tests of the model to confirm the propositions and the model are described in Chapter Six.

5.1 The Utilization of Professional Ability

The work of an engineer may include numerous tasks that are hard to quantify and measure, for example, evolving new ideas, devising new methods, combining known concepts and applying new information. The efficiency with which these tasks are carried out cannot be measured by a productivity index, as can be done for work by, say, factory piece-workers. Utilization of professional ability, as already defined, is the effective use of acquired professional skills. It involves the use of the individual's time and talents on professional tasks. The time spent on work should challenge the professional capacity of the individual at a high level for significant portions of the time spent in such professional activities. The concept of utilization of professional ability encompasses the proper use of overall competence, of education and training, and of personal skills, in challenging work assignments and job requirements that match the person's capabilities.

5.2 Antecedents of the Utilization of Professional Ability

The subsections that follow describe six antecedent factors of utilization. These form part of the overall model

of utilization in the model shown in Figure 3.

5.2.1 Professional Competence

Professional competence is a state of having sufficient knowledge, judgement and skill, to carry out the required professional work. Professional competence recognizes that there is a basic competence acquired through the initial period of education and training leading to admission to the profession. This provides evidence of professional competence at the time of admission only. Competence must be updated continually through personal effort to keep it current. Professional competence is indicated by the extent to which a professional is remaining up-to-date with developments in his or her job-relevant field. Post-graduate degrees and recent formal technical and non-technical studies indicate that professional competence is being maintained. Similarly, recent participation in professional societies and seminars, publication of technical articles, or innovations involving devices, products or processes are indications of the currency of professional competence.

The review of the literature in Chapter Four provides support for claiming a close linkage between professional competence and the utilization of professional ability. For example, Randle's (1959) investigation found that 85 percent of professional development was attributable to work experiences. Similarly, Margulies and Raia (1967), seeking to

Figure 3

**MODEL OF THE UTILIZATION OF
PROFESSIONAL ABILITY IN ORGANIZATIONS**

determine the activities seen as most important for professional growth, found that on-the-job problem solving elicited the highest proportion of responses. Gomersall (1971) found that work itself has the greatest impact on the professional job motivation of engineers. Ritti (1971b) also found that performance of tasks, that is, the utilization of ability, allows engineers to demonstrate their capabilities, and Adams' (1984) survey of 1100 engineers found that work assignments are the most important way to stay current. Engineers whose work assignments continue to challenge them are fortunate, since this allows them to increase their competence on-the-job, but continuing education off-the-job is also important. We have already noted that Kornhauser (1962) found that engineers with advanced degrees are more likely to be given challenging assignments, thus showing the value of academic education after the Bachelor's degree. On the other hand, the 1986 Survey (AAES 1986: 20) found that 47 percent of the time of respondents was occupied by duties which involve managerial and communications skills. Thus, enhanced competence in these skills is essential if work assignments with greater supervisory responsibility, which allow greater utilization of professional ability, are to be obtained.

A professional engineer who makes an effort to maintain professional currency in his or her work is demonstrating a desire to acquire greater knowledge. It seems logical to

assume that this acquisition is directed at using the new knowledge, rather than simply to being more knowledgeable, and that such engineers are driven towards having their ability utilized at work.

Proposition 1: Professional engineers who remain current with developments in their field of work experience a greater utilization of their professional ability than those who do not.

5.2.2 Career Aspirations

A professional's career can be defined as a course of continued progress and achievement in one's chosen field of lifetime endeavour. The strength of a professional engineer's career aspirations is an indication of the extent of desire to realize his or her ambitions, ideals, and goals in their career. Engineers with strong career aspirations will have a current clear plan for their careers, and will demonstrate a strong identification with their work. An engineer's interest in becoming a highly proficient specialist or in advancing through greater supervisory responsibility are indications of engineering career aspiration. The former is often indicated by undertaking post-graduate degrees or studies in engineering, and the latter by studies in management.

Ritti (1971b) concluded from his study that the work goals of engineers are achieved through performance of tasks, and that the desire to progress into management is a desire for greater utilization of professional ability. The ASRE

(1965) study and the 1986 Survey authors similarly concluded that the desire to progress into management is a recognition of its greater decision making scope. While greater management responsibilities provide an opportunity for more fulfilling work, greater technical product or service involvement also lead to greater utilization.

Proposition 2: Professional engineers who exhibit strong career aspirations will experience a greater utilization of their professional ability than those who have weak career aspirations.

5.2.3 Professional Responsibility

The level of professional responsibility held by an engineer is an attribute of the position, not of a person. It is a recognition of the knowledge required to perform the job (and thus of associated experience), of the extent to which problems can be solved by standard methods or by knowing how to obtain assistance, of the participation in planning and decision making, and of the originality and ingenuity required for devising practical and economical solutions to problems. In organizations, the level of responsibility also may be a function of the number of persons directly supervised, or of the extent of authority exercised over other personnel not directly supervised. The Professional Engineers of Ontario's (PEO) annual salary surveys (PEO 1994, 1995) describe seven levels of professional responsibility which encompass both of these alternatives. The highest levels of responsibility involve

basic operating policies and the solution of problems to accomplish objectives in the most economical manner (PEO 1995: 14).

Ritti (1971b) in his survey of engineers found that the extent to which engineers are able to influence decisions is negatively correlated (-0.83) with underutilization. The ASEE (1965) survey found evidence that control of decision making, associated with greater levels of assigned responsibility, leads to greater utilization of professional ability. Finally, the 1986 Survey (AARS 1986) concluded that the desire to be well utilized drives engineers toward managerial and administrative positions with greater responsibility because of greater decision making freedom.

Proposition 3. Professional engineers holding higher levels of professional responsibility will have greater utilization of their professional ability than those holding positions with lower levels of responsibility.

5.2.4 Organizational Structure

An organic structure has been shown in Chapter Four, generally, to be more effective than a mechanistic structure in managing professionals. Organic structures are described as those that have low formalization, low specialization, and low centralization. Mechanistic organizations are characterized by high specialization, particularly through horizontal differentiation, high formalization, and high centralization. Even in so-called decentralized organizations, the chief executive officer of an organization can have a great deal of

influence on the degree of centralization; highly autocratic leaders tend to establish administrations that are highly centralized around them. In some cases the organizational environment permits some of these mechanistic organizations to be successful. Where the mechanistic structure extends to the engineering units, underutilization of professional talent through reduced decision-making authority is likely. The work of Lawrence and Lorsch (1969) indicates that it is possible to have organically structured engineering groups working in organizations where other groups have mechanistic structures. Low formalization permits engineers to have greater freedom in carrying out their work, and permits more alternative behaviour. Decentralization allows engineers to have greater decision making authority.

Burns and Stalker (1961) showed that organic organizations are more successful under conditions of uncertainty or when innovation is required. Ouchi and Jaeger (1978) also showed that professional groups can be managed organically, leading to greater utilization of professional ability, while other workers are managed mechanistically. Mintzberg (1983) suggested that the organizational design configuration affects the degree to which the organization is organic or mechanistic and thus the freedom of professionals to direct their work. The organic forms of Mintzberg's design configurations appear to be more effective in the management of professionals.

The number of organizational levels affects the type of communications between top and bottom levels in the hierarchy. Raudsepp's (1963b,c,d) surveys showed that there is a serious problem in communications among engineering personnel, with the problem becoming more serious in the lower levels than among middle supervisors. It is apparent that poor communications will lead to poor utilization of professional ability. Fewer levels of hierarchy and good communications are characteristics of organic structures. Engineers working in matrix structures with looser supervision are also working in an organic structure.

Proposition 4: Professional engineers working in an organic organizational structure will experience a greater utilization of their professional ability than those working in a mechanistic organizational structure.

5.2.5 Organizational Practices

Human resource policies and practices which can affect the utilization of professional ability, include the extent of support personnel and services available, the extent and effectiveness of training and development programs, and the fairness of the performance evaluation and reward systems.

As described in Chapter Four, the human resource policies and practices of an organization can have a positive or a negative influence on the management of professionals. Ritti's (1971b) study showed that the unavailability of technical support personnel is directly related with misutilization. The 1986 Survey (AAES 1986) also showed that

the support of technicians and others, together with availability of necessary equipment and facilities is an important factor in the greater utilization of professional engineering ability.

Kaufman (1974) found that organizational policies and control systems affect individual competence. Granrose and Portwood (1987) found that training and development programs improve an employee's ability to carry out the job and to perform at a greater level of responsibility. More recently, Nathan, Mohrman, and Millman (1991) showed that the organization's performance evaluation and reward systems influence employee performance.

Proposition 5: Professional engineers working in an organization which has professionally oriented human resource practices will experience greater utilization of professional ability than those working in organizations without professionally oriented human resource practices.

5.2.6 Supervisory Competence

Supervisory competence involves the ability to influence group behaviour (Robbins 1993: 365). It involves management and leadership competence. The management of professional persons requires special competence and knowledge of the work.

Kaufman (1974), based on his research on engineering supervisors, concluded that they are an important influence on utilization of professional ability. In his subsequent work, Kaufman (1979b) also found that utilization is a prob-

lem where supervisors are not technically competent to evaluate the work of engineers. Raudsepp's (1963a) earlier survey found that engineers complained that their supervisors failed to keep them informed of plans affecting their work.

Chapter Four contains a review of Bass and Avolio's (1990) description of transactional versus transformational leadership. While the transactional leader promises rewards for good performance, recognizes accomplishments, watches for deviations from standards, intervening only if standards are not met, the transformational leader gives personal attention, and treats each employee as an individual, coaching and advising. Transformational leadership is more effective in the motivation of professionals than transactional leadership and thus in the utilization of their professional ability. Supervisors who practice transformational leadership demonstrate greater competence in the management of their professionals than those who practice transactional leadership.

Proposition 6: Professional engineers, whose work is directly supervised by supervisors who demonstrate competence in managing professionals, experience greater utilization of their professional ability than those who are supervised by less competent supervisors.

5.3 Outcomes of Professional Ability Utilization

The two subsections that follow describe two outcomes of the utilization of professional ability: job satisfaction, and organizational commitment and the two propositions that link them to utilization.

5.3.1 Job Satisfaction

Job satisfaction refers to an individual's general attitude towards his or her work. While, as noted in Chapter Four, no consistent relationship has been found between job satisfaction and productivity, the satisfaction - performance correlations are relatively stronger for professional workers. Strong relationships between the utilization of professional ability and job satisfaction have been reported and were reviewed in Chapter Four. For example, Danielson (1960) identified poor utilization of abilities and skills, and inability to prove oneself as important reasons for dissatisfaction. Similarly, Kornhauser (1962) found that poor utilization of professional skills leads to dissatisfaction with the work. Herzberg (1966), based on his study of engineers, suggested that achievement and the work itself are strong determinants of job satisfaction. Ritti (1971b) found a strong negative correlation between job satisfaction and underutilization. Locke's (1976) review of the literature indicated that mentally challenging work is an important factor conducive to job satisfaction, offering professionals, in particular, the opportunity to use their skills and abilities. Dawis et al. (1974: 59) also found a significant correlation between ability utilization and overall satisfaction. Finally, the 1986 Survey (AAES 1986) also found a strong correlation between high utilization and high satisfaction with engineers' work.

Proposition 7: Professional engineers whose work involves a high level of utilization of their professional ability will experience a higher level of job satisfaction than those whose work involves a low level of professional utilization.

5.3.2 Organizational Commitment

Organizational commitment is a state in which an individual identifies with a particular organization and its goals and wishes to maintain membership in order to facilitate these goals (Mowday, Steer and Porter, 1979). As described in Chapter Four, Ritti found that engineers, unlike scientists, are very much oriented towards the objectives of the organization in which they are employed. This is because they see that the fulfilment of their personal need for achievement lies in the group achievement facilitated by the organization. The basic condition of engineers, therefore, appears to be to exhibit a strong organizational commitment. A poor organizational environment, however, that does not respect the engineer's need for self-actualization, can result in a reduced organizational commitment. Steers' (1977) study of engineers found that achievement, and being able to utilize their professional abilities, are significantly and positively associated with organizational commitment.

Proposition 8: Professional engineers whose work involves a high level of utilization of their professional ability will exhibit a greater degree of organizational commitment than those whose work involves a low level of utilization of their professional ability.

5.4 Summary

A model with six independent variables is hypothesized to predict the utilization of professional ability. Two of these variables are personal antecedents: professional competence and career aspiration. The four organizational antecedents of utilization are: professional responsibility, organization structure, organizational practices and supervisory competence. Job satisfaction and organizational involvement are hypothesized to be two consequences of the utilization of professional ability. A summary of the eight propositions is contained in Appendix 1.

CHAPTER SIX

PROCEDURES AND MEASURES

The purpose of this chapter is to describe the procedures and measures used in this research. The chapter begins with an overview of the research design. This is followed by descriptions of the procedures, and of the measures of the nine concepts used in the model of utilization.

6.1 Overview of the Research Design

The study was conducted using a mail questionnaire. In addition to providing a sample of the population at the lowest cost, the fact that anonymity could be guaranteed helped to reduce the tendency to respond in socially desirable ways that is inherent in personal interviews. The cross-sectional design provided greater generalizability of the results by including individuals in many organizations, in many industries, of all ages and at all levels of professional and supervisory responsibility.

The sample for the study was randomly selected from the membership of registered professional engineers in the province of Ontario who were residing in Canada at the time the sample was drawn in March, 1995. Ontario registered members represent about forty percent of all registered professional engineers in Canada, which permits the results of the analy-

sis to have a reasonable degree of validity for the Canadian engineering profession as a whole.

Individual engineers were asked a series of questions which were used to develop measures for each of the nine concepts. In addition, a number of demographic questions were asked to allow cross-checking of the sample characteristics with those of other samples of the same engineering membership carried out annually by the engineering profession.

6.2 Procedures

Questionnaires to assess all of the variables included in the model, were mailed to a random sample taken from the total population of professional engineers, all of whom are registered by the Professional Engineers of Ontario (PEO). At the time of the survey there were approximately 59,000 professional engineers listed in the membership mailing list. Permission was sought and obtained from the PEO to access their list. A random sampling of this population was made by the PEO, and questionnaires were mailed directly by them to half of one percent, i.e. 300, of the members. Although the membership includes engineers who have retired from active work, they were excluded before the sample was drawn and thus were not surveyed. There were also approximately 3 percent of PEO members with non-Canadian addresses who also were excluded, since mailing, including the use of postage-paid

return envelopes, was difficult to arrange and foreign experience was not considered representative of Canadian practices.

A Canada-wide survey had been considered, since it would have been fully representative, but was rejected for the present survey due to the added cost and complexity. There are ten provincial associations of professional engineers, each with its own membership list, requiring that separate access to these lists be obtained, and that a stratified proportionate sampling design be used. Further, with francophone engineers in the Province of Quebec, the instrument would have had to be translated into French.

The questionnaire was described to recipients as a survey of professional engineering work, to avoid the priming effects of labelling the research as a study of the utilization of professional ability. Respondents were assured of, and provided with, anonymity; the author at no time had access to the names of the persons receiving the questionnaire. The proposed survey instrument incorporated suggestions made by Dillman (1978, 1983). It thus placed sensitive demographic information such as age, income and gender at the end. To hold respondents' initial interest, the main attitude questions were placed relatively early. To maximize the response rate, Dillman's suggestion regarding a follow-up mailing was followed. A reminder was sent by PEO to all recipients one week after the initial mailing to jog memories and encourage responses. Dillman's suggestion of a second

personalized follow-up letter to those who had not replied within three weeks could not be pursued because, as noted, the arrangement made with PEO did not permit access to the mailing list. To enhance the potential response rate, some of Duncan's (1979) suggestions were incorporated: return postage paid, sponsorship by a professional society (the endorsement of the PEO was referred to in the covering letter), and a social utility appeal (it was also included in the covering letter). His suggestion regarding personalization could not be used because of the direct mailing by PEO. A copy of the covering letter which was sent with the questionnaire is included as Appendix 2.

6.3 Measures

Details of the operationalization of each of the variables are provided below. In some cases, previously validated measures of the constructs of interest were adopted or slightly modified. Sources reviewed in the identification process included the conceptual literature reviewed in Chapters Two, Three and Four, and, particularly, references identified in a compendium of measures on the experience of work (Cook, Hepworth, Wall, & Warr, 1981). Scales used as measures for each of the nine concepts are displayed in Appendix 3. The questionnaire was pretested with engineers in a variety of occupations and levels of responsibility. A copy of the questionnaire as sent, is included as Appendix 4.

6.3.1 Utilization of Professional Ability

The primary measure for the utilization of professional ability (UPA) was based on the Engineering Utilization Index (EUI) developed for the 1986 Survey. The EUI was selected because a review of previous studies on utilization had indicated the lack of a reliable measure for engineering utilization. The 2,318 usable returns completed by engineers for the 1986 Survey were used to develop the EUI and other measures; a series of factor analyses was conducted by which the results were synthesized. The EUI is a scale score based on each individual's responses to 14 items selected from the 1986 Survey questionnaire. Appendix 5 lists the scale items included in the EUI, the response categories, and the percentage of the total sample who selected each response category for each of the EUI items. The first two questions obtained engineers' views on the relevance, to the present or last job, of their engineering experience and educational background. These two questions were not retained in the utilization of professional ability measure, since they were relevant to the proposed antecedent concept, professional competence. Similarly, the third EUI item measured organizational practices, another of the proposed antecedent concepts and was thus excluded. Of the eleven questions in Item 14 only four were retained for the utilization measure, with four of them in modified form: "utilization of education and training" as "proper utilization of your education and training,

"match between job requirements and capabilities" was unchanged, "challenging work assignments" as "challenging personal assignments", and "opportunities to work on long term goals" as "opportunity to achieve personal goals". The other seven questions are measures associated with the proposed antecedent concept, organizational practices, and thus were not used in the utilization of professional ability measure. Question 1 of Item 14, "use of overall technical competence", was retained as "use of your overall professional competence".

The composite indicator scale for the utilization of professional ability concept consists of 10 items: five based on the EUI questions (as described above) and five additional questions which are variations of these five. This scale is shown in Appendix 3 Section A. As was the case for the EUI, only the questionnaire responses associated with the characteristics of the work environment were included in the first utilization measure.

Four other indicators of utilization were also determined. The second indicator of utilization was the extent of underutilization, and the third, the extent of misutilization. Both were based on the work of Ritti (1971b), who found that underutilization occurs with light intellectual and light time demands, while misutilization occurs with light intellectual demands and heavy time demands. Scales measuring intellectual and time demands of

the job were combined with an amount of work scale to give compound underutilization and misutilization scales. Reported amount of work was based on the first question in the amount of work sub-scale of the Index of Organizational Reactions by Smith (1976). The first item was changed to "I prefer to do more work" rather than "It is never too heavy", to correspond with the question used by Ritti (1971b) in his research.

The fourth indicator of utilization was efficient use of time, based on the percent of work time spent on work that could be done by someone with less training. The fifth indicator, time spent on original work, was based on the percent of time spent doing work not done previously.

The five scales are shown in Appendix 3 Part A.

6.3.2 Professional Competence

Professional competence has been described in Chapter Five as the state of having sufficient knowledge, judgement and skill, to carry out the required professional work; it must be updated continually to maintain currency. The first indicator selected was a compound scale which measured recent academic education external to the organization.

Four additional scales were used to provide an indication of the extent of professional competence: number of years since the Bachelor's degree (a simple measure of experience), the highest degree achieved (since it is a simple

indication of competence beyond the basic Bachelor's degree which, essentially, all currently active professional engineers have), time spent keeping up-to-date (as a measure of effort), and the extent of professional achievements (a dichotomous scale based on whether the respondent had written a technical article; made a major contribution to a device, product or process innovation; or disclosed, applied for, or received a patent, in her or his career. The scales for these indicators are described in Appendix 3, Section B 1.

6.3.3 Career Aspirations

The first measure of career aspirations used was based on one item of the scale developed by Allen and Katz (1986) to study career preferences among nearly 1500 engineers and scientists in nine U.S. organizations. Engineers were asked to indicate the degree of their career preferences in terms of increasing managerial responsibility.

Two other measures were also used: reported job motivation, and reported attendance at professional meetings. McKelvey and Sekaran (1977) focussed on career advancement of professionals in research organizations. They used Patchen, Pelz, and Allen's (1965) Job Motivation Index and tested it on a group of 441 scientists and engineers. They found significant correlates with Satisfaction with Opportunity to Use Knowledge and Skills (0.33) and Satisfaction with the Opportunity to Work on Difficult Problems (0.35). One of the

four measures in the Index was selected, with slightly expanded wording to clarify the meanings of the five choices. The attendance at professional meetings scale is a dichotomous scale based on whether or not the respondent has attended any meeting of a professional society in the previous two years. These are generally evening meetings to discuss matters of general professional interest and with the exception of certain technical conferences with published proceedings, attendance at these meetings does not contribute significantly to increasing professional competence. It thus was selected as representative of activities indicating strong career aspirations. These scales are described in Appendix 3, Section B 2.

6.3.4 Professional Responsibility

The first indicator was based on the reported level of professional responsibility. As defined in Chapter Five, the level of professional responsibility held by an engineer is an attribute of the position, not of the person. The Professional Engineers of Ontario (PEO) conducts two annual surveys, one of its engineer members and one of employers of engineers; both are based on years of professional experience since graduation and on level of professional responsibility. Seven levels of professional responsibility are described in detail in the annual survey reports sent to all engineers (PEO 1994, 1995). Most engineers are thus able to determine

their own levels of responsibility and to make a comparison of their salary with those of other engineers with the same level of responsibility and years since graduation. To assist respondents who were not familiar with these levels, summary descriptions of each level were provided in the questionnaire.

A second complementary indicator was based on the reported level of direct supervisory responsibility. There is a strong relationship between the two measures of responsibility in the case of those engineers who have direct supervision of other personnel, but the supervisory level indicator does not capture the responsibilities of specialists and generalists with senior levels of professional responsibility. These scales are described in Appendix 3, Section B 3.

6.3.5 Organizational Structure

The first indicator of organizational structure was the reported extent of organic management. In Chapter Five, it was argued that "organic" structures are more effective for the management of professionals. Organic structures were described as having low formalization, low specialization and low centralization. The scale developed was the sum of the z-scores of five sub-scales which measured vertical, horizontal and spacial specialization, formalization, and centralization. This scale is in Appendix 3, Section B 4.

Two other measures were used: the reported organic

versus mechanistic design configuration, and the amount of work in a matrix team structure. The former is dichotomous and is based on Mintzberg's five design configurations as described in Chapter Four. The five configurations are associated with the domination by one of the five basic parts. Mintzberg's *machine* and *professional bureaucracies*, and his *division form* fall into the mechanistic category. His *simple structure* and *adhocracy* are examples of organic forms, providing greater freedom for engineers to direct their own work. The five items listed were based on the descriptions in Chapter Four. The amount of work in a matrix structure is a simple one item scale with six choices. These scales are described in Appendix 3, Section B 4.

6.3.6 Organizational Practices

Five measures of organizational practices were developed. The first indicator was the reported availability of support services, a compound scale with four items. The first three items of the scale measure the extent of support provided by the organization "with technical (e.g. computer) problems", "with administrative or personnel problems", and "with routine clerical (e.g. filing) work". The fourth item was based on the percentage by which the respondent's effectiveness was increased by an assistant (described as a secretary or administrative assistant); this item was thus zero for those without an assistant.

As described in Chapter Five, organizational practices also include the extent and effectiveness of training and development programs, the fairness of the performance evaluation practices, and of the reward system. Three additional corresponding measures were accordingly developed. The extent of development programs was a five-item scale measuring the extent to which job-related training courses have improved work effectiveness. Appropriateness of reward systems was six-item scale, based on the three-item scale used by Allen and Katz (1986) in their study of career preferences. Respondents were asked to indicate the degree of disagreement or agreement with three questions regarding whether they would like their careers to be a progression in managerial, or in technical, responsibility, or a progression of challenging projects. These questions were followed by three parallel questions regarding the most likely form of reward in their job. Fairness of performance evaluations is a two-item scale measuring the extent to which the reward system is "fair and equitable", and to which promotions are based on competence. The salary differential with PEO scale was based on a comparison of the reported salary with the deciles and quartiles of salaries reported in the latest PEO annual surveys (PEO 1994, 1995) for the same years of experience since the Bachelor's degree.

These scales are described in Appendix 3, Section B 5.

6.3.7 Supervisory Competence

Supervisory competence as described by Robbins (1993: 365) involves management and leadership. The supervision of engineers also involves technical competence. For the first 2-item measure of supervisory competence, respondents were asked to rate their direct supervisor: "as a manager of people", and "as a technical leader".

The extent of delegation indicator used a 6-item scale. The questions included asked whether the direct supervisor "allows you to make the decisions you feel are necessary", and whether he or she "allow[s] you to make the decisions which you feel are necessary".

These scales are described in Appendix 3, Section B 6.

6.3.8 Job Satisfaction

Based on the work of Scarpello and Campbell (1983), who found that a single global rating is as effective as a summation score, the first indicator of job satisfaction is reported degree of job satisfaction, based on the question "All things considered, how satisfied are you with your present job?".

The second measure of job satisfaction, work satisfaction, is a three-item scale based on the degree of satisfaction with "your career choice", "your present job" and "your present pay".

These scales are shown in Appendix 3, Section C 1.

6.3.9 Organizational Commitment

Porter and Smith's (1970) Organizational Commitment Questionnaire (OCQ) measures the relative strength of an individual's identification with, and involvement in, a particular organization and was used as the first indicator of the organizational commitment concept. The short form of the scale (9 out of 15 items) was used with minor changes to the wording for clarity (based on a pretest of the questionnaire). Coefficient alpha is 0.84 in Ivancevich's (1979) study of 154 project engineers and compares favourably with most attitude measures (Smith, Kendall and Hulin, 1969). To obtain evidence of convergent validity, the OCQ was correlated with the Sources of Organizational Attachment Questionnaire, a 12-item scale designed to measure the perceived influence of various aspects of the job, work environment, and organization on the individual's desire to remain or leave the organization. Convergent validities across six diverse samples ranged from 0.63 and 0.74, with 0.63 as the value for the sample of scientists and engineers. Evidence of predictive validity was found in that highly committed employees were less likely to leave their jobs or be absent. For scientists and engineers, the correlation at -0.28 was significant at the 0.01 level (Mowday, Steers and Porter 1979: 239). Evidence of discriminant validity was sought through a correlation with the Job Descriptive Index (Smith, Kendall and Hulin 1969) and a median value of 0.41 was

obtained (Mowday, Steers and Porter 1979: 237)

A second indicator, reported unpaid overtime provided another measure of organizational commitment. The scale measured the extent of extra time spent regularly at work and ~~at home on work-related matters~~. The two scales are shown in Appendix 3, Section C 2.

6.3.10 Demographic Descriptors

Respondents were asked to state their current employment status, their industry of employment, employment function, engineering field, and the size of their organization. As will be described in Chapter Seven, the profiles obtained from these data were compared with those of the annual surveys carried out for the Canadian Engineering Manpower Inventory by the engineering profession. Also measured was the extent to which the work function is technical or administrative. A gender question was included, but the relatively small percentage of females in the total membership meant that a comparison of results by gender did not provide useful results.

The descriptors are shown in Appendix 3, Section D.

6.4 Summary

This chapter has reviewed the procedures and measures that were used in this study. One or more measures have been described for each of the nine concepts described in Chapter

Five: the utilization of professional ability, professional competence, career aspirations, professional responsibility, organization structure, organizational practices, supervisory competence, job satisfaction and organizational commitment. The questionnaire used to develop the measures was pretested with engineers in a variety of employments.

CHAPTER SEVEN

RESULTS

The purpose of this chapter is to present the results of the data analysis. First, the responses to the questionnaire will be described and certain of the demographic measures evaluated. Then the scale measures will be individually evaluated. The correlation matrix of all the proposed scales, which was used to make a preliminary assessment of the scales to retain for further use, will be reviewed. Tests of the model of utilization of professional ability will be described to determine whether it satisfies the hypotheses proposed, and whether alternative hypotheses provide better models of utilization. The chapter concludes with a summary of the findings.

7.1 The Data

One hundred and thirty seven responses to the questionnaire shown in Appendix 4 were received. This represents a response rate of 45.7%. The responses to each of the 171 individual questions have been recorded (as percentages, except where otherwise stated) in Appendix 6, which reproduces the questionnaire format (with the mean value of scalar questions shown as "M," beside or below the corresponding question, and with the total number of missing responses shown as "NA", at the right hand side of each question). The

individual questions were coded using the variable names shown in Appendix 7, which also shows the range of acceptable values, the scale (nominal, ordinal or interval) and the coding number of the variable used in a subsequent scale (where applicable).

On average, respondents were 46.0 years old, graduated in 1973, and had 21.3 years of work experience since graduation, having worked in 2.9 organizations, and in 3.5 different functional areas. They had worked 10.8 years in their present organization and been 5.8 years in their current position, having spent 6.4 years in their previous position. Thirty nine percent worked in a multinational corporation, with 58% of the head offices being located in Canada. The average size of the work unit or group was 97.1 persons, and the average number of engineers in a group was 30.3 persons. Fifty percent of respondents worked often, or almost always, in a matrix structure. Forty-nine percent held supervisory positions with direct responsibility for staff performance. On average, these supervisors directed the work of 6.0 persons each, and the 27.6% who supervise the work of engineers, directed the work of 4.6 engineers each. Forty-nine percent reported that the number of persons in their Canadian organization had decreased. Ninety-six percent of respondents were male. Further details are shown in Table 4.

As was noted in Chapter Three, Shemilt (1976) identified, from the data for over 9,000 Canadian graduate

Table 4
Characteristics of Respondents

Age	- average	46.0 yrs.
	- range	29 - 93 yrs
	- standard deviation	10.8 yrs.
Years since graduation	- average	21.3 yrs.
	- range	6 - 51 yrs.
	- standard deviation	9.9 yrs.
Year of Bachelor degree	- average	1973
	- range	1944 - 1989
Sex	- male	96 %
	- female	4 %
Holds	- Masters degree	25.7%
	- Doctorate	3.7%
Employment status	- full-time	88 %
	- part-time	2 %
	- not employed	3 %
	- self-employed	7 %
Functional area	- Design	20 %
	- Project management	17 %
	- Marketing, sales	9 %
	- Plant operation/prodn.	8 %
	- Development	7 %
	- Business administration	7 %
	- Research	5 %
	- Other	27 %
Industry	- Durable manufacturing	15 %
	- Engineering. consulting	12 %
	- Utilities	10 %
	- Resources	8 %
	- Construction	7 %
	- Telecom/computer services	7 %
	- Federal government	7 %
	- Commerce, finance	6 %
	- Other	28 %
Undergrad. Education	- Civil engineering	27 %
	- Electrical & electron.	27 %
	- Mechanical & aerospace	21 %
	- Mining & metallurgical	13 %
	- Other	12 %

Table 4 - Continued

Characteristics of Respondents

Graduate Education	- Civil & construction	11 %
	- Business admin.	10 %
	- Electrical & electron.	7 %
	- Other	16 %
	- Not applicable	56 %
Current Work	- Civil & construction	21 %
	- Electrical & electronics	18 %
	- Mechanical & aerospace	16 %
	- Business administration	13 %
	- Other	32 %
Supervisory responsibility	- No direct responsibility	22 %
	- Project leadership	29 %
	- First level of supvn.	15 %
	- Higher levels	34 %
Canadian organizn. size	- 1 to 100	26 %
	- 26 to 1000	21 %
	- 1001 +	54 %

engineers, that only 60% worked in the same field as their undergraduate studies. The present study, carried out 19 years later, shows that only 58% of respondent engineers work in the same field as their undergraduate studies. Thus his conclusion that "caution must be used in supporting extension of highly-specialized courses" continues to be relevant today.

Chi-square tests were run to determine whether or not the respondents in the study matched the sampling frame of the December 1994 Salary Survey of PEO members. Occupational status, highest degree, professional level of responsibility, year of graduation and organization size were available in

the PEO Survey. The respondents did not differ significantly on occupational status and highest degree, but did in organization size: the chi-square for occupational status was 5.32 ($p = 0.26$), for highest degree, 2.33 ($p = 0.31$), and for organization size, 9.34 ($p = 0.03$). The younger engineers, however, did not respond in proportion to their number in the population as shown in Table 5. The comparison of the

Table 5

Comparison by Bachelor Year

<u>Category</u>	<u>Year-Group</u>	<u>Cases Observed</u>	<u>Cases Expected</u>	<u>Residual</u>
1	Before 1955	14	2.56	11.44
2	1956 - 1960	12	6.34	5.66
2	1961 - 1965	15	10.84	4.16
4	1966 - 1970	14	15.93	-.93
5	1971 - 1975	24	18.20	5.80
6	1976 - 1980	27	21.47	5.53
7.	1981 - 1985	21	26.48	-5.48
8	1986 - 1990	10	28.12	-18.12
9	1991 - 1994	<u>0</u>	8.08	-8.08
Total		137		

responses with the expected values, based on the PEO survey, gives a chi-square of 82.1 ($p < .001$). A similar comparison by level of responsibility shows a larger representation from the higher levels; the chi-square was 53.3 ($p < .001$).

However, this does not appear to pose a serious threat to the proposed utilization model, since (as will be shown in subsection 7.3, Table 13) there was a nonsignificant correlation between years since graduation and utilization (the correla-

tion coefficient with the first measure of utilization of professional ability, UPA_1, was 0.031, $p = 0.728$). A similar test of the differences between age groups and utilization, based on the results of the much larger 1986 Survey, had a nonsignificant chi-square value of 7.2 with 6 degrees of freedom ($p = 0.30$). It must be recognized, however, that over half of those surveyed were non-responders and, as shown in Table 5, that many of these appear to be the younger members; this could have led to other biased results.

7.2 The Measures

This section provides a review resulting from direct analysis of the statistics compiled from the completed questionnaires. The subsections follow the same format as was used in Chapters Five and Six.

The 28 measures, which have been described in Chapter Six and in Appendix 3, are summarized in tabular form in Appendix 8, giving the formulae used in their derivation.

7.2.1 The Utilization of Professional Ability

The key section of the questionnaire which deals with utilization asked the respondent to give relative evaluations in two categories: the importance of a particular aspect of utilization "to you personally", and the extent to which the same aspect was characteristic "in your work environment". This allowed the respondents to set a relative priority of

aspects ideal for utilization, and then to follow up with a relative evaluation of how closely the real world of the respondent matched his or her standard of utilization.

Table 6 shows selected data concerning the utilization of engineers. On the generic question whether "use of your overall professional competence" was important to the respon

Table 6
Utilization of Professional Ability

	<u>Important Personally %</u>	<u>Characteristic of Work Environment %</u>
Use of your overall professional competence	90	67
Chance to use your abilities and skills	92	68
Challenging personal work assignments	92	68
Chance to achieve your full potential	88	43
Proper utilization of your education and training	70	50

dent, an overwhelming 90% indicated that it was extremely or very important personally. On the parallel question of whether such use of overall professional competence was characteristic of the work environment, only 67% of respondents indicated that it was extremely or very characteristic. Similarly, the responses to the generic question whether the "chance to use your abilities and skills" was important to

the respondent, an overwhelming 92% indicated that it was extremely important or very important personally. On the parallel question of whether a chance to use such abilities and skills was characteristic of the work environment, only 68 percent of respondents indicated that it was extremely or very characteristic. These are large differentials and indicate that a significant number of engineers felt that the utilization of their professional ability is extremely important to them, but that the reality of the workplace is that their professional ability is under utilized.

Another aspect of the utilization of professional ability is the extent to which there are "challenging work assignments". Ninety-two percent of respondents indicated that this was extremely or very important to them. However, only 68 percent indicated that this was characteristic of their work environment. Similarly, 88 percent responded that the "chance to achieve your full potential" was extremely or very important to them personally, but only 43 percent indicated that this was characteristic of their work environment. A slightly different dimension of the use of professional ability was addressed by asking the respondent about the "proper utilization of your education and training". In this case, only 70 percent of respondents indicated that this was extremely or very important personally, while 50 percent indicated that this was extremely or very characteristic of their work environment. The gap between the number of respon-

dents wishing for, and experiencing, this form of utilization is not as great as for other dimensions of utilization.

Table 7 reproduces the data from U.S. surveys carried out over a period of 20 years, which was shown in Table 1, with the addition of the results of the present Canadian study for direct comparison. The results are consistent with all the U.S. surveys, with a comparable 92 percent of respondents stating that challenging work assignments, and the opportunity to use their skills and abilities are extremely or very important; both were ranked first in importance by Canadian engineers. A higher proportion of Canadians (68%) than Americans (their average was 50%) reported that it is characteristic of their job. As a result, the relatively consistent difference of from 31 to 39 percentage points between the two U.S. scales is less, at 24 percentage points, for Canadian engineers. Thus, the utilization of Canadian engineers appears to be somewhat greater than that of their colleagues to the south. Part of the difference may be due to the composition of the memberships, which was described in Chapter Three; the U.S. technical societies include members who would qualify as engineering technologists or engineering technicians, rather than as professional engineers, in Canada.

The first measure of utilization of professional ability (UPA₁) is composed of 10 such items. The coefficient alpha is 0.915 based on 133 responses. A histogram of this measure

TABLE 7

**IMPORTANCE OF UTILIZATION OF ENGINEERS AND HOW CHARACTERISTIC IT IS OF
THEIR JOBS - WITH CANADIAN RESULTS**

<u>UTILIZATION INDICATOR & SOURCE</u>	<u>SAMPLE & YEAR</u>	<u>IMPORTANCE %* RANK</u>	<u>CHARACTER. %* RANK</u>	<u>DIFFCE. OF %</u>
Opportunity to use special abilities (Case, et al., 1967)	953 B.S. Berkeley & UCLA alumni, 1961	71 1	39 6	32
To use skills and abilities in challenging work (Perrucci & LeBold, 1967)	1926 B.S. Purdue alumni 1964	89 1	54 1	35
To use skills and abilities in challenging work (LeBold, et al., 1966)	3234 industry engineers, 1965	85 1	48 2	37
Opportunity to use skills and abilities in challenging work (LeBold, et al., 1983)	2300 technical society members, 1981	81 (77) 2 (2)	44 (46) 5 (4)	37 (31)
Challenging work assignments	3868 members of U.S. engineering societies, 1984	95 1	56 5	39
Use of overall technical competence (AAES, 1986)		94 2	59 4	35
Challenging personal work assignment	134 members Professional Engineers Ontario 1995	92 1	68 1	24
Chance to use your abilities & skills (This report, 1995)		92 1	68 1	24

Secondary source of table including first four items: Kaufman, 1986: 90
 * percent responding "extremely" or "very" important or characteristic
 () indicates weighted percentage

shows a relatively normal distribution, with a mean of 23.7,
 standard deviation of 5.46. (A summary table of this
 measure, and of the other measures to be described, is

included with subsection 7.2.10 as Table 11 which also has kurtosis and skewness measures.)

A further aspect of the utilization of professional ability is the workload. Forty-two percent of respondents indicated that their workload was often or almost always too heavy. Similarly, 46% indicated that the time demands of their job were very heavy or extremely heavy, while only 7% percent stated that they were light. Twenty-two percent of respondents stated that the intellectual demands of their job were light. Light time demands and light intellectual demands result in underutilization, a second measure of professional ability (UPA_2) based on two items, while heavy time demands together with light intellectual demands result in the two-item misutilization measure (UPA_3). The responses suggest that there are more cases of misutilization than underutilization among the respondents. The underutilization measure (UPA_2) has a mean of 10.6, a standard deviation 1.97, a kurtosis 6.83 and a skewness of -2.38. Misutilization (UPA_3) exhibits a flat distribution with a mean of 10.3, a standard deviation of 1.25, kurtosis of -1.01 and skewness of -0.089. Thus both of these measures are non-normal.

Table 8 reproduces Table 2, which listed details of the results of U.S. studies, and adds the results of this study for comparison. Ritti found severe problems of utilization among the 17 percent who are highly underutilized (with light

TABLE 8
INDICATORS OF UTILIZATION PROBLEMS AMONG ENGINEERS
INCLUDING RESULTS OF THIS STUDY

<u>PROBLEM AND INDICATOR</u>	<u>PERCENT PRIOR STUDIES</u>	<u>PERCENT THIS STUDY</u>
<u>Underutilization</u>		
1. Light intellectual demands and light time demands	17	5
2. Prefer to do more work	29 (15*)	20
<u>Misutilization</u>		
3. Light intellectual demands and heavy time demands	7	8
4. Too much work	10	11
<u>Overall</u>		
5. Light intellectual demands	36 (29*)	22
6. Under + misutilization		
(1 + 3)	24	13
(2 + 4)	39 (25**)	31

Secondary source of table: Kaufman, 1986: 90

Primary sources: Ritti, 1971a: 136 & 142

* Landis 1971: 386, 387

** Landis' 15% plus Ritti's 10%

intellectual and light time demands), and among the 7 percent who are highly misutilized (with light intellectual and heavy time demands), giving a total of 24 percent with utilization problems. Canadian engineers show much less underutilization (5%) but about the same misutilization (8%). The U.S. surveys also showed that between 29 percent and 15 percent "prefer to do more work", an indication of underutilization, and that 10 percent have too much work, an indication of misutilization, giving a total of between 39 percent and 25 percent of engineers indicating utilization problems. The

Canadian percentages were 20 percent and 11 percent, for a total of 31 percent who indicated utilization problems. This percentage was within the range of that of U.S. engineers.

A fourth measure of utilization of professional ability, the efficient use of time (UPA_4), was based on the percent of work time spent on work that could be done by someone with less training, and ranged from 0% to 100%, with a mean of 25.5 percent. The histogram of UPA_4 exhibits a positive skew. The mean was 74.2, the standard deviation 16.6, the kurtosis, 4.37 and the skewness, 1.48. A log transformation (UPA_4W) showed a more normal distribution, with a mean of 0.53, standard deviation of 0.38, kurtosis of .84, and skewness of - 0.14.

The fifth measure of utilization of professional ability, time spent on original work (UPA_5), is based on the percent of work time spent doing work not done before. As with efficient use of time (UPA_4), percentage responses ranged from 0 to 100. The histogram shows a significant negative skew. The standard deviation of 23.3 is equal to the mean value of 23.5 percent, the kurtosis is 1.18 and the skewness is 1.42. A log transformation (UPA_5_LG) improves the shape of the histogram, giving a mean of 1.17, standard deviation of 0.47, kurtosis of 0.25 and skewness of -0.50.

On the basis of these initial assessments, the first measure of utilization (UPA_1), which is a 10-item scale, was retained for use in the LISREL model of utilization. A

second measure (UPA_2), based on two items, was retained to provide another measure in spite of its severe departure from normality. The other measures, each with only one or two items are non-normal and appear to be measuring a slightly different construct; they were not retained.

7.2.2 Professional Competence

Several questions were designed to establish measures of professional competence. One measure was originally based on the number of academic courses taken during the past two years (PROCMP1), however, very few respondents had taken any courses: nineteen percent had taken a non-degree-credit technical course and 13 percent, a non-degree non-technical course, and only 1 percent had taken a university course leading to a graduate degree. (While a full university course usually lasts 13 weeks, the length of time spent on non-degree-credit courses was not requested and short, one-day courses may have been counted, making the addition of courses questionable.) This measure was modified to a dichotomous scale which showed whether the respondent had taken any academic courses during the past two years; 71.6% responded "no" and 28.4%, "yes".

A related set of questions, to determine the highest degree achieved, was the basis for a third measure of professional competence (PROCMP3). Twenty percent of respondents had a Master's degree in engineering, 5%, a Master's

degree in business administration, and only 4%, a PhD in engineering. A modified, dichotomous measure (PROCMP3W) of professional competence was developed based on whether the respondent had any graduate degree (24.9% had one). The low number of positive responses to both of these questions made the measures less useful than if responses had been more equally distributed. However, the responses did indicate that professional competence is obtained mainly on-the-job.

The Bachelor degree year of graduation provided another measure, years of work experience (PROCMP2). This has already been commented upon in subsection 7.1, The Data, regarding the demographic comparison with a previous PEO survey. While registration has required two years of practical experience, there were relatively few respondents for the group with less than 10 years experience. The histogram exhibits a small positive skew, with a mean of 21.3, a mode of 15.0 and a skewness of 0.56; the standard deviation is 9.91 and the kurtosis, -0.11.

A fourth measure of professional competence was based on the percent of time devoted to keeping up-to-date (PROCMP_4) and ranged between 0 and 50 percent of the work time, with an average of 11.2%. Five responses were at 50%, and thus over three standard deviations away from the mean value of 11.3 percent, giving a kurtosis of 4.71 and a skewness of 3.02. While these responses could have been treated as missing, this would have affected the listwise deletion used for the

LISREL modelling. A square-root transformation (PRCMP4_S) gave a more normal distribution in its histogram, with a mean of 3.0, standard deviation of 1.43, kurtosis of 0.81 and skewness of 0.70. Answers to a supplementary question showed that 68 percent had completed some job-related training by their organization in the past two years, with an average of 10 days spent in total (i.e. 5 days per year). This appears to be the major source of formal training for most respondents. A further supplementary question regarding the number of memberships in professional societies (other than the compulsory PEO), showed a range of from 0 to 10 societies with a mean of only 1.2, suggesting that this is not a major source for maintaining professional competence.

The fifth measure of professional competence was based on the number of professional achievements. The number of positive responses to each of the three relevant questions regarding evidence of publications, innovations, or patents, ranged from 11 to 48 percent, indicating that the number of such achievements is not a suitable measure. A dichotomous measure (PROCMP5) was developed based on whether or not there was a positive response to any of the three questions, with 60.4 percent indicating such a positive response.

A further review of the value of these measures in the LISREL model of utilization follows in subsection 7.3, which reviews the correlation matrix of measures.

7.2.3 Career Aspirations

Respondents' career aspirations were measured by the extent to which they would like their career to be a progression up the managerial ladder to a higher position (CARASP1). The distribution of managerial aspirations was reasonably normal, with a mean of 4.30, standard deviation of 1.56, kurtosis of -0.15 and skewness of -0.41. A square-root transformation of managerial progression (CARAS1_S) provided a more normal distribution with a mean of 2.80, a standard deviation of 0.44, a kurtosis of 1.07 and a skewness of 0.30. An alternative measure (CARASP1A) was computed, for possible use, as the sum of the three scales regarding progressions up the technical professional ladder, up the managerial ladder and through a series of challenging projects. Three of the responses were more than three standard deviations below the mean of 14.0; the standard deviation was 2.56, the kurtosis was 2.65 and the skewness was -1.00.

The second measure of career aspirations, job motivation (CARASP2), used a single item 5-point scale, with responses narrowly centred on two of the middle items. The mean value was 3.58, the standard deviation 0.73, the kurtosis 1.29 and the skewness -0.47. A square-root transformation (CARA2_S) resulted in a slightly more normal distribution with a mean of 1.54, standard deviation of 0.24, kurtosis of 0.69 and skewness of -0.16.

The third measure of career aspirations was attendance

at professional meetings (CARASP3). The two items making up the scale were answered by a small number of respondents (11% and 34%). If the missing answers are assumed to be non-respondents assumed to be non-attendants, the dichotomous scale had 53.7 percent as non-attendants and 46.3 percent as attendants.

A further discussion of the value of these measures for use in the LISREL model of utilization is included in sub-section 7.3 which reviews the correlations between the measures.

7.2.4 Professional Responsibility

Two scales were chosen to measure professional responsibility. As already discussed in sub-section 7.1, neither the age of respondents nor the range of PEO levels of responsibility conformed with those of a recent larger PEO survey, that is, the respondents were older and their level of responsibility was greater. However, the histogram of the PEO level of responsibility, the first measure of professional responsibility (PRFRESP1), was generally normal in distribution around the mean of 5.00 (level E), with a standard deviation of 1.11, a kurtosis of -0.52 and a skewness of -0.18.

The second scale (PRFRESP2) measured the extent of direct supervision (defined as having direct and principal responsibility for staff performance reviews and salary reviews). Responses to the associated question displayed a

relatively flat histogram, with 22% having no direct supervisory responsibility, 29% no direct supervisory responsibility but with project or team leadership responsibility, and the balance being relatively evenly distributed over four higher levels of direct supervision (based on the six level scale, the mean was 2.9, the standard deviation, 1.66, the kurtosis -0.92, and the skewness, 0.56). A square-root transformation (PRFRE2WR) provided a slight improvement in the skewness (to 0.22) at the expense of the kurtosis (to -1.15).

Both the original measures were satisfactory for use in the LISREL model of utilization.

7.2.5 Organizational Structure

The first organizational structure measure was designed to determine the relative extent to which the respondent's organization structure is organic (positive) or mechanistic (negative). It was based on three sub-measures: (negative) complexity, (negative) centralization and (negative) formalization. Complexity itself was formed from three subscales: spacial complexity, horizontal complexity and vertical complexity. Spacial complexity was based on the extent to which persons with whom the respondents dealt with regularly are geographically dispersed (49% stated that they were to a greater than average extent while 37% stated that they were to a less than average extent). Horizontal complexity measured the extent to which "persons perform specialized

tasks" (61% stated that they did so to a greater than average extent, while 22% did so to a less than average extent). Vertical complexity was composed of the sum of two items, regarding the number of direct supervisory levels below, and above, the respondent's position. This also provided a check on the answers given to whether the respondent was a direct supervisor (48% indicated that they had zero levels below them, while 51% stated that they had no direct supervisory responsibility, i.e. a reasonably close agreement). Formalization was measured with three items: the extent of rules (68% had rules to a greater than average extent versus 12% who had them to a less than average extent); the freedom to use one's discretion (53% had discretion to a greater than average extent versus 13% who had discretion to a less than average extent), and standardization of work (52% were standardized to a greater than average extent versus 23% who were standardized to a less than average extent). Together these answers to the three items indicated a relatively high degree of formalization, and hence a tendency to be working in mechanistic structures.

Centralization was measured with five items. Sixty-three percent stated that important decisions were made by top executives to a greater than average extent versus 17%, who stated that they were made to a less than average extent. Communications downward from more senior management, an important source of information, had respondents evenly

divided (38% stated that there was such communication to a greater than average extent, while 40% said there was, to a less than average extent). With communications upward these percentages were not as balanced (50% said that there was such communication to a greater than average extent while only 31% said there was, to a less than average extent). Respondents were about evenly divided on whether the management style of their organization was more democratic than average (42%), versus more autocratic (36%). The first measure proposed (ORGSTRU1) was based on the sum of the z-scores of the five subscales. An examination of the histograms of the separate subscales indicated that spacial complexity had a flat distribution. The characteristics of the five subscales are shown in Table 9, with spacial complexity

Table 9
Extent of Organic Management Scale
Characteristics of the Subscales

<u>Subscale</u>	<u>Mean</u>	<u>Std.Dev.</u>	<u>Kurtosis</u>	<u>Skewness</u>
Vertical Complexity	3.64	2.14	-0.05	0.67
Horizontal Complexity	4.80	1.63	-0.47	-0.56
Spacial Complexity	4.21	2.09	-1.31	-0.21
Formalization	11.93	3.80	-0.50	-0.19
Centralization	19.71	5.69	-0.39	-0.30

having a flat kurtosis of -1.31. Coefficient Alphas for formalization and centralization were also computed. Formalization with three items had a coefficient alpha of 0.72, while centralization with 4 items had a coefficient alpha of 0.79. The centralization measure was reversed to give a negative centralization score (N_CENTRZ) for use as a positive measure of organic structure in the LISREL model of utilization.

The second measure of organization structure was based on Mintzberg's theory regarding the location of the dominant component of an organization. A review of the answers to the two complementary questions shows that the respondents placed themselves fairly evenly in each of Mintzberg's five parts of the organization (30% in the *Operating Core*, 20% in the *Strategic Apex*, 24% in the *Middle Line*, 17% in the *Technostructure*, and 10% in the *Support Staff*). Answers to the question "which is the dominant part?" were not similarly distributed, with responses being heavily weighted toward the *Operating Core* and away from the *Support Staff* (45%, 34%, 13%, 7%, 1%). Mintzberg claimed that if employees work in the *Operating Core* (where employees "perform the basic work related to the production of goods and services), or are members of the *Support Staff* (who "provide indirect services for the organization"), and if these are the dominant parts of the organization, then they are working in an organic structure. Thus 46 percent work in organic structures and 54

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percent in mechanistic structures. The correlation coefficients between Mintzberg's measure and the five subscales of the organic structure scale (ORGSTRU1) are shown in Table 10. The levels of significance indicate very little correlation between the two measures of organic structure suggesting that the word "dominant" may have been misinterpreted to mean the

Table 10
Comparison of Mintzberg and Organic Structure Sub-measures

<u>Subscale</u>	<u>Varname</u>	<u>Correlation Coefficients</u>	<u>Significance (2-tailed)</u>
Vertical Complexity	NVER_COM	-.065	.46
Horizontal Complexity	NHOR_COM	.091	.30
Spacial Complexity	NSPA_COM	.093	.29
Formalization	N_FORMZN	-.095	.29
Centralization	N_CENTRZ	.080	.37

largest-sized group. Mintzberg's measure was dropped from further consideration for use in the LISREL model of utilization.

A third measure, the extent of work done in a matrix structure (ORGSTRU3), also measured the extent to which the organization structure was organic, with greater participation in a matrix structure indicating a more organic structure. The histogram of the responses to the extent of participation in a matrix structure had a very flat shape. The mean was 3.41, the standard deviation, 1.71, and the skewness, -0.14, while the kurtosis was -1.30.

7.2.6 Organizational Practices

Questions suitable to determine five measures of organizational practices were included in the questionnaire. The first measure was the availability of support services provided by the organization (ORGPR1). Three items formed this scale; the histogram showed a fairly normal distribution, with a mean of 12.7, a standard deviation of 4.50, a kurtosis of -0.19 and a skewness of 0.17. The reliability of this scale was determined giving a coefficient alpha of 0.71. Fifty-six percent of respondents indicated that their organization supported them to a greater than average extent with technical problems, while only 27 percent indicated that it supported them to a less than average extent. Thirty-seven percent stated that it supported them to a greater than average extent with administrative or personnel matters against a nearly equal percent (34%) who stated that it supported them to a less than average extent. However, only 26 percent stated that their organization supported them to a greater than average extent with routine clerical work against 49 percent who stated that it supported them to a less than average extent. The results indicated that this measure was satisfactory for further use in the utilization model.

Several supplementary questions concerned the support provided by an assistant, defined as either a secretary or an administrative assistant. Sixty-seven percent of respondents

had such an assistant, who devoted an average of 25.1 percent of their time to the respondent's work, increasing their effectiveness by an average of 17.8 percent. Only a minority of forty-one percent of those with an assistant agreed with the statement that if he or she had better training, their effectiveness would increase more (by an average of 26.0% more). Over two-thirds (71%) of those without an assistant could not justify having one. The 29 percent who could justify having an assistant indicated they could use his or her services for an average of 45.0 percent of their time, to increase their effectiveness by an average of 30.1 percent.

The second measure was the extent to which development programs had improved the effectiveness of the respondent, particularly by keeping her or him up-to-date (ORGPRA2). Responses to the benefits of job-related courses, attendance at conferences and new computer software showed a balance between positive and negative replies (36% vs. 33%, 46% vs. 30%, and 45% vs. 35%, respectively). "On-the-job problem solving" and "on-the-job colleague interaction" showed much greater positive (69% and 83%, respectively) than negative responses (12% and 4%, respectively), while "external general education courses" showed a slightly negative response (34% positive vs. 56% negative). The latter response was consistent with the low number of university and college courses completed. The two items regarding "external general education courses" and "reading of publications" (46% positive vs.

26% negative) were deleted from the development programs scale, since they were believed to be more representative of organizational practices. The reliability of the ORGPRA2 scale for the five items retained had a coefficient alpha of 0.62. The mean value was 22.7, the standard deviation, 4.83, the kurtosis, -0.058, and the skewness, -0.464. A square-root transformation (ORGPR2_S) improved the distribution only marginally, with a mean of 3.59, standard deviation of 0.67, kurtosis of -0.29, and skewness of 0.00. The original measure was thus retained for use in the LISREL model of utilization.

Two supplementary questions also indicated favourable organization practices: payment of tuition for courses, and payment of salary while attending courses. Fifty-seven percent of those who responded that they had completed university or college courses (who as already noted under professional competence were very much in the minority, ranging from 1% percent for graduate degrees to 19 percent for non-degree courses) indicated that their organization paid for tuition, and 43 percent, that it paid their salary while attending. The small numbers involved did not permit this result to be used as a further measure of organizational practices.

The third measure, the appropriateness of the reward system (ORGPRA3), was based on answers to two sets of questions. The first asked whether the respondent would like his

or her career to be a progression of technical professional or managerial steps, or a progression of challenging projects; the second used the same categories to determine the most likely form of reward. Differences between the scores of the respondent's answers to the first set of questions were used to determine whether the respondent favoured one of the alternatives over the other two. The measure then scores the responses on the appropriate scale on the second set of questions. The histograms of the responses has a reasonably normal distribution with a mean of 4.75, a standard deviation of 1.60, a kurtosis of 0.11 and a skewness of -0.70. A square root transformation (ORPRA3_S) provided a not substantially significant improvement in skewness (to 0.11) with a slight deterioration in the kurtosis (to 0.21). The original measure was retained for further use with the LISREL model of utilization.

The fourth measure, the fairness of the reward system (ORGPR4), was based on answers to two direct questions regarding rewards. The responses had a reasonably normal distribution. The scale was retained for subsequent use with the utilization model.

Answers to a supplementary question indicated that job performance was evaluated in writing for 74 percent of respondents, with a range of between 3 and 36 months between such evaluations. The positive answer by a majority of respondents indicated that this is normal practice and does not

provide a differential measure of organizational practices.

The fifth measure, the salary differential with the reported Professional Engineers of Ontario (PEO) annual salary survey for the same year of graduation (ORGPRA5) used a scale of 1 to 6 to compare the reported salary with the deciles and quartiles of the PEO survey. A histogram of the scale showed a fairly flat distribution with a mean of 3.59, standard deviation of 1.70, kurtosis of -1.18 and skewness of 0.15, but was retained for further use in the utilization model.

7.2.7 Supervisory Competence

The first of the two measures of supervisory competence is a combination of managerial competence and technical leadership (SUPCMP1), measured on separate 1 to 5 items, each of which was evenly distributed around its mean. Twenty-eight respondents (20.9% of the sample surveyed) did not reply to these questions because they did not have direct supervisors (only those respondents who had direct supervisors were used in the LISREL model of utilization). The composite scale had a mean value of 6.15, a standard deviation of 1.86, and a nearly normal kurtosis of -0.33 and skewness of -0.25. The scale was retained for further use with the utilization model.

The second scale, based on answers to six questions regarding the respondent's direct supervisor (SUPCMP2), had

the same number of missing responses as the first measure and for the same reason. The reliability of the 6-item scale was computed, giving a coefficient alpha of 0.91. A histogram of the responses shows a considerable negative skew, indicating that a majority of respondents rated their supervisors as better than average. The mean was 23.2 (with a maximum of 30), the standard deviation 5.37, the kurtosis 0.45, and the skewness -0.93. A square-root transformation (SUCMP2_S) provided an improvement in the skewness (to 0.24) with a decrease in the kurtosis (to 0.24). The original measure was retained for further use.

Two supplementary questions were asked. The first was whether the supervisor is an engineer (59% responded in the affirmative). Analysis of the responses showed that while 54 percent of respondents who had engineers as their supervisors rated their supervisor above average as a manager of people, only 26 percent of respondents who had non-engineers as supervisors rated them above average. More significantly, while 52 percent of respondents with engineers as supervisors rated their supervisors at above average as a technical leader, only 7 percent of respondents who had non-engineers as supervisors rated them at above average.

A supplementary question asked respondents to rate their direct supervisor's assessment of their own performance (29% said it was objective and 28% said it was subjective). Engineers with direct supervisory responsibility were also

asked to rate their own measurement of the work performance of their staff (38% said it was objective and 18% said it was subjective). Similarly, all respondents were asked to rate their direct supervisor's measurement of their own productivity (32% said it was objective and 37% said it was subjective). On the other hand, engineers who are direct supervisors rated their own measurement of the work productivity of their staff more favourably (40% said it was objective, while 18% said it was subjective).

7.2.8 Job Satisfaction

Two measures of job satisfaction were computed. The first, reported job satisfaction (JOBSATN1), was based on the simple question "how satisfied are you with your present job" on a scale of 1 to 6. The histogram of the responses shows a slight negative skew (-0.51), and an excellent kurtosis (-0.00). A square-root transformation (JBSAT1_S) improves the skewness (to -0.01) but at the expense of the kurtosis (to -0.51), and thus the original measure was retained for further use.

The second measure, work satisfaction (JOBSATN2), was a composite of three items regarding satisfaction with "your career progress", with "your present employer", and with "your present pay". The reliability of the 3-item scale was calculated to give a coefficient alpha of 0.78. The histogram showed a slight negative skew (-0.25) and a slight

negative kurtosis (-0.45).

A supplementary question was asked to determine the respondent's degree of success "at this point in your professional life". Seventy eight percent answered that they were either somewhat successful, or very successful. Similarly, a question regarding satisfaction with "your career choice" was answered "very" or "extremely" satisfied by 63 percent of respondents.

7.2.9 Organizational Commitment

Two measures of organizational commitment were calculated. The first (ORGCOM1) was a composite of 6 items. The calculated reliability gave a coefficient alpha of 0.91. The histogram exhibited a nearly normal distribution with a skewness of -0.11 and a kurtosis of -0.22.

The second measure was based on the amount of unpaid overtime worked (ORGCOM2). The histogram of the measure showed a severe positive skew (a skewness of 1.07) and a kurtosis of 1.09. A log transformation (ORC2_WL) reduced the skewness (to -0.37) and the kurtosis (to -0.67) and was considered for subsequent use in the model of utilization.

7.2.10 Summary of the Measures

Table 11 shows the characteristics of the original 28 concept measures. Distortions from normality in some of the measures have been discussed in the preceding subsections and

Table 11

Characteristics of the Original Concept Measures

<u>Variable</u>	<u>Varname</u>	<u>Mean</u>	<u>Std Dev</u>	<u>Kurt</u>	<u>Skew</u>
Utilzn. of prof. abil.	(UPA_1)	23.72	5.46	.22	-.16
Underutilization	(UPA_2)	10.63	1.97	6.82	-2.38
Misutilization	(UPA_3)	10.28	10.00	-1.01	-.09
Effective. use of time	(UPA_4)	74.16	16.61	3.37	-1.48
Time on original. work	(UPA_5)	23.97	23.61	1.18	1.42
Job satisfaction	(JOBSATN1)	4.3	1.19	-.00	-.51
Work satisfaction	(JOBSATN2)	11.91	3.24	-.45	-.25
Organizatl. commitment	(ORGC0M1)	28.12	7.78	-.22	-.11
Unpaid overtime worked	(ORGC0M2)	8.92	7.73	1.09	1.07
Academic course work	(PROCMP1)	1.28	.45	-1.07	.97
Yrs. profl. experience	(PROCMP2)	21.32	9.91	-.12	.56
Graduate degree	(PROCMP3)	1.29	.53	2.05	1.70
Time keeping up-to-date	(PROCMP4)	11.29	10.59	4.71	2.02
Professl. achievements	(PROCMP5)	1.60	.49	-1.84	-.43
Managerial aspirations	(CARASP1)	4.30	1.56	-.15	-.41
Job motivation	(CARASP2)	3.58	.73	1.29	-.47
Attend. @ profl. mtgs.	(CARASP3)	1.46	.50	-2.01	.15
Profl. resp. level	(PRFRESP1)	4.97	1.11	-.52	-.18
Superv. resp. level	(PRFRESP2)	2.92	1.66	-.92	.56
Extent organic struct.	(ORGSTRU1)	.01	2.47	.06	-.26
Organic structure	(ORGSTRU2)	1.65	.48	-1.61	-.64
Extent of matrix work	(ORGSTRU3)	3.41	1.71	-1.30	-.14
Availab. support serv.	(ORGPRA1)	12.68	4.59	-.19	.17
Extent develop. progs.	(ORGPRA2)	22.68	4.83	.06	.46
Appropriate rewards	(ORGPRA3)	3.29	2.23	-1.52	.24
Fairness reward syst.	(ORGPRA4)	7.44	2.98	-.63	-.12
Mgrl. and tech. compet.	(SUPCMP1)	6.15	1.86	-.33	-.25
Supervisor competence	(SUPCMP2)	23.19	5.37	.45	-.93

led to transformations.

7.3 Bivariate Correlations Between the Measures

The SPSS CORRELATIONS procedure was used to calculate the correlation coefficients between the measures. The next two subsections discuss the correlations between measures of the same concept, and between one measure of each of the endogenous concepts and the exogenous concept measures.

7.3.1 Correlations Between Measures of the Same Concept

Table 12 lists the correlations between measures of the same concept. There were five original measures of utilization plus transformations of the third and fifth. Only the correlation between the first two (UPA_1 and UPA_2) was significant ($p < 0.001$, 2-tailed). The misutilization measure (UPA_3) is the sum of two items: light intellectual demands (LITEINTD), based on the lighter half of the time demands question, and heavy time demands (HEAVTIMD), based on the heavier half of the time demands question. Only 7 percent of respondents stated that their time demands were less than "about right". The histogram of heavy time demands was quite flat (its kurtosis is -1.34). When heavy time demands are added to light intellectual demands the resulting negative misutilization scale (UPA_3) also presents a flat distribution in its histogram (its kurtosis is -1.01). The low correlation indicates that the misutilization measure is not

Table 12

Correlation Coefficients Between the Measures of the Same Concept

<u>Measure:</u>	<u>Measure:</u>	<u>UPA_2</u>	<u>UPA_3</u>	<u>UPA_4</u>	<u>UPA_5</u>
Utilzn. of prof. abil.	UPA_1	.357*** ¹	.022	.150	.047
Neg. Underutilization	UPA_2	1.000	-.152	.002	.313
Neg. Misutilization	UPA_3		1.000	.027	-.097
Effective. use of time	UPA_4			1.000	-.136
Time on original work	UPA_5				1.000

<u>Measure:</u>	<u>Measure:</u>	<u>JOBSATN2</u>
Job satisfaction	JOBSATN1	.672***
Work satisfaction	JOBSATN21	.000

<u>Measure:</u>	<u>Measure:</u>	<u>ORGC0M2</u>
Organizatl. commitment	ORGC0M1	.175*
Unpaid overtime worked	ORGC0M2	1.000

<u>Measure:</u>	<u>Measure:</u>	<u>PROCMP2</u>	<u>PROCMP3</u>	<u>PROCMP4</u>	<u>PROCMP5</u>
Recent Academic Educ.	PROCMP1	-.230**	-.059	-.097	.001
Yrs. profl. experience	PROCMP2	1.000	.223	.259**	.014
Graduate degree	PROCMP3		1.000	.189*	.200*
Time keepg. up-to-date	PROCMP4			1.000	.027
Professl. achievements	PROCMP5				1.000

<u>Measure:</u>	<u>Measure:</u>	<u>CARASP1A</u>	<u>CARAS1_S</u>	<u>CARASP2</u>	<u>CARASP3</u>
Managerial aspirations	CARASP1	-.542***	-.536***	.042	.105
Mgl & professl. aspirs.	CARASP1A	1.000	-.992***	.329***	.121
Sqrt mgl & prof aspirs.	CARAS1_S		1.000	-.301***	-.140
Job motivation	CARASP2			1.000	.142
Attend. @ profl. mtgs.	CARASP3				1.000

¹ * $p \leq .05$; ** $\leq .01$; *** $\leq .001$ (all 2 - tailed significance)

Table 12 - Continued
Correlation Coefficients Between Measures of the Same Concept

<u>Measure:</u>	<u>Measure:</u>	<u>PRFRESP2</u>	<u>PRFRE2WR</u>
Profl. resp. level	PRFRESP1	.555***	.525***
Superv. resp level	PRFRESP2	1.000	.992***
Sqrt. superv. level	PRFRE2WR		1.000

<u>Measure:</u>	<u>Measure:</u>	<u>ORGSTRU2</u>	<u>ORGSTRU3</u>
Extent organic struct.	ORGSTRU1	-.031	.108
Organic/ mechl. struct.	ORGSTRU2	1.000	-.008
Extent matrix work	ORGSTRU3		1.000

<u>Measure:</u>	<u>Measure:</u>	<u>N_CENTRZ</u>	<u>N_FORMZN</u>	<u>NHOR_COM</u>	<u>NVER_COM</u>	<u>NSPA_COM</u>
Ext. organic struct.	ORGSTRU1	-.327***	-.533***	-.593***	-.506***	-.463***
Neg. centralization	N_CENTRZ	1.000	.065	.017	-.174	-.105
Neg. formalization	N_FORMZN		1.000	.171*	.128	-.057
Neg. horiz. complex.	NHOR_COM			1.000	.121	.147
Neg. vert. complex.	NVER_COM				1.000	.088
Neg. spac. complex.	NSPA_COM					1.000

<u>Measure:</u>	<u>Measure:</u>	<u>ORGPRA2</u>	<u>ORGPRA3</u>	<u>ORGPRA4</u>	<u>SAL_DECI</u>
Avail. support serv.	ORGPRA1	.292***	.274**	.389***	.409***
Extent devel. progs.	ORGPRA2	1.000	.257**	.200*	.275**
Appropriate rewards	ORGPRA3		1.000	.348***	.245**
Fair reward syst.	ORGPRA4			1.000	.471***
Salary decile	SAL_DECI				1.000

<u>Measure:</u>	<u>Measure:</u>	<u>Q_20_B1</u>	<u>SUPCMP2</u>	<u>SUCMP2_S</u>
Mgrl. & tech. comp.	SUPCMP1	.841***	.575***	-.569***
Managerial competce.	Q_20_B1	1.000	.601***	-.594***
Supervisor competce.	SUPCMP2		1.000	-.981***
Sqrt. super. comp.	SUCMP2_S			1.000

1 * $p \leq .05$; ** $\leq .01$; *** $\leq .001$ (all 2 - tailed significance)

suitable and was excluded from the LISREL utilization model. The fourth measure of utilization (UPA_4), effective use of time (i.e. 100% minus the time "spent on work that could be done by someone with less training"), and the fifth measure (UPA_5), time on original work (i.e. "time "spent doing work which you have not done before"), both have low correlations with the other utilization measures. It is not obvious why these measures were not effective as measures of utilization (on average respondents indicated that one-quarter of their time was spent on each category). It is possible that some respondents interpreted the questions as a negative reflection on their competence. On the other hand, highly utilized engineers may feel the same as less highly utilized engineers regarding this type of underutilization of their ability. Three of the measures of utilization were excluded from further analysis, leaving only the first two, utilization of professional ability and under-utilization (UPA_1 and UPA_2). The under-utilization measure (UPA_2) is composed of only two items while the utilization measure (UPA_1) is composed of eight items. As such, the utilization measure (UPA_1) captures a broader range of phenomena, and was selected as the best measure of the utilization concept.

The two job satisfaction measures were significantly correlated ($p < 0.001$). The second measure, work satisfaction consists of three items and was therefore selected over the one item first scale as the better measure.

The two organizational commitment measures were less strongly correlated ($p < 0.05$). The six item first measure (ORGC0M2) was selected over the two item second measure (ORGC0M2) as the preferred measure, since it captures a broader range of phenomena.

Among the five measures of professional competence, years of professional experience, on the one hand, and post graduate degree, and time spent keeping up to date, on the other, were both significantly correlated ($p < 0.01$). The post graduate degree measure was also significantly correlated with time keeping up to date and professional achievements.

Of the three measures of career aspirations and their transformations, the first measure, managerial career aspirations (CARASP1) had no significant correlations with either of the other two measures, job motivation (CARASP2) or attendance at professional meetings (CARASP3). However, the combined measure of managerial and professional career aspirations (CARASP1A) had a significant correlation ($p < 0.001$) with the job motivation measure of career aspirations. The correlation between the job motivation measure and the attendance at professional meetings measures, however, was not significant.

The two professional responsibility measures were significantly correlated ($p < 0.001$).

The three organizational structure measures were not

significantly correlated. The extent of organic structure was composed of five sub-scales. The sub-scales were not significantly correlated among themselves, except for the formalization and horizontal complexity measures ($p < 0.05$).

The five measures of organizational practices were all significantly correlated with each other, as were the two measures of supervisory competence.

7.3.2 Correlations between Endogenous and Exogenous Measures

Table 13 lists the correlations between one measure of each of the three dependent variables, utilization of professional ability (UPA_1), job satisfaction (JOBSATN2), and organizational commitment (ORGC0M1), and the twenty-eight original measures plus six transformations and nine subscale measures of the six independent variables. Using listwise deletion, the number of usable responses was reduced to 127 when the supervisor measures were excluded, and to 105 when the supervisor measures were included, from the 134 of the 137 responses that arrived in time to be included in the analysis.

Both the job satisfaction measures (JOBSATN1 and JOBSATN2) have very significant correlation coefficients with the dependent concept measures of utilization and of organizational commitment ($p \leq .001$) and were retained for use with the utilization model. This result also confirms the strong positive correlation between utilization and satisfaction

Table 13
Correlation Coefficients With Dependent Measures¹

Independent Variable <u>Measure:</u>	Dependent Variable <u>Measure:</u> <u>Varname</u>	Utili- zation <u>(UPA_1)</u> <u>Coeff.</u>	Job Satisfn. <u>(JOBSATN2)</u> <u>Coeff.</u>	Orgl. Commit. <u>ORGC0M1</u> <u>Coeff.</u>
Utilzn. of prof. abil.	(UPA_1) ²	1.000	.640*** ³	.691***
Neg. Underutilization	(UPA_2) ²	.357***	.124	.308***
Neg. Misutilization	(UPA_3)	.022	-.028	-.012
Effective. use of time	(UPA_4)	.150	.086	.026
Log. effec. use of time	(UPA_4W)	.100	.079	-.013
Time on original work	(UPA_5)	.047	-.018	.045
Log. time on orig. work	(UPA_5_LG)	.104	.006	.076
Job satisfaction	(JOBSATN1) ²	.607***	.672***	.701***
Work satisfaction	(JOBSATN2) ²	.640***	1.000	.667***
Organizatl. commitment	(ORGC0M1) ²	.691***	.667***	1.000
Unpaid overtime worked	(ORGC0M2) ²	.119	.144	.175*
Academic	(PROCMP1)	-.064	-.241**	.066
Yrs. profl. experience	(PROCMP2)	.031	.027	.042
Graduate degree	(PROCMP3)	-.057	-.166	-.020
Time keeping up-to-date	(PROCMP4)	.063	.094	.115
Sqrt. up-date time	(PRCMP4_S)	.125	.149	.174*
Professl. achievements	(PROCMP5)	.149	.117	.057
Managerial aspirations	(CARASP1)	-.075	-.176*	-.149
Sqrt. managl. aspirs.	(CARAS1_S)	.014	.124	.027
Mgl & professl. aspirs.	(CARASP1A)	.028	-.108	.005
Job motivation	(CARASP2)	.282***	.142	.321***
Sqrt. job involvment.	(CARA2_S)	-.270**	-.149	-.315***

¹ Number of cases = 127 to 132 (= 107 for SUPCMP1, Q_20_B1, SUPCMP2).

² Variables selected initially for use in LISREL model.

³ * p ≤ .05; ** ≤ .01; *** ≤ .001 (All 2 - tailed significance)

Table 13 - Continued
Correlation Coefficients With Dependent Measures¹

<u>Independent Variable Measure:</u>	<u>Dependent Variable Measure:</u>	<u>Utili- zation (UPA_1)</u>	<u>Job Satisfn. (JOBSATN2)</u>	<u>Orgl. Commit. ORGC0M1</u>
	<u>Varname</u>	<u>Coeff.</u>	<u>Coeff.</u>	<u>Coeff.</u>
Attend. @ profl. mtgs.	(CARASP3)	-.071	-.058	-.021
Profl. resp. level	(PRFRESP1) ²	.336***	.316***	.284***
Superv. resp level	(PRFRESP2) ²	.375***	.287***	.376***
Sqrt. superv. level	(PRFRE2WR)	.381***	.265**	.374***
Extent organic struct.	(ORGSTRU1) ²	.206*	-.207*	-.175*
Organic/ mechl. struct.	(ORGSTRU2)	.036	.058	.006
Neg. centralization	(N_CENTRZ) ⁴	.529***	.398**	.406**
Neg. formalization	(N_FORMZN)	.026	-.029	-.020
Neg. horiz. complex.	(NHOR_COM)	-.122	-.022	-.148
Neg. vertical complex.	(NVER_COM)	.040	.045	.116
Neg. spacial complex.	(NSPA_COM)	-.040	.055	.010
Extent matrix work	(ORGSTRU3) ²	.241**	.170*	.186*
Availab. support serv.	(ORGPRA1) ²	.389***	.334***	.403***
Extent develop. progs.	(ORGPRA2) ²	.348***	.257**	.259**
Appropriate rewards	(ORGPRA3) ²	.289***	.225**	.181*
Fairness reward syst.	(ORGPRA4) ²	.641***	.684***	.670***
Salary decile	(SAL_DEC1) ²	.330***	.512***	.269**
Mgrl. and tech. compet.	(SUPCMP1) ²	.394***	.377***	.368***
Managerial competence	(Q_20_B1) ⁴	.356***	.321***	.341***
Supervisor competence	(SUPCMP2) ²	.513***	.442***	.376***
Sqrt. superv. comp.	(SUCMP2_S)	.508***	-.436***	-.382***

¹ Number of cases = 127 to 132 (= 107 for SUPCMP1, Q_20_B1, SUPCMP2).

² Variables selected initially for use in LISREL model.

³ * p ≤ .05; ** ≤ .01; *** ≤ .001 (All 2 - tailed significance)

⁴ Included after first LISREL runs (Q_20_B1 replaced SUPCMP1,
and N-CENTRZ replaced ORGSTRU1)

that was found in the 1986 Survey as reported in Chapter Four.

The correlation coefficient of the reported organizational commitment measure (ORGCOM1) with the utilization of professional ability measure (UPA_1) was highly significant ($p \leq 0.001$). The second measure of organizational commitment, unpaid overtime hours worked, had non-significant correlations with the utilization and job satisfaction measures, but was retained to provide a second measure for use in the LISREL model.

Five professional competence measures were proposed (PROCMP1 to PROCMP5). The first measure, academic coursework demonstrated a significant correlation with the job satisfaction measure ($p \leq 0.01$) but not with the other two endogenous measures. The second measure, years of professional experience (PROCMP2), is essentially equivalent to age, since a majority of engineers have received their Bachelor degrees at 22 to 23 years of age and were registered two years later to begin their years of experience. As has been described in subsection 7.1, the correlation between age and utilization was not significant. It is thus not surprising that this measure should demonstrate the same result. Utilization was thus not related to professional competence as measured by experience. Similarly, having a higher degree (PROCMP3) and more time spent keeping up-to-date (PROCMP4) did not affect the degree of utilization (a small improvement in the signifi-

cance of the correlation coefficient with organizational commitment ($p \leq 0.05$) was obtained in the square root transformation). Finally, the fifth measure, professional achievements (PROCMP5), also did not exhibit significant correlations. As discussed in subsection 7.2.2, this measure had to be modified from a scale of the number of such achievements to a dichotomous measure because a majority of respondents (69%, 52% and 89%) had no achievements in the three areas. The measure thus did not provide a useful differentiation of professional competence. The poor correlations between the five measures and the three dependent measures, indicated that the professional competence concept, one of the two individual level personal concepts hypothesized, does not have a significant effect on the endogenous concepts. As a consequence the competence concept was deleted from the model of utilization. The deletion of the professional competence concept from the model does not detract from the value of the finding that underutilization and misutilization are concerns for all professionals, regardless of their level of competence.

Three measures of career aspirations were proposed. The first measured managerial aspirations (CARASP1). It showed a significant negative correlation coefficient with the job satisfaction measure only. It thus appears that the greater the managerial aspiration the less the job satisfaction. This may be the result of poor promotion possibilities in the

organization, unreasonable expectations on the part of the respondents, or simply because wanting something you don't have can be a source of dissatisfaction. A variant which measured both managerial and professional career aspirations (CARASP1A) did not exhibit significant correlations with any of the three dependent variable measures. Including professional aspirations than managerial aspirations alone in the measure may have provided greater scope for satisfaction because the professional work itself provides a measure of satisfaction. The second measure, job motivation (CARASP2) demonstrated highly significant correlations with the utilization and organizational commitment measures ($p \leq 0.001$). This measure may have captured a job-versus-home related, rather than a career aspirations, response (the measure asked respondents to make a determination of the balance between their commitment to their work and to their personal activities, and as such responses could have been affected by cognitive dissonance). The third measure, attendance at professional meetings (CARASP3), was originally set to measure the number of such meetings, but few engineers indicated any attendance, so the measure was dichotomized. However, the negative answers to the two questions regarding attendance were in the majority (84% and 61%), making the measure less useful. The low and insignificant correlations of the reported managerial aspirations and reported attendance at professional meetings measures of career aspirations

indicated that this second individual level concept did not warrant being included in the LISREL model of utilization. Removal of the two individual level concepts from the model did not, however, invalidate the validity of the measures.

The two measures of professional responsibility, professional responsibility level (PRFRESP1) and supervisory responsibility level (PRFRESP2) demonstrated highly significant correlations with the three endogenous measures ($p \leq .001$) and were retained for use in the utilization model.

Three measures were adopted for organizational structure. The first, the extent of organic structure (ORGSTRU1), as described in subsection 7.2.5, and above, was a composite formed by adding the z-scores of five subscales: negative centralization (N_CENTRZ), negative formalization (N_FORMZN), negative horizontal complexity (NHOR_COM), negative vertical complexity (NVER_COM), and negative spacial complexity (NSPA_COM). Using a Bonferroni adjustment to assess individual correlations would result in rejecting the null-hypothesis that an individual correlation is zero, if $p < \alpha/n$, where α is the overall rate and n is the number of correlations in the group under study. Thus, with $\alpha = .05$ and $n = 3$, the null-hypothesis would be rejected if $p < .05/3 = .017$. Since the correlations with the three dependent measures had p-values of ≤ 0.05 they are uninteresting since the values are part of a large number of tests.

Only the centralization subscale showed significant correlations with the three dependent measures. While the overall extent of organic structure measure was retained for further use, it was subsequently replaced by the more specific negative centralization scale as the measure of organic structure in the utilization model. The second measure, the Mintzberg measure of organic structure, was dropped from further use in the utilization model because as discussed in subsection 7.2.5, its low correlation with all the sub-measures of an organic structure, indicated that responders may have misinterpreted the intended meaning of the word "dominant" to mean the largest-sized group. The third measure, the extent of work in a matrix structure (ORGSTRU3), showed positive correlations with two of the three measures ($p \leq .05$). While as noted above, these are not interesting correlations, the measure was retained as a second measure because of the significant positive correlation with the utilization measure ($p \leq .01$). This finding is a particularly interesting finding on its own.

The five measures of organizational practices developed: availability of support services (ORGPR1), extent of development programs (ORGPR2), appropriateness of rewards (ORGPR3), fairness of the reward system (ORGPR4), and salary decile compared to other engineers (SAL_DEC1), all demonstrated very significant correlations with the three dependent measures and were retained for further use in the

utilization model.

Although the correlation between managerial competence (SUPCMP1) and the three dependent concept measures was good, it was decided, after the initial simulations with the LISREL model of utilization, that the two items composing the measure, managerial competence and technical leadership, should be separated and the managerial competence measure only (Q_20_B1) was retained for subsequent LISREL model runs.

Based on the bivariate correlations, it would appear that the first utilization measure (UPA_1) is positively and significantly related to both measures of job satisfaction (JOBSATN1 and JOBSATN2), and to organizational commitment (ORGCOM1), and that it is also positively related to both measures of professional responsibility (PRFRESP1 and PRFRESP2), two measures of organizational structure (ORGSTRU1 and ORGSTRU3), the five measures of organizational practices (ORGPR1, 2, 3, 4 and SAL_DECI) and both measures of supervisory competence (SUPCMP1 and SUPCMP2). The first measure of utilization (UPA_1) was not, however, found to be related significantly to professional competence. It was, however, significantly and positively related to the job motivation measure of career aspirations (CARASP2). It would thus appear that the degree of utilization of a professional's ability is not affected by the extent of her or his competence (i.e. highly competent engineers are just as likely to be underutilized as less competent engineers), but is partly

affected by the extent of career aspirations and ambitions.

The 17 measures retained for use in the LISREL model as a result of this assessment of the bivariate correlations, allowed for at least two measures for each concept (they have been marked by a footnote in Table 13).

7.4 The PRELIS Program - Preparation for LISREL

The PRELIS program is a preprocessor for LISREL and provides a descriptive look at the raw data. It can read raw data on continuous and ordinal variables, and compute measures of association between pairs of such variables. Continuous variable observations are assumed to come from an interval or ratio scale and to have metric properties, and observations for ordinal variables are assumed to represent responses to a set of ordered categories, such as a seven-category Likert scale. Starting with the raw data file, an SPSS (active) system file was created, and the PRELIS procedure used to produce a matrix system file, which was then used as the data source for LISREL. PRELIS was used to compute a covariance matrix; this is the preferred input for LISREL although PRELIS also can be used to calculate the correlation matrix. For those variables declared ordinal, PRELIS replaces the arbitrary score values by their corresponding normal scores before the matrices are computed. PRELIS can handle missing data using either pairwise or listwise deletion. Listwise deletion, which guarantees that the

covariance and correlation matrices are non-negative-definite was adopted for the analysis reducing the number of usable responses to 105 persons. The PRELIS matrix used in the LISREL analyses contains the 43 measures listed in Table 13.

7.5 The LISREL Model of Utilization

The model hypothesized for investigating the causal links between the exogenous concepts, on the one hand, and the utilization of professional ability, job satisfaction and organizational commitment, on the other, is depicted in Figure 4. This LISREL model has seven concepts: four exogenous and three endogenous. (A brief introduction to LISREL is included as Appendix 9.) For the reasons advanced in subsection 7.3.2, professional competence and career aspirations were removed from further consideration as model concepts; a seven concept LISREL model of utilization thus remained.

According to Hayduk (1987: 218): "If you are considering building a model with multiple indicators, I suggest beginning with the single best indicator of each concept.... This...provides the clearest conceptual definitions and subsequently eliminates many sources of problems and indeterminacies". This advice was followed. Single measures were selected for each of the seven concepts based on the analyses in subsections 7.2 and 7.3. For the reasons presented in these subsections, the best measure of utiliz-

Figure 4

LISREL MODEL OF UTILIZATION OF PROFESSIONAL ABILITY

$$\eta = \beta \eta + \Gamma \xi + \zeta \quad Y = \Lambda_Y \eta + \epsilon \quad X = \Lambda_X \xi + \delta$$

ation of professional ability was the 10-item reported utilization measure (UPA_1). The 3-item, work satisfaction measure of job satisfaction (JOBSATN2), was chosen over the single item job satisfaction measure (JOBSATN1). The 6-item measure of organization commitment (ORGCOM1), which demonstrated a highly significant correlation with the three endogenous measures, was selected as the best measure of this concept. The direct supervisory responsibility level (PRFRESP2) was selected as the best indicator of the professional responsibility concept because it was considered to be a relatively less subjective measure than professional responsibility level. For the reasons discussed in subsection 7.2.5 and 7.3 the 5-item, negative centralization subscale (N_CENTR2), which had highly significant correlations with the three dependent measures, was chosen as representative of the extent of organic structure measure. The extent of development programs (ORGPRA2) was chosen as most representative of the organizational practices concept. The managerial competence measure (Q_20_B1) was selected as most representative of supervisory competence.

Figure 5 depicts the basic structural equation model of the utilization of professional ability for investigating causal links between four exogenous concepts, professional responsibility, organizational structure, organizational practices and supervisory competence and the utilization of professional ability concept, on the one hand, and outcome

Figure 5

Basic Structural Equation Model of Utilization
Showing Structural and Measurement Relationships

links between utilization and each of job satisfaction and organizational commitment concepts, on the other. Each concept was assigned a single indicator as discussed in the previous sub-section. The values of the concepts themselves, while unknown, are the corresponding true scores if no errors had been introduced by domain sampling, coding errors, misunderstanding of questions, or deliberate deception or exaggeration. The four arrows leading to utilization from the exogenous variables in Figure 5 represent hypotheses that each of these four variables causally influences utilization, with the strength of the influences of these variables to be determined by model estimation (with small values of the standardized structural coefficients indicating that the variance in utilization is less attributable to the associated exogenous concept). Similarly, arrows leading from the exogenous variables to job satisfaction and to organizational commitment represent hypotheses that the exogenous variables causally and directly influence them. The direct causal effects of the exogenous concepts on the endogenous concept, job satisfaction are considered to be effects over and above the effects transmitted by them through the intervening utilization concept. Similarly, the effects of the exogenous variables on organizational commitment are postulated as being in addition to any effects transmitted by them through the utilization or job satisfaction concepts.

Figure 5 shows the possible effects among the seven

concept variables, the measurement error terms on each of the measurement variables, and the effects of the concept error terms on the concept variables. Hayduk states (1987):

It is our view that measurement reliabilities should routinely be fixed rather than free. The researcher's familiarity with the data collection procedures provides information about measurement quality that is lost unless the researcher takes the initiative and incorporates this information by specifying particular measurement reliabilities [p. 118].

The error variances for the measurement error terms (shown at the top and bottom) were determined by assessing an appropriate proportion of the error variance based on judgment about the content and accuracy of each of the measures. Table 14 lists the indicators selected for the utilization model, their means, standard deviations, variances, assessed percentage of error variance, and error variance. The

Table 14

Error Measures for the Indicators in the Utilization Model

<u>Indicator</u>	<u>Mean</u>	<u>Std. Dev.</u>	<u>Var.</u>	<u>Assessed Error Portion of Variance</u>	<u>Calculated Error Variance</u>
Repd. Utilization	23.52	4.84	23.43	5%	1.5
Repd. Job Satisfn.	11.36	2.90	8.41	5%	0.3
Organizl. Commitnt.	26.83	6.67	44.49	5%	3.0
Supervisory Level	3.92	1.66	2.76	25%	0.6
Neg. Centralizn.	20.33	5.54	30.69	25%	6.6
Extent Devpt. Progs.	23.29	4.78	22.85	10%	2.3
Managerial Competce.	3.21	1.01	1.02	10%	0.1

assessed values were justified as follows. Key punch errors were assessed at zero as a result of careful double-checking of all data entries. The reported utilization of professional ability measure was made up of a 10-item scale and was based on the 1986 Study; it had a coefficient alpha of 0.91, and nearly normal distribution. Similarly, reported job satisfaction was a three item scale with a coefficient alpha of 0.78, while reported organizational commitment was a 6-item scale with a coefficient alpha of 0.91. These three measures were thus judged to have a low error variance and were assigned 5 percent as the error portion of their variance. The 25 percent assigned to the single item supervisory responsibility level and to the negative centralization measures allowed for errors in self-assessment of the level of management responsibility, in the former, and for variations in the interpretations of the 5-item scale for negative centralization (which had a coefficient alpha of 0.79). Extent of development programs, a 5-item scale with a coefficient alpha of 0.71, and managerial competence, with a simple 1 to 5 scale, were each assigned 10% error variances to reflect the low coefficient alpha, in the former, and the single item scale, in the latter. (A sensitivity assessment of the error values was carried out and is reported later. See Table 18).

The basic LISREL model was tested with the minimum required one degree of freedom. To include all the linkages,

two models, each with one degree of freedom were selected. In the first, a causal linkage between the supervisory competence and organizational commitment concepts was selected as the sole fixed linkage (with the coefficient fixed at zero). In the second, the single fixed causal linkage selected was that between organizational practices and organizational commitment

The basic models 1 and 2 are listed in Table 15, where the "X's" indicate those linkages between the endogenous concepts (the Free Beta Links) and between the exogenous and endogenous concepts (the Free Gamma Links) which were set free. The maximum likelihood estimation chi-square measure of good fit is shown together with the model's degrees of freedom and associated probability. The chi-square for the basic model 1 with only one degree of freedom was 0.39 (with a probability of 0.530). The chi-square for the basic model 2 with one degree of freedom is 0.06, with a probability of 0.806.

The LISREL maximum likelihood estimates for each of the coefficients of the two basic model are shown in Figure 6 (with the coefficients for model 2 shown in brackets) As can be seen there is little difference between the two sets of coefficients except for the case where the linkage was set at zero to provide the minimum degrees of freedom of one. These coefficients may be interpreted as the number of unit changes in the dependent variable resulting from a unit change in

Table 15

Utilization Model Fit Assessment with Various Free Linkages

FREE											χ^2	d.f.	P
MOD.	BETA LINKS ¹				FREE GAMMA LINKS ²								
<u>(2.1)(3.1)(3.2) (2.1)(2.2)(2.3)(2.4) (3.1)(3.2)(3.3)(3.4)</u> ³													
Basic Models:													
1	X	X	X	X	X	X	X	X	X	X	0.39	1	.530
2	X	X	X	X	X	X	X	X	X	X	0.06	1	.806
Nested Modifications of Model 1:													
3	X	X	X	X	X	X	X	X	X	X	1.04	2	.596
4	X				X		X	X	X	X	2.52	5	.774
Nested Modifications of Model 2:													
5	X		X	X	X	X	X	X	X	X	0.77	2	.682
6		X	X	X	X	X	X	X	X	X	1.04	3	.792
7	X		X		X	X		X	X	X	1.05	4	.902
8	X	X	X			X		X	X	X	1.22	4	.875
9	X		X			X		X	X	X	1.58	5	.903
10	X	X				X		X	X	X	6.76	5	.239
11	X		X			X		X	X	X	1.54	5	.908
12	X	X	X			X		X	X	X	1.26	5	.939
13	X		X			X		X	X	X	1.82	6	.935

¹ Beta coefficients link the endogenous concepts.

² Gamma coefficients link the endogenous and exogenous concepts.

³ The bracketed numbers indicate relationships and direction between the numbered concepts shown in Figure 7. Thus an "X" below free beta (2,1) indicates a free linkage between the job satisfaction concept (2) and the originating utilization concept (1).

Figure 6

Two Basic Structural Equation Models of Utilization
with Maximum Likelihood Estimation Coefficients *

* Coefficients for Model 1 shown outside, and for Model 2, Inside, brackets

the independent (causal) variable. Since the model uses single measures, the measures themselves are affected in this way. The 1.0's shown in Figure 6 linking the concepts with their measures not only link specific indicators to specific concepts but also set the scale on which the values of the underlying concepts (0.180), and, with weaker influences, by organizational structure (0.075), supervisory competence (0.046) and professional responsibility (0.035), in that order. Organizational commitment is are measured. Thus a unit change on the concept is scaled to be the same as a unit change in the indicator. (With multiple measures only one of the measures is linked to its concept with a 1.0 thus designating the scale of the concept.) To assist in interpreting the strength of association, the standardized coefficients linking the endogenous variables and those linking the endogenous and exogenous variables in the case of basic models 1 and 2 are shown in Table 16 (with the coefficients for model 2, where different, shown in brackets). Again there is little difference between the two sets of coefficients. The standardized coefficients provide evidence of the strong associations between utilization and each of the professional responsibility (0.313) and organizational structure (0.486) concepts, with weaker evidence of associations between utilization and the organizational practices (0.089) and supervisory competence (0.122) concepts. A finding that greater responsibility, and particularly supervisory responsibility,

Table 16

Two Basic Structural Equation Models of UtilizationStandardized SolutionsMaximum Likelihood Coefficients for Model 1
(and Model 2 where Different in Brackets)

<u>Between Endogenous</u> <u>Concept Variables:</u>	<u>Utilization</u>	<u>Job</u> <u>Satisfaction</u>	<u>Organizational</u> <u>Commitment</u>
Utilization	.000	.000	.000
Job Satisfaction	.515(.516)	.000	.000
Organizational Commitment	.158(.157)	.245(.249)	.000

<u>Bet. Endogenous</u> <u>& Exogenous Vars</u>	<u>Professl.</u> <u>Responsib.</u>	<u>Organizl.</u> <u>Struct.</u>	<u>Organizl.</u> <u>Practices</u>	<u>Supervis.</u> <u>Competce.</u>
Utilization	.313(.311)	.486(.477)	.089(.085)	.122(.140)
Job Satisfaction	.035(.033)	.075(.073)	.180(.180)	.046(.048)
Organiz. Commit.	.274(.260)	.299(.265)	.014(.000)	.000(.065)

<u>Correlation</u> <u>Matrix</u>	<u>Utilization</u>	<u>Job</u> <u>Satisfaction</u>	<u>Organizational</u> <u>Commitment</u>
Utilization	1.000		
Job Satisfaction	.657	1.000	
Organizatl. Commit.	.637	.592	1.000
Professl. Respons.	.456	.343	.482
Organizl. Struct.	.630	.478	.565
Organizl. Practice	.320	.381	.299
Supervisory Compet.	.468	.356	.424

<u>Correlation</u> <u>Matrix (Cont'd)</u>	<u>Professl.</u> <u>Responsib.</u>	<u>Organizl.</u> <u>Struct.</u>	<u>Organizl.</u> <u>Practices</u>	<u>Supervis.</u> <u>Competce.</u>
Professl. Respons.	1.000			
Organizl. Struct.	.185	1.000		
Organizl. Practice	.281	.273	1.000	
Supervisory Compet.	.231	.514	.123	1.000

<u>Within the Endogenous</u> <u>Variables</u>	<u>Utilization</u>	<u>Job Satis-</u> <u>faction</u>	<u>Organizational</u> <u>Commitment</u>
	.465(.464)	.529(.529)	.446(.450)

leads to greater utilization is perhaps not surprising since those responsible for others are likely to be well occupied by the demands of their staff, if not by their own efforts. Similarly, there is confirmation that a more organic structure, with less centralization, results in greater utilization of professional ability. Job satisfaction is most influenced by utilization (0.515), and through utilization by the four exogenous concepts, as well as directly by organizational practices most strongly influenced by job satisfaction (0.245), and directly by professional responsibility (0.274) and organizational structure (0.299).

Standardized residuals, which are easier to interpret are also shown in the LISREL output, with half of the standardized residuals having a value of -0.634, and the other half 0.632, in the case of basic model 1 (and with half of the standardized residuals having a value of -0.247 and the other half, 0.245, in the case of basic model 2), i.e. the outliers all lay between two-thirds and one-quarter of one standard deviation. The Q-Q plot showed two parallel vertical lines, indicating that the residuals were normally distributed and much less variable than would be expected on the basis of the asymptotic variances used in standardizing the residuals. The standardized output results shown in Table 16 were complemented in the LISREL output by a set of T-values. These are the coefficient estimates divided by their standard errors. T-values greater than 2, providing 95% confidence,

were found in both model 1 and 2 in the case of the linkages between utilization and satisfaction, between utilization and organizational commitment, and between organizational structure and utilization (and between organizational structure and organizational commitment in the case of basic model 1). T-values greater than 1.0 providing 68% confidence were found in the linkages between professional responsibility and each of utilization and organizational commitment, and between organizational practices and job satisfaction (and between organizational structure and organizational commitment in model 2). All of these coefficients were positive, confirming the direction of causality hypothesized, i.e. utilization affects job satisfaction and organizational commitment directly, and utilization affects organizational commitment indirectly through job satisfaction.

Having completed the tests necessary to confirm or reject the hypotheses of this thesis, several modifications to the basic model were tested to find more parsimonious solutions; these models are also listed in Table 15. Nested models of both model 1 and model 2 were developed by fixing additional constraining linkages one at a time (increasing the degrees of freedom by one in the process). This allows use of the fact that the difference between the two chi-squares is also distributed as a chi-square with degrees of freedom equal to the difference between the degrees of freedom for the two models (Hayduk 1987: 164). Models 3 and 4

are nested within model 1, Testing to see if the difference between model 1 and model 4 is significant with four degrees of freedom indicated whether the additional restraints had significantly reduced the model's ability to fit the data. In this case the chi-square difference of 2.13 had a $p \leq 0.250$, so the fit of the model was not significantly hindered by introducing the additional restraints.

The second set of modifications were nested models starting with model 2. There appears to be very little difference in the p-values of models 7, 9, 11, 12 and 13. The same chi-square difference test was applied to model 12 to see if the difference of 1.20 in chi-squares with model 2 was significant with four degrees of freedom, and noted that the observed chi-square has a $p \leq .250$, so the fit of model 2 was not significantly hindered by introducing the additional constraints. Second, testing model 13 to see if the difference of 1.20 in chi-squares with model 12 was significant with one degree of freedom, the observed chi-square had a $p \leq .250$, thus the fit of model 12 was not significantly hindered by introducing the additional constraint of fixing the linkage between utilization and organizational commitment at zero. Model 13 appears to be the most parsimonious model. Figure 7 shows the relationships and coefficients of the parsimonious model 13 of utilization (with the maximum likelihood coefficients of model 12 also listed in brackets for comparison). The fit is extremely good, suggesting that the

Figure 7

Two Parsimonious Structural Equation Models of Utilization
with Maximum Likelihood Estimation Coefficients *

* Coefficients for Model 13 shown outside, and for Model 12, inside, brackets

model's predicted correlation matrix is sufficiently close to the observed correlation matrix for the remaining differences to be mere sampling fluctuations. The probability of 0.935 means accepting the model as adequate with the observed sampling fluctuations appearing in 93.5% of the cases, i.e. a nearly perfect model. An examination of the residuals of model 13 can be made by examining the discrepancies between the observed covariances and the model implied covariances. The smallest fitted residual was -0.167 and the largest was 0.616. The smallest standardized residual was -1.012, and the largest, 1.008, i.e. the outliers are marginally greater than one standard deviation. The Q-Q plot showed a relatively straight line at a slope greater than 45°, indicating that the residuals were normally distributed and less variable than would be expected on the basis of the asymptotic variances used in standardizing the residuals. The standard solution of model 12 is shown in Table 17 (together with that of model 13, in brackets). T-values greater than 2 were found in five of the seven coefficients linking the exogenous and endogenous variables, providing further support for the claims that professional responsibility and organizational structure have a causal effect on utilization, and that organizational practices affect job satisfaction, and that professional responsibility and organizational structure affect organizational commitment. There is a weaker case for claiming that organizational practices and supervisory compet

Table 17

A Parsimonious Structural Equation Model of UtilizationStandardized SolutionMaximum Likelihood Coefficients for Model 13
(and Model 12 where Different)

<u>Between Endogenous</u> <u>Concept Variables:</u>	<u>Utilization</u>	<u>Job</u> <u>Satisfaction</u>	<u>Organizational</u> <u>Commitment</u>
Utilization	.000	.000	.000
Job Satisfaction	.601(.600)	.000	.000
Organiz. Commit.	.000(.147)	.283(.262)	.000

<u>Bet. Endogenous</u> <u>& Exogenous Vars</u>	<u>Professl.</u> <u>Responsib.</u>	<u>Organizl.</u> <u>Struct.</u>	<u>Organizl.</u> <u>Practices</u>	<u>Supervis.</u> <u>Competce.</u>
Utilization	.382(.316)	.507(.490)	.063(.083)	.092(.124)
Job Satisfaction	.000	.000	.188(.189)	.000
Organizl. Commit.	.378(.281)	.375(.303)	.000	.000

<u>Correlation</u> <u>Matrix</u>	<u>Utilization</u>	<u>Job</u> <u>Satisfaction</u>	<u>Organizational</u> <u>Commitment</u>
Utilization	1.000		
Job Satisfaction	.661	1.000	
Organizatl. Commit.	.621(.641)	.583(.582)	1.000
Professl. Respons.	.514(.460)	.362(.329)	.546(.490)
Organizl. Struct.	.639(.634)	.435(.432)	.564(.560)
Organizl. Practice	.320	.381	.316(.308)
Supervisory Compet.	.471(.472)	.307	.388(.381)

<u>Correlation</u> <u>Matrix (Cont'd)</u>	<u>Professl.</u> <u>Responsib.</u>	<u>Organizl.</u> <u>Struct.</u>	<u>Organizl.</u> <u>Practices</u>	<u>Supervis.</u> <u>Competce.</u>
Professl. Respons.	1.000			
Organizl. Struct.	.175(.181)	1.000		
Organizl. Practice	.281(.278)	.273(.274)	1.000	
Superviz. Competce.	.283(.2650)	.520(.519)	.125(.125)	1.000

<u>Within the Endogenous</u> <u>Variables</u>	<u>Utilization</u>	<u>Job Satis-</u> <u>faction</u>	<u>Organizational</u> <u>Commitment</u>
	.416(.459)	.531(.531)	.417(.447)

ence affect utilization. There is relatively little difference between these free coefficients and the same coefficients of the original basic model (with one degree of freedom). Thus the conclusions regarding the strength of association between the concepts remain the same. That is, the strongest causal associations are those from professional responsibility and organizational structure to utilization, from organizational practices to job satisfaction, and from professional responsibility and organizational structure to organizational commitment. The strongest linkages between the endogenous variables link utilization to job satisfaction and job satisfaction to organizational commitment.

A study was carried out to determine the sensitivity of the model fit to variations in the selected error terms. Table 18 lists these tests and the resulting chi-squares (and associated probabilities). As can be noted there is relatively little variation in the chi-square measure of fit, indicating that it is not overly sensitive to the selected error variances.

A sensitivity study was also carried out to determine the effect of choosing different measures for the concepts. Table 19 displays the results which confirm the earlier indications that the underutilization measure (UPA_2) was not compatible with the utilization measure used in the reference and other best fit models. When professional responsibility level (PRFRESP1) was used as the measure of the

Table 18

Sensitivity of Error Measures in the Utilization Model

<u>Indicator</u>	<u>Assessed Portion of Error Variance</u>	<u>Calcul. Error Variance</u>	<u>Modified Error Variance</u>	<u>χ^2</u>	<u>d.f.</u>	<u>R</u>
Repd. Utilization	5%	1.5	1.6	1.78	6	.939
			1.3	1.92	6	.927
Repd. Job Satisfn.	5%	0.3	0.6	1.72	6	.942
			0.1	1.87	6	.931
Organizl. Commitnt.	5%	3.0	5.0	1.82	6	.935
			2.0	1.82	6	.935
Supervisory Level	25%	0.6	0.7	1.07	6	.983
			0.5	2.90	6	.821
Neg. Centralizn.	25%	6.6	8.6	1.41	6	.965
			2.6	2.50	6	.856
Extent Devpt. Progs.	10%	2.3	4.3	1.81	6	.936
			1.3	1.84	6	.935
Managerial Competce.	10%	0.1	0.15	1.82	6	.935
			0.05	1.82	6	.935

Table 19

Effect of Different Measures on Parsimonious Fit
Model of Utilization

<u>Replacement Concept Measures:</u>	<u>χ^2</u>	<u>d.f.</u>	<u>R</u>
Negative Underutilization (UPA_2)	14.81	5	.012
Professl. Resp. Level (PRFRESP1)	7.09	5	.214
Extent of Matrix Work (ORGSTRU3)	2.86	5	.721
Avail. of Supporting Serv.(ORGPRAl)	1.45	5	.919
Appropriate Rewards (ORGPRAl3)	3.08	5	.688
Fairness of Reward Syst. (ORGPRAl4)	2.49	5	.788

professional responsibility concept, there was a significant deterioration in the chi-square measure, showing up the weakness described in subsection 7.2, regarding possible poor assessment of responsibility level. The other four measures appear to be reasonable measures, on the strength of this sensitivity study. Thus, the most consistent measures of utilization and professional responsibility are the utilization of professional ability (UPA_1) and managerial level of responsibility (PRFRESP2). The extent of matrix work (ORGSTRU3) is a useful measure of organization structure in addition to the organic structure measure, negative centralization (N_CENTRZ). The three measures of organizational practices, availability of support services (ORGPRA1), appropriateness of the reward system (ORGPRA3), and fairness of the reward system (ORGPRA4) are suitable additional measures in addition to the extent of development programs (ORGPRA2) which were chosen for the single measure of organizational practices. The importance of these findings is that the description of these concepts can safely be broadened to embody the descriptions in the latter four measures.

7.6 A Multiple Measure Model of Utilization

A model of a multiple measure model of utilization is shown in Figure 8. It maintains the same relationships between the concepts as those in the "parsimonious fit" models (shown in Figure 7). The chi-square (with 64 degrees

Figure 8

A Multiple Measure Model of Utilization
(with Maximum Likelihood Estimation Coefficients)

of freedom) is 96.07 which has a probability of 0.007. This represents a significant lack of fit. The standardized solution shows some values greater than 1.0 in the correlation matrix of endogenous and exogenous variables, indicating that LISREL has produced an invalid model. The T-values table had values greater than 2.0 standard deviations for the relationships between organizational practices and both utilization and job satisfaction, and for the causal link from job satisfaction to organizational commitment (the link from utilization to job satisfaction has a less satisfactory value of 1.4). A number of variations of the linkages between the concepts was tried without improving the chi-square value. The conclusion was that the multiple measure model, using measures that measure a concept differently, is difficult to fit properly. Rather than use multiple measures, it may be more appropriate to use a larger number of concepts and associated measures.

7.7 Summary

The analysis indicates that utilization of professional ability is a predictable concept. As shown in Table 16, the basic structural equation models of utilization explain 46 percent of the variance in utilization scores, and account for 53 percent and 45 percent of the of the variances in job satisfaction and organizational commitment, respectively. There were, however, some unexpected results as well.

Results related to each of the eight propositions hypothesized in Chapter Five are summarized below.

Proposition 1: Professional engineers who remain current with developments in their field of work will experience a greater utilization of their professional ability than those who do not do so.

This proposition was not supported. No evidence was found linking professional competence with utilization.

Proposition 2: Professional engineers who exhibit strong career aspirations will experience a greater utilization of their professional ability than those who have weak career aspirations.

This proposition was partially supported. Two of the three measures of career aspirations showed non-correlations with utilization. However, the third, job motivation, was strongly, positively correlated with utilization.

Proposition 3. Professional engineers holding higher levels of professional responsibility will have greater utilization of their professional ability than those holding positions with lower levels of responsibility.

Professional responsibility was found to be significantly and positively related to utilization. It was also found to be significantly and positively related to organizational commitment.

Proposition 4: Professional engineers working in an organic organizational structure will have a greater utilization of their professional ability than those working in a mechanistic organizational structure.

This proposition was strongly supported. In addition, the finding that engineers working in a matrix structure have greater utilization of their professional ability is of particular interest.

Proposition 5: Professional engineers working in an organization which has professionally oriented human resource practices will experience greater utilization of professional ability than those working in organizations without professionally oriented human resource practices.

This proposition was supported, but weakly.

Proposition 6: Professional engineers whose work is directly supervised by supervisors who demonstrate competence in managing professionals experience greater utilization of their professional ability than those who are supervised by less competent supervisors.

This proposition also was supported, but weakly.

Proposition 7: Professional engineers whose work involves a high level of utilization of their professional ability will experience a higher level of job satisfaction than those whose work involves a low level of professional utilization.

This proposition was very strongly supported.

Proposition 8: Professional engineers whose work involves a high level of utilization of their professional ability will exhibit a greater degree of organizational commitment than those whose work involves a low level of utilization of their professional ability.

This proposition was strongly supported, but the results indicated that the effect of this support is mediated through job satisfaction and organizational commitment.

This research has painted a coherent picture of utilization as a concept that has a useful place in the lexicon of terms for use in organizational management of professional workers. It differs significantly from productivity, and provides a measure of the potential to do work that is not captured by job performance. The research has shown that the finding of previous U.S. studies, that underutilization and

misutilization is a serious problem among U.S. engineers, is applicable to Canadian professional engineers. Utilization is a very strong predictor of job satisfaction for professionals in organizations, and a strong predictor of organizational commitment. Improvement in utilization can result from being assigned greater professional responsibility and through work in a more organic organizational structure. It can also result from improved organizational practices and supervisory managerial competence.

CHAPTER EIGHT

DISCUSSION AND CONCLUSIONS

The purpose of this chapter is to provide an interpretation of the results presented in Chapter Seven. It begins with a discussion of the utilization of professional ability construct. Then the causes and consequences of the utilization of professional ability are reviewed. Next the boundaries of the LISREL model of utilization are analyzed together with some comments on the implications of the results. A discussion of the contributions and limitations of the research follows. The chapter concludes with some suggestions for future research.

8.1 The Utilization of Professional Ability Construct

This research was motivated by the desire to improve the utilization of professional engineers in organizations, with potential benefits to both individual engineers and their organizations. Research on the productivity of professionals, except in quantifiable work such as sales, is difficult to measure. Most measures of job performance are usually determined by the subjective assessment of the employee's direct supervisor, thus it reflects the work objectives of the employing organization. A professional may receive a very high job performance rating, indicating that she or he is performing the organization's defined work to

full satisfaction. Such a rating, however, may not capture the extent of use by the organization of the professional's full ability to perform additional or more creative work for the organization.

The utilization of professional ability is a concept which is measurable, albeit subjectively, from both the organization's and the individual's point of view. It thus provides a broader platform than, but complementary to, job performance. It provides an assessment of the individual's ability to carry out work different from that in the formal job description. A 1986 survey, based on the responses by 3,868 engineers, concluded that "American engineers are highly under-utilized ... (and) ways must be found to improve the utilization of engineers if the United States is to retain a favored technological position in the arena of world-wide competition." (AAES 1986: 1). This 1986 Survey found that several factors were major contributors to the under-utilization of engineers: management interactions, extent of support services, amount of continuing development available, and information sources available to the individual engineer.

This thesis has sought to build on the American work by assessing the extent of underutilization of engineers in Canada, and to examine its causes and consequences. Thus the managerial problems being addressed were "how can more effective utilization of professional ability be achieved?" and

"does greater utilization of professional ability lead to greater job satisfaction and greater organizational commitment?" The findings of this survey confirm that, like their U.S. colleagues, a significant percentage of Canadian engineers feel that their professional ability is underutilized.

While the population for the U.S. study only included engineers who had stayed in the technical field and who were employed in private industry, the population used for this study included all the members of the Professional Engineers of Ontario. This body of professionals is engaged in a wide variety of work functions and industries, and includes supervisory engineers at all levels. The measure developed for the U.S. study was based on the individual's own assessment of his or her professional utilization. It was the sum of a number of scaled questions regarding the extent to which the item was characteristic of the work environment. Some of these questions were adapted for Canadian professional engineers. The resulting 10-item utilization measure (Cronbach's Alpha = 0.91) was thus essentially the same as the U.S. study's Engineering Utilization Index's (EUI) 15-item measure (Cronbach's Alpha = .87). All of the ten items of the utilization scale contributed equally to the scale.

The generalizability of the utilization scale was examined by looking at the age of respondents. As was found in the 1986 Survey, there was not a significant difference in utilization based on age. While a review of the answers to

questions provided by the females in the sample did not indicate any notable differences with the rest of the sample, the small number of females in the population and in the sample did not permit a statistical determination of possible differences. Other differences, such as the level of professional responsibility and of managerial responsibility were addressed as causal factors of utilization. It is important to recognize that utilization is a relative measure and is concerned with measuring differences in the utilization of whatever ability an individual possesses; it does not measure differences in ability *per se*.

While a thorough analysis of measurement issues can help to refine definitions, a construct takes its meaning from the network of relationships within which it exists. The conditions that result in utilization and the results of such utilization, also provide a context for interpreting the utilization of professional ability.

8.2 The Causes of Utilization of Professional Ability

Why are the abilities of professionals under-utilized? The results of the basic utilization models described in Chapter Seven provide strong support for the claim that the assignment of greater professional responsibility, and working within an organic organizational structure contribute to greater utilization of professional ability. There was also support, but weaker, for the claims that engineers working in

an organization which has professionally oriented human resource practices, and whose work is supervised by supervisors who demonstrate competence in managing professionals, experience greater utilization of their professional ability.

The hypothesis that professional engineers, who remain academically current with developments in their field of work to enhance their competence, experience a greater utilization of their professional ability was not supported. The five measures chosen for this concept showed insignificant correlations with the measures of utilization. There was thus no case for suggesting that professionals with greater competence are utilized more than those with less competence, while those with less competence are utilized less.

The hypothesis that professional engineers who exhibit strong career aspirations will experience a greater utilization of their professional ability than those who have weak career aspirations was partly supported. One of the three measures of career aspirations, job motivation, was strongly and positively correlated with utilization. However, the other two measures showed insignificant correlations with utilization.

Despite the lack of support for the professional competence hypothesis and the weak support for the career aspirations hypothesis, it seems that the utilization of professional ability is a reasonably predictable construct based on the model of utilization which was tested and found

to explain 46% of the variance in utilization scores. The four organizationally oriented hypotheses were supported: those individuals who are assigned greater professional responsibility, who work in an organization which has an organic structure or in a matrix structure, and which has supportive organizational practices, and who report to a competent supervisor, exhibit greater utilization of their professional abilities.

8.3 The Consequences of Utilization of Professional Ability

Does greater utilization of professional ability result in greater job satisfaction? And does greater utilization of professional ability result in greater organizational commitment? The results of the utilization model provide strong support for a positive link between utilization and job satisfaction. While a longitudinal study of the degree of utilization of professional ability would be required for a stronger test of the consequences of utilization, the finding that utilization leads to job satisfaction is consistent with other research on job satisfaction reported in Chapters Four and Five.

The possible effect of the utilization of professional ability on organizational commitment was also studied. It was hypothesized that utilization directly and positively affects organizational commitment, and this was confirmed. This study also found that organizational commitment is a

direct outcome of job satisfaction, and thus is also indirectly affected by utilization through job satisfaction.

Possible direct effects by the exogenous variables on job satisfaction and on organizational commitment were hypothesized and were also investigated. A strong direct effect of organizational practices, and to a lesser extent of organizational structure and supervisory competence, on job satisfaction was found. These effects are, however, weaker than the direct effect of utilization on job satisfaction.

Strong direct effects of the exogenous variables professional responsibility, organizational structure and supervisory competence on organizational commitment were found. The only strong effect by a variable on job satisfaction was from organizational practices.

8.4 The LISREL Models of Utilization

The LISREL models of utilization provided a comprehensive method for studying the simultaneous effect of a number of exogenous concepts on utilization, and of the effect of the utilization concept on other endogenous concepts.

The two basic models of utilization had highly significant chi-squared fits ($p = 0.806$ and $p = 0.530$ and root mean square residuals of 0.080 and 0.049). The variances explained were 46 percent for the utilization measure, 53 percent for the job satisfaction measure and 45 percent for the organizational commitment measure. Thus, almost half the

variance in utilization and organizational commitment (and more than half for job satisfaction) is thus explained by the relationships in the model. The LISREL model, due to its flexible specification in terms of fixed and free parameters, together with the availability of overall measures of fit such as the chi-square value permits a convenient way of studying the total model hypothesized. It facilitates the inclusion of the errors in the measurement of the variables, in a way that is difficult to do with multiple regression models. This is particularly true when using the model with single measures. Use of the alternative path analysis approach would require the assumption that each factor was measured without error, which is an unrealistic assumption in this case, as it usually is in much social science research. The LISREL approach used amounts to an "errors in variables" analysis, which cannot be analyzed using ordinary least squares. Using LISREL is an appropriate way of implementing an "errors in variables" analysis.

The LISREL model also permits a study of the benefit, if any, of improvements to the hypothesized model. Parsimonious fit models were investigated by fixing the direct effects of certain variables. A very parsimonious model was found when the direct linkage between utilization and organizational commitment was dropped as a causal factor (but the indirect link through job satisfaction retained), and other links retained only between organizational practices and job satis-

faction, and between each of professional responsibility and organizational structure, on the one hand, and organizational commitment, on the other. The variance explained by the parsimonious model increased for utilization (from 46% to 58%) and for organizational commitment (from 45% to 58%), but decreased for job satisfaction (from 53% to 47%).

8.5 Implications of the Research

The findings regarding the causes and consequences of the utilization of professional ability have implications for our understanding of utilization.

The results are significant for organizations employing professionals, and for employed professionals. The results provide answers to the managerial problems which motivated this thesis. This research suggests that more effective utilization can be achieved by providing professionals with greater responsibility (be it professional or managerial, but commensurate with ability), and by providing an organic organization structure in which to work. It also suggests the importance of supporting professionals with professionally oriented organizational practices including: adequate supporting staff and services, support or provision of continuing development programs, appropriate reward systems for professionals, fair promotions, and adequate professional compensation based on responsibility. Finally, more effective utilization can also be achieved by training

all professional engineers to use their supporting staffs more effectively, where it is provided, and by training supervisors, and especially professional supervisors, to become more competent managers of professionals. This means ensuring that credit is given for work, that the opportunity is provided to broaden the scope of work, that decision-making and corresponding authority is delegated, that supervision is general (rather than close), and that supervised professionals are allowed to participate in establishing their work responsibilities. These are actions that are within the scope of organizations employing and managing professionals.

Answers to the question of more effective utilization should be of interest to educational institutions, such as faculties of engineering and schools of business, which are preparing professionals to become more effective future managers. (They could, for example, collaborate to establish undergraduate concentration in management options, and even- ing diplomas in engineering management.) The answer is also of value to Canadian professional engineering organizations, such as the Canadian Council of Professional Engineers (CCPE) and its major committees, the Canadian Engineering Accreditation Board and the Canadian Engineering Qualifications Board, and provincial associations, such as the Professional Engineers of Ontario, all of which are responsible for determining, and particularly for enhancing, the competence of

professional engineers, including the management of professional engineering work. (They could, for example, insist that management subjects are included in the undergraduate engineering curricula.) The results are of benefit to government decision makers responsible for labour and industrial legislation and its implementation, since improvements in utilization of professional engineers can bring economic benefits to the nation. (They could, for example, permit engineers employed in organizations to deduct part of the cost of participating in CEQB approved professional development seminars from their taxes, as is now allowed for doctors in private practice.) Finally, the results are of particular benefit to professional engineers, by providing an understanding of how to improve their own utilization, through on, and off, the job training, and, if they are managers of other engineers, of the importance of improving the utilization of their fellow engineers.

This research provides a positive answer to both aspects of the second managerial question: "Does greater utilization of professional ability lead to greater job satisfaction and organizational commitment?" This result is important to organizations employing professionals since it indicates that the utilization of professional ability is a major factor in job satisfaction and in organizational commitment. There is a high cost of turnover, both in the loss of dissatisfied, experienced engineers and in the cost of training replacement

engineers. The system of rewards and work practices needs to consider the different needs of professionals and non-professionals. The large number of downsizings of organizations in recent years is straining the concept of organizational commitment by professionals, who see that organizations are only too ready to release staff with downturns in business cycles. Organizations which permit the full use of the abilities of their professionals should find greater organizational commitment among the professionals so treated. The specific recognition by individual professionals that it is through the utilization of their professional abilities that they can achieve more job satisfaction, allows them to focus their demands on more challenging work assignments.

8.6 Contributions and Limitations of the Thesis

The primary contribution of this thesis is to enhancing our understanding of the utilization of professional ability, and specifically that of Canadian professional engineers working in an organizational setting. While other Canadian studies have focussed on productivity and job performance, this study addresses the causes and consequences of the utilization of professional ability.

This thesis enhances the results of previous U.S. studies, especially the 1986 Utilization Survey (AAES 1986), described in Chapter Two, which was based on a *post hoc* synthesis of the results of the questionnaire survey. In the

present study, an *a priori* model was specified and tested. The hypotheses to be proven were set out, and the results have confirmed the four organizationally-related hypotheses, and, partially, one of the two personally-related hypotheses, in the form of a model of utilization which could be used to predict the extent of utilization of professional ability in organizations. The model, while tested on professional engineers in Ontario, should be applicable to all Canadian professional engineers, and, in fact, to American engineers.

Like any research, this thesis is subject to some limitations. Financial support was sought unsuccessfully from several private and government sources to carry out a mail survey of 1 percent of the engineering population in Ontario (600 persons). Private funds and a welcome research grant from Carleton University only supported a mail survey of half this number with a single follow-up. The larger survey would have at least doubled the number of responses, assuming the same rate of response, to about 275 (and to 350-400 with second and third follow-ups), and provided the opportunity to carry out tests with subgroups (such as industry, discipline and functional area), something that was not possible with the sample size obtained. Nevertheless, a sample of over 100 provides a reasonable size to test the LISREL model and the corresponding hypotheses using chi-square statistics (Bearden, Sharma and Teel 1982).

The LISREL modelling format provides an indication of

the direction of causality as commented upon in Chapter Seven and in Appendix 9. Thus the LISREL model suggests that utilization is a "cause" of job satisfaction rather than the reverse. However, since the research is not longitudinal in design, causal inferences cannot be made formally. The results showed that improved utilization does result from higher levels of professional responsibility, an organic organization structure, professionally oriented organizational practices, and supervisory competence.

It has been noted in Chapter Seven that the younger engineers did not respond to the randomly sampled survey in proportion to their number in the population. While this did not affect the basic model, because utilization was found to be relatively insensitive to age, it precluded analyses of the sensitivity of factors other than utilization to age.

Finally, in spite of running numerous models of utilization, the full benefit of exploring the LISREL model was not exhausted. While several models which included multiple measures were analyzed, the fits were not as satisfactory as were those obtained with single measures. An improvement in the effectiveness of the measures may have provided a more satisfactory fit for the multiple measure models.

8.7 Suggestions for Future Research

The utilization of professional ability is a useful concept on which to base future studies of the work of pro-

professionals in organizations. The basic measures used for each of the concepts studied provide a useful base for such further work. The questionnaire results also provide useful information with which to improve the other measures.

A larger survey of Canadian engineers, with improvements to the questionnaire, is warranted. Such a survey, which would require translation of the survey instrument into French for Quebec engineers, could provide useful information regarding details of the organizational work environment which are not captured in present annual salary surveys, which only include demographic questions.

Another extension would be to test the model of utilization of professional ability in organizations with professionals other than engineers, such as nurses, doctors and accountants working in organizational environments.

A contribution of this research has been to confirm that the problem of underutilization of American engineers applies to professional engineers in Canada. The research has also developed and tested a model of utilization of professional ability in organizations which can be used to predict utilization, job satisfaction and organizational commitment. The research has also made a modest contribution through its review of the literature on the utilization of professional engineers in organizations, and on the practice of professional engineering itself.

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APPENDIX 1

RESEARCH PROPOSITIONS

Proposition 1: Professional engineers who remain current with developments in their field of work will experience a greater utilization of their professional ability than those who do not do so.

Proposition 2: Professional engineers who exhibit strong career aspirations will experience a greater utilization of their professional ability than those who have weak career aspirations.

Proposition 3. Professional engineers holding higher levels of professional responsibility will have greater utilization of their professional ability than those holding lower levels of responsibility.

Proposition 4: Professional engineers working in an organic organizational structure will have a greater utilization of their professional ability than those working in a mechanistic organizational structure.

Proposition 5: Professional engineers working in an organization which has professionally oriented human resource practices will experience greater utilization of professional ability than those working in organizations without professionally oriented human resource practices.

Proposition 6: Professional engineers whose work is directly supervised by supervisors who demonstrate competence in managing professionals experience greater utilization of their professional ability than those who are supervised by less competent supervisors.

Proposition 7: Professional engineers whose work involves a high level of utilization of their professional ability will experience a higher level of job satisfaction than those whose work involves a low level of professional utilization.

Proposition 8: Professional engineers whose work involves a high level of utilization of their professional ability will exhibit a greater degree of organizational commitment than those whose work involves a low level of utilization of their professional ability.

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3 March, 1995

Dear Engineer:

I am asking you to participate in a major study of professional engineers' work. The results will be, I believe, of interest and value to you.

Professional engineers play a very significant role in their organizations. Most of the research in this field has been done from an organizational, human resource viewpoint but there is evidence that the views of professional engineers, including managers, may not be the same. A study from the viewpoint of engineers can provide significant benefits to individual engineers, as well as to their organizations, especially if it leads to more effective use of their professional ability. The results will be made available to you through the PEO's journal, Engineering Dimensions.

You may be assured of complete anonymity. There is no way to identify the person returning a questionnaire. The survey procedure has been approved by the Ethics Committee of Carleton University, and the PEO's Executive Committee has approved the use of the membership list to conduct this survey. Your name is being selected by PEO in a random sampling and mailing of questionnaires is being carried out directly by PEO without releasing your name. The study itself, however, is being conducted independently of PEO. If you have any concerns please contact me or Professor L. Dyke at the School of Business.

It is extremely important that each questionnaire be completed as fully as possible, and returned promptly in the postage-paid envelope, to ensure that the results reflect the experience of all professional engineers. Your participation is essential to the success of this study. The valuable time which you spend in completing the questionnaire (about 25 minutes) is much appreciated. Thank you very much for participating.

A handwritten signature in cursive script that reads "Derek B.A. Chase".

Derek B.A. Chase, P.Eng.

APPENDIX 3

CONCEPTS AND INDICATORS

A. THE PRINCIPAL ENDOGENOUS CONCEPT: UTILIZATION OF PROFESSIONAL ABILITY (U_{PA}) (Concept Notation: η_1)

A 1.1 First Indicator: Reported Utilization of Professional Ability (Modified Engineering Utilization Index (AAES 1986)

Number of items: 10

Range: 4 - 40 (Sum of Characteristic replies only)

Please indicate the importance to you personally and the extent it is characteristic of your work environment of the following descriptions:

Importance to You				Characteristic of Your Work Environment			
Personally							
1	2	3	4	1	2	3	4
<u>None/Some/Very/Extremely</u>				<u>None/Some/Very/Extremely</u>			

- (a) Use of your overall professional competence
- (b) Proper utilization of your education and training
- (c) Match between job requirements and your capabilities
- (d) Challenging personal work assignments
- (e) Chance to evolve new ideas and methods
- (f) Opportunity to achieve your personal goals
- (g) Chance for personal advancement and growth
- (h) Chance to achieve your full potential
- (i) Chance to make use of your abilities and skills
- (j) Chance to do the kind of work you do best.

A 1.2 & A 1.3 Second and Third Indicators: Negative Underutilization and Negative Misutilization

Number of items in each: 3

Underutilization = (light intellectual demands + light time demands + light amount of work), thus

Underutilization is sum of three sub-scales:

- (i) (light intellectual demands) sub-scale (c) items 1,2,3 scored 1,2,3; items 4-7 scored 0
- (ii) (light time demands) sub-scale (b) items 1,2,3, scored 1,2,3; items 4-7 scored 0
- (iii) (light amount of work) if sub-scale (a) item 1 is chosen, double scores in (ii), if item 2 is chosen, multiply scores in (ii) by 1.5, else multiply scores in (ii) by 1.0

Underutilization Range: 0 - 12

Misutilization = (light intellectual demands + heavy time demands + heavy amount of work), thus
Misutilization is sum of three sub-scales:

- (i) (light intellectual demands) sub-scale (c) items 1,2,3, scored 1,2,3; items 4 - 7 scored 0
- (ii) (heavy time demands) sub-scale (b) items 5,6,7, scored 3,2,1; items 1 - 4 scored 0
- (iii) (heavy amount of work) if sub-scale (a) item 5 is chosen, double scores in (ii), if item 2 is chosen, multiply scores in (ii) by 1.5, else multiply scores in (ii) by 1.0.

Misutilization Range: 0 - 12

Negative underutilization and negative misutilization scales were computed as reverse scores.

- (a) Reported Amount of Work (First of the four questions in the Amount of Work sub-scale of the Index of Organizational Reactions (Smith, 1976) with first item changed)

How do you feel about your workload?

- 1. I almost always prefer to do more work
- 2. I often prefer to do more work
- 3. It is neither too light nor too heavy
- 4. It is often too heavy
- 5. It is almost always too heavy

- | | Extremely
Light | Slightly
Light | Slightly
Heavy | Extremely
Heavy | | | |
|---|--------------------|-------------------|-------------------|--------------------|---|---|---|
| (b) How would you rate the <u>time demands</u> of your present job? | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| (c) How would you rate the <u>intellectual demands</u> of your present job? | 1 | 2 | 3 | 4 | 5 | 6 | 7 |

A 1.4 Fourth Indicator: Efficient Use of Time

Number of items: 1

Scale: 100 minus item (a)

Range: 0 to 100

- (a) What percent of your time is spent on work that could be done by someone with less training? ____% of my work time

A 1.5 Fifth Indicator: Time on Original Work

Number of items: 1

Scale: 100 minus item (a)

Range: 0 to 100

- (a) How much of your work time is spent doing work which you have not done before? ____% of my work time

B. THE EIGHT EXOGENOUS CONCEPTS:

B 1. PROFESSIONAL COMPETENCE (Concept Notation: ξ_1)

B 1.1 First Indicator: Reported Recent Academic Education

Number of items: 4

Dichotomous scale: If any Yes score 2, else score 1

Range: 1,2

During the past TWO YEARS have you completed any of the following: university or college courses			No.of Courses
	No	Yes	If yes
(a) Non-degree-credit technical?	1	2	—
(b) Non-degree-credit non-technical?	1	2	—
(c) Technical leading to graduate degree?	1	2	—
(d) Non-tech. leading to graduate degree?	1	2	—

B 1.2 Second Indicator: Years Since Bachelor's Degree

Number of items: 1,

Scale is survey year, i.e. 1995, minus Year of
Bachelor's degree

Range: 2 - 70

B 1.3 Third Indicator: Reported Highest Degree achieved

Number of items: 3,

Scale: If no "Yes" responses for Items (a), (b) or (c)
score 2, else score 1.

Range: 1,2

(a) Any graduate degrees?	No	Yes
(a) MAsC, MEng	—	—
(b) MBA	—	—
(c) PhD (Engineering)	—	—
(d) Other (specify)	—	—

B 1.4 Fourth Indicator: Reported Effort Keeping Up-to-Date

Number of items: 1

Range: 0 - 100

Approximately what percent of your total work time do
you devote to keeping up-to-date in your field of work?
_____ % of the time.

B 1.4 Fifth Indicator: Professional Achievements

Number of items: 3,

Scale: If no "Yes" responses for Items (1), (2) or (3)
score 2, else score 1.

Range: 1,2

Have you ever:	No	Yes	No.
(1) Written technical articles and had them published in a professional journal?	1	2	—
(2) Made a major contribution to a device, product or process innovation?	1	2	—
(3) Disclosed, applied for, or received a patent?	1	2	—

B 2. CAREER ASPIRATIONS (Concept Notation: ξ_2)

B 2.1 First Indicator: Reported Career Aspirations

Number of items: 3, each scored 1 to 7

Range: 1 - 7

Strongly Disagree	1	2	3	4	5	6	7	Strongly Agree
Would you like your career to be:								
A progression up the managerial ladder to a higher-level position?								

B 2.2 Second Indicator: Reported Job Motivation (Job Motivation Index, Item 2 only, modified, Patchen, Pelz and Allen, 1965)

Number of items: 1, scored 1 to 5

Range: 1 - 5

Some people are completely involved in their job - they are absorbed in it night and day. For other people their job is simply one of several interests. How involved do you feel in your job?

- _____ Very little involved in my job; very strongly involved in my other interests
- _____ Slightly involved in my job; strongly involved in my other interests
- _____ Moderately involved in my job; my other interests are equally absorbing to me
- _____ Strongly involved in my job; slightly involved in my other interests
- _____ Very strongly involved; my work is the most absorbing interest in my life.

B 2.3 Third Indicator: Reported Attendance at Professional Meetings

Number of items: 2

Scale: If no "Yes" responses for Items (1), (2) or (3) score 2, else score 1.

Range: 1, 2

During the past TWO YEARS have you: No Yes Number

(1) Attended PEO branch or committee meetings?	1	2	—
(2) Attended other professional society meetings?	1	2	—

B 3. PROFESSIONAL RESPONSIBILITY (Concept Notation: ξ_3)

B 3.1 First Indicator: Reported PEO Level of Professional Responsibility

Number of items: 1, scored 1 to 7

Range: 1 - 7

What is your present PEO (APEO) Level of Professional Responsibility?

- ☐ Level A: Engineer-in-Training
- ☐ Level B: 2 - 3 yrs. experience, work under close supervision
- ☐ Level C: Min. 3 - 5 yrs. experience, fully qualified level, make independent studies
- ☐ Level D: Min. 5-8 yrs. experience, first level of full specialization or of direct supervision of other engineers, decisions accepted as accurate
- ☐ Level E: Min. 9 - 12 yrs. experience, specialist in field, or knowledge of more than one field, authority over small group of professionals in complex applications, or supervision of large groups, make decisions, except those involving large sums of money, or long range objectives
- ☐ Level F: Broad experience, including administrative duties, or recognized authority in an engineering field, conceive programs and problems to be investigated, make decisions on all matters, including establishment of policies and expenditure of large sums of money
- ☐ Level F+: Hi degree of originality, skill and proficiency, plan and approve projects requiring the expenditure of large amounts of human resources and financial investment, long range planning and far-reaching management decisions

B 3.2 Second Indicator: Reported Level of Direct Supervisory Responsibility

Number of items: 1, scored 1 to 6

Range: 1 - 6

If direct supervision is defined as having direct responsibility for staff performance reviews and salary reviews, what is your responsibility? (One only)

- ☐ No direct supervisory responsibility
- ☐ No direct supervisory responsibility but project or team leader

- ___ First level of direct supervision
- ___ Direct supervision of lower management
- ___ Direct supervision of middle management
- ___ Direct supervision of upper management

B 4. ORGANIZATIONAL STRUCTURE (Concept Notation: E₄)

B 4.1 Main Indicator: Reported Extent of Organic Management

Number of items: 5

Sum of z-scores of five sub-scales:

(1) Vertical Complexity Sub-Scale: Item a(1) + a(2).

Range: 0 - 10

(2) Horizontal Complexity Sub-Scale: Item (b)(5).

Range: 1 - 7

(3) Spacial Complexity Sub-Scale: Item (b)(6).

Range: 1 - 7

(4) Formalization Sub-Scale:

Sum of Items (b)(1), (b)(2), (b)(3).

Range: 3-21

(5) Centralization Sub-Scale:

Sum of Items (b)(4), (b)(7), (b)(8), (b)(9), & (c).

Range: 5 - 35

Overall Range: 5 x (-3.5 to + 3.5)

(a) Levels of Supervision

(1) How many levels of direct supervision are there between you and the chief executive?

0 1 2 3 4 5 6 7+

(2) How many levels of direct supervision are there below you in your organization?

0 1 2 3 4 5 6 7+

To a Small
Extent

To a Great
Extent

1 2 3 4 5 6 7

(b) In your work unit or group, to what extent:

(1) are rules, procedures and standards used?

(2) is there freedom to use one's discretion?

(3) is there standardization of the work?

(4) are the important decisions made by
top executives?

(5) do persons perform highly specialized
tasks?

(6) are personnel with whom you deal with
regularly, geographically dispersed?

- (7) is there regular, trustworthy feedback on your group performance?
 (8) is there free communication downward from more senior management to you?
 (9) is there free communication upward from you to more senior management?

(c) What is the management style of your organization:	Highly autocratic				Highly democratic		
	1	2	3	4	5	6	7

B 4.2 Second Indicator: Reported Organic vs. Mechanistic Design Configuration (Mintzberg's Five Design Configurations, Mintzberg, 1983)
 Number of items: one, Item (b).

If answer is 1 or 5, then = 1 (Organic), else if 2, 3, or 4, then = 2 (Mechanistic)
 Range: 1 - 2

A Canadian engineer has proposed that there are five basic parts to any organization:

1. The *Operating Core* includes employees who perform the basic work related to the production of goods and services,
2. The *Strategic Apex* includes the top-level managers who have overall responsibility for the organization,
3. The *Middle Line* includes the managers who connect the Operating Core with the Strategic Apex,
4. The *Technostructure* includes the analysts who establish the procedures and practices for the organization, and
5. The *Support Staff* provide indirect services for the organization.

(a) In which of the five parts would you place yourself? _____

(b) In your organization which is the dominant part? _____

B 4.3 Third Indicator: Reported Amount of Work in a Matrix Team Structure
 Number of items: 1
 Range: 1 - 6

In a matrix structure, individuals have two bosses, a functional department manager, and a project manager. Do you work as a project leader or manager or member of a matrix team?

- (1) Never _____ (2) Seldom _____ (3) Sometimes _____
 (4) Often _____ (5) Almost Always _____ (6) Always _____

B 5. ORGANIZATIONAL PRACTICES (Concept Notation: ξ_5)**B 5.1 First Indicator: Availability of Support Services**

Sum of items (a)(1), (a)(2), & (a)(3), each 1 - 7:

plus Item (b): if (b)(1) = "No", score 1, if (b)(1) = "Yes", score (b)(2) = (% of time) + 7

Range: 4 - 28

	To no					To a Great	
	Extent					Extent	
1	2	3	4	5	6	7	

(a) To what extent does your organization provide you with support:

(1) with technical (e.g. computers) problems?

(2) with administrative and personnel matters?

(3) with routine clerical (e.g. filing) work?

(b) (1) Do you have, or share, an assistant (e.g. secretary or administrative assistant)? No Yes

(2) By how much is your effectiveness increased? by ___ %

B 5.2 Second Indicator: Reported Extent of Development**Programs**

Number of items: 7

Scale: sum of score on items (a)(1), (a)(3), and (a)(5) to (a)(7)

Range: 5 to 35

	To a Small					To a Great	
	Extent					Extent	
1	2	3	4	5	6	7	

(a) To what extent have the following improved your work effectiveness?:

(1) job related training courses

(2) external general education courses

(3) meetings and conferences

(4) reading of publications

(5) on-the-job colleague interaction

(6) on-the-job problem solving

(7) learning new computer software

B 5.3 Third Indicator: Reported Fairness of Performance**Evaluations**

Number of items: 4, a composite of one (a) and three

(b) items:

If (a)(1) = "No", then score = 0

If (a)(2) = "Yes", score = sum of items

(b)(1), (b)(2), & (b)(3), each scored 0 for "No" and 1 for "Yes", else score = 0

Range: 0 - 3

(a) Is your performance evaluated formally? No ____ Yes ____

(b) If yes: No Yes
 is the evaluation based on the
 results of your work? ____ ____
 is your career discussed? ____ ____
 do you participate actively? ____ ____

B 5.5 Fourth Indicator: Reported Fairness of Reward System

Composite scale is sum of 2 items:
 (a)(1) & (a)(2), scored 1 to 7
 Range: 2 - 14

	To a Small Extent					To a Great Extent	
	1	2	3	4	5	6	7
(a) In your organization, to what extent:							
(1) is the reward system fair and equitable?							
(2) are promotions based on competence?							

5.6 Fifth Indicator: Salary Differential with PEO Survey

Number of items: 2, Item (a), is compared with the salary deciles and quartiles for the same Bachelor's degree year, item (b) and scored 1 to 6
 Range: 1 - 6

(a) What was your total base salary in 1994 \$ _____
 (i.e. excluding non-cash benefits)?

(b) If you have a Bachelor's degree:
 In what year did you graduate? 19____

B 6. SUPERVISORY COMPETENCE (Concept Notation: ξ_6)

B 6.1 First Indicator: Reported Degree of Technical and People Leadership

Number of items: 2, each scored 1 to 5
 Range: 2 - 10

If you report to a direct supervisor (i.e. one who has direct responsibility for your performance and salary reviews), how would you rate your direct supervisor?

	Well Below <u>Average</u>	Below Average	Average	Above Average	Well Above <u>Average</u>
As a manager of people	1	2	3	4	5
As a technical leader	1	2	3	4	5

B 6.2 Second Indicator: Reported Extent of Delegation

Number of items: 6, each scored 1 to 5

Range: 6 - 30

Does your direct supervisor: Never Seldom Some- Often Almost
times Always

(1) ensure that you receive credit for your work?	1	2	3	4	5
(2) provide you with opportunity to broaden the scope of your work?	1	2	3	4	5
(3) allow you to make the decisions which you feel are necessary?	1	2	3	4	5
(4) delegate enough authority to match your assigned responsibility?	1	2	3	4	5
(5) exercise general (rather than close) supervision of your work?	1	2	3	4	5
(6) allow you to participate in establishing your work responsibilities?	1	2	3	4	5

C. THE TWO OUTCOME ENDOGENOUS CONCEPTS**C 1. JOB SATISFACTION (Concept Notation: η_2)****First Indicator: Reported Job Satisfaction** (Scarpello & Campbell, 1983)

Number of items: 1, Item (4), scored 1 to 6

Range: 1 - 6

Second Indicator: Reported Work Satisfaction

Number of items: 3, items (2),(3),(5)

Range: 3 - 18

All things considered how satisfied are you with:	Very Dis-satisfied	Dis-satisfied	Neutral	Satisfied	Very satisfied	Extremely satisfied
(1) Your career choice	1	2	3	4	5	6
(2) Your career progress	1	2	3	4	5	6
(3) Your present employer	1	2	3	4	5	6
(4) Your present job	1	2	3	4	5	6
(5) Your present pay	1	2	3	4	5	6

C 2. ORGANIZATIONAL COMMITMENT (Concept Notation: η_3)**C 2.1 First Indicator: Reported Organizational Commitment Questionnaire** (Short Form, 9 out of 15 items, Porter and Smith, 1970)

Number of items: 6, each scored 1 to 7

Range: 6 - 42

of/de

PM-1 3½"x4" PHOTOGRAPHIC MICROCOPY TARGET
NBS 1010a ANSI/ISO #2 EQUIVALENT

PRECISIONSM RESOLUTION TARGETS

Please indicate the extent of your disagreement or

Disagree	Neutral	Agree	Strongly agree
1	2	3	4
5	6	7	

I am willing to put in a great deal of effort in order to help my organization be successful

I would accept almost any type of job assignment in order to keep working for my organization

I find that my values and my organization's values are very similar

I am proud to tell others that I am part of my organization

My organization really inspires the very best in me in the way of job performance

For me this is the best of all possible organizations for which to work.

C 2.2 Second Indicator: Reported Unpaid Overtime

Scale is sum of items (3)(a) & 4

Range: 0 - 40

- (1) What are your organization's regular working hours per week? Hrs/Week
- (2) On average how much time do you actually spend at your office each week? Hrs/Week
- (3) If you regularly work overtime on average how much is:
 (a) Unpaid overtime?..... Hrs/Week
 (b) Paid overtime? Hrs/Week
- (4) How much additional time on average do you spend at home each week on work-related matters? Hrs/Week

D. THE DEMOGRAPHIC DESCRIPTORS

D 1. What is your current employment status?

- ___ Full-time employee
- ___ Part-time employee
- ___ Contract or term employee
- ___ Self-employed
- ___ Owner - manager
- ___ Not currently employed
- ___ Other (please specify) _____

D 2. What industry do you work in?

1 Durable manufacturing	11 Resources industry
2 Non-durable manufacturing	12 Construction industry

- 3 Educational institutions 13 Research laboratories
 4 Federal government 14 Engineering consulting
 5 Prov'l/ Terr'l governments 15 Health/ Social services
 6 Municipal/Reg'l governments 16 Transportation
 7 Telecom or computer services
 8 Utilities (electrical, gas, water, telephone)
 9 Commerce, Finance, Insurance or Real estate
 10 Other (please specify) _____

D 3. Would you say your work function is:

- _____ entirely technical
 _____ primarily technical
 _____ half technical, half non-technical
 _____ mainly non-technical but technical background needed
 _____ mainly non-technical - technical background not needed

D 4. What functional area best describes your principal activity at work?

_____ Research - basic or applied	_____ Business management
_____ Development - product or system	_____ Corporate planning
_____ Design - product or system	_____ Project planning
_____ Computer services and systems	_____ Project management
_____ Manufacturing	_____ Administration
_____ Plant operation/ production	_____ Economics
_____ Quality control	_____ Marketing, sales
_____ Construction	_____ Purchasing
_____ Exploration	_____ Legal Services
_____ Teaching	_____ Personnel
_____ Finance	_____ Accounting
_____ Public relations	_____ Other

D 5. What is the discipline of:

	Your undergraduate education	Your graduate education	Your current work
Not Applicable	_____		
Chemical	_____	_____	_____
Civil (incl. Construction)	_____	_____	_____
Systems & Computers	_____	_____	_____
Electrical & Electronics	_____	_____	_____
Petroleum & Geological	_____	_____	_____
Industrial	_____	_____	_____
Mechanical & Aerospace	_____	_____	_____
Mining & Metallurgical	_____	_____	_____
Business administration	_____	_____	_____
Other	_____	_____	_____
(please specify) _____			

D 6. Is your organization a multinational corporation?

No Yes
 1 2

If yes, is the head office in Canada?

1 2

D 7. Approximately how many persons,
are employed in your organization?

0 1-5 6-25 26-100 101-500 501-1000 1001+

(1) Total outside Canada

(2) Total in Canada

(3) Total in your plant or office?

D 8. Did you obtain your Bachelor's
degree in Canada? No ☐ Yes ☐ No degree ☐

D 9. In what year were you born? 19____

D 10. Are you Female ☐ Male ☐

D 11. Extent of Job Mobility and Variation

Since becoming a P.Eng.:

(1) How many organizations have you worked in? ____

(2) How many functional areas have you worked in? ____

How many years have you

(3) worked in your present organization? ____ Years

(4) been in your current position? ____ Years

APPENDIX 4

Professional Engineers' Work

An Independent Survey of the Profession

**Conducted by Derek Chase, P.Eng.
School of Business, Carleton University,
Ottawa K1S 5B6**

**With the Approval of
the Ethics Committee of Carleton University
and
the Executive Committee of the PEO**

Instructions

- 1 Please read the accompanying letter carefully.**
- 2 If you are self-employed, consider your personal environment as your organization. If you are not currently employed, please describe your most recent activity. Please write "N/A" (Not Applicable) beside any question which does not apply to you and proceed to the other questions. If the response you are looking for is not listed, please write in your response.**
- 3 This is a survey; it is not a test. There are no right or wrong answers. Please be as truthful as possible. Remember that the individual information you provide is important and will remain confidential.**
- 4 When you have completed the questionnaire please fold it in thirds, seal it in the postage-paid envelope and return it to me at Carleton University.**
- 5 If you have any concerns, please contact me or Professor L. Dyke at the School of Business, Carleton University. If you have any comments please write them on the back cover.**

Thank you very much for your participation.

1. What is your current occupational status?
☐ 1 Full-time permanent employee	☐ 5 Owner-manager
☐ 2 Full-time contract employee	☐ 6 Unemployed
☐ 3 Part-time employee	☐ 7 Retired
☐ 4 Self-employed	☐ 8 Other _____
2. What functional area best describes your principal activity at work?
☐ 1 Research - basic or applied	☐ 13 Business management
☐ 2 Development - product/ system	☐ 14 Corporate planning
☐ 3 Design - product/ system	☐ 15 Project planning
☐ 4 Computer services and systems	☐ 16 Project management
☐ 5 Manufacturing	☐ 17 Administration
☐ 6 Plant operation/ production	☐ 18 Economics
☐ 7 Quality control	☐ 19 Marketing, sales
☐ 8 Construction	☐ 20 Purchasing
☐ 9 Exploration	☐ 21 Legal Services
☐ 10 Teaching	☐ 22 Personnel
☐ 11 Finance	☐ 23 Accounting
☐ 12 Public relations	☐ 24 Other _____
3. What industry do you work in? (If you work in a Crown corporation please mark the relevant industry category rather than the government category.)
☐ 1 Durable manufacturing	☐ 11 Resources industry
☐ 2 Non-durable manufacturing	☐ 12 Construction industry
☐ 3 Educational institutions	☐ 13 Research laboratories
☐ 4 Federal government	☐ 14 Engineering consulting
☐ 5 Prov'l/ Terr'l governments	☐ 15 Health/ Social services
☐ 6 Municipal/Reg'l governments	☐ 16 Transportation
☐ 7 Telecom or computer services	
☐ 8 Utilities (electrical, gas, water, telephone)	
☐ 9 Commerce, Finance, Insurance or Real estate	
☐ 10 Other (please specify) _____	
4. What is the discipline of:
	(a) your under-graduate education	(b) your graduate education	(c) your current work
Not Applicable	☐ 0	☐ 0	
Chemical	☐ 1	☐ 1	☐ 1
Civil & construction	☐ 2	☐ 2	☐ 2
Systems & computers	☐ 3	☐ 3	☐ 3
Electrical & electronics	☐ 4	☐ 4	☐ 4
Petroleum & geological	☐ 5	☐ 5	☐ 5
Industrial	☐ 6	☐ 6	☐ 6
Mechanical & aerospace	☐ 7	☐ 7	☐ 7
Mining & metallurgical	☐ 8	☐ 8	☐ 8
Business administration	☐ 9	☐ 9	☐ 9
Other	☐ 10	☐ 10	☐ 10
(please specify) _____	_____	_____	_____
5. Would you say your work function is....
☐ 1 Entirely technical
☐ 2 Primarily technical
☐ 3 Half technical and half non-technical
☐ 4 Mainly non-technical with some technical background needed
☐ 5 Mainly non-technical and no technical background needed
6. Since becoming a P.Eng.: (a) in how many organizations have you worked? _____ Organizations
- (b) in how many functional areas (see Question 2 above) have you worked? _____ Areas

14. What is your present *PEO (APEO) Level of Professional Responsibility*?

- ___ 1 Level A: Engineer-in-Training, 1 - 2 yrs. experience as P.Eng.
- ___ 2 Level B: 2 - 3 yrs. P.Eng. experience, work under close supervision
- ___ 3 Level C: Min. 3 - 5 yrs. P.Eng. experience, fully qualified level, make independent studies
- ___ 4 Level D: Min. 5 - 8 yrs. P.Eng. experience, first level of full specialization or of direct supervision of other engineers, decisions accepted as accurate
- ___ 5 Level E: Min. 9 - 12 yrs. P.Eng. experience, specialist in field or knowledge of more than one field, authority over small group of professionals in complex applications or supervision of large groups, make responsible decisions except those involving large sums of money or long range objectives
- ___ 6 Level F: Broad experience, including administrative duties or recognized authority in an engineering field, conceive programs and problems to be investigated, make responsible decisions on all matters, including establishment of policies and expenditure of large sums of money
- ___ 7 Level F+: High degree of originality, skill and proficiency, plan and approve projects requiring the expenditure of large amounts of human resources and financial investment, long range planning and far-reaching management decisions

15. If direct supervision is defined as having direct and principal responsibility for staff performance reviews and salary reviews, what is your responsibility? (One only)

- ___ 1 No direct supervisory responsibility
- ___ 2 No direct supervisory responsibility, but project or team leadership
- ___ 3 First level of direct supervision (i.e. those you supervise do not supervise others)
- ___ 4 Direct supervision of first level management
- ___ 5 Direct supervision of middle management
- ___ 6 Direct supervision of senior management

16. (a) How many levels of direct supervision are there between you and the chief executive? 0 1 2 3 4 5 6 7+

(b) How many levels of direct supervision are there below you in your organization? 0 1 2 3 4 5 6 7+

17. How many persons, and engineers only, do you directly supervise? (0 = None) (1) Persons ____ (2) Engineers ____

18. (a) In a matrix structure, individuals have two bosses, a functional department manager, and a project manager. Do you work as a project leader or manager, or member of a matrix team?

Never __ 1 Seldom __ 2 Sometimes __ 3 Often __ 4 Almost Always __ 5 Always __ 6

(b) If you are a project leader or manager only, but not a direct supervisor, how many persons' and engineers' work do you personally direct? (1) Persons ____ (2) Engineers ____

19. (a) Does your organization have a dual career ladder structure, in which specialist professionals and administrative managers are rewarded equivalently?

No ____ 1 Yes ____ 2

(b) If yes only, are you rewarded in this manner?

No ____ 1 Yes ____ 2

20. If you report to a direct supervisor (i.e. who has principal responsibility for your performance and salary reviews), please continue. If not, please check here ____ and skip to Question 21.

(a) How many persons, and engineers only (including yourself) report to the same direct supervisor as you do?

(1) Persons ____ (2) Engineers ____

(b). How would you rate your direct supervisor:

Well Below Average Below Average Average Above Average Well Above Average

(1) as a manager of people?

1 2 3 4 5

(2) as a technical leader?

1 2 3 4 5

(c) Is your direct supervisor an engineer?

No ____ 1 Yes ____ 2

(d) Does your direct supervisor:

Never Seldom Sometimes Often Almost Always

(1) ensure that you receive credit for your work?

1 2 3 4 5

(2) provide you with opportunity to broaden the scope of your work?

1 2 3 4 5

(3) allow you to make the decisions which you feel are necessary?

1 2 3 4 5

(4) delegate enough authority to match your assigned responsibility?

1 2 3 4 5

(5) exercise general (rather than close) supervision of your work?

1 2 3 4 5

(6) allow you to participate in establishing your work responsibilities?

1 2 3 4 5

21. If you are a direct supervisor (i.e. who has principal responsibility for your staff's performance), please continue. If not, please check here ____ and skip to Question 22.

Do you:

Never Seldom Sometimes Often Almost Always

(1) ensure that your staff receive credit for their work?

1 2 3 4 5

(2) provide your staff with opportunity to broaden the scope of their work?

1 2 3 4 5

(3) allow your staff to make the decisions which they feel are necessary?

1 2 3 4 5

(4) delegate enough authority to match your staff's assigned responsibility?

1 2 3 4 5

(5) exercise general (rather than close) supervision of your staff's work?

1 2 3 4 5

(6) allow your staff to participate in establishing work responsibilities?

1 2 3 4 5

22. Please indicate the importance to you personally, and the extent it is characteristic of your work environment, of the following descriptions:	(1) Importance to You Personally				(2) Characteristic of Your Work Environment			
	None	Some	Very	Extre- mely	None	Some	Very	Extre- mely
(a) Use of your overall professional competence	1	2	3	4	1	2	3	4
(b) Proper utilization of your education and training	1	2	3	4	1	2	3	4
(c) Match between job requirements and your capabilities	1	2	3	4	1	2	3	4
(d) Challenging personal work assignments	1	2	3	4	1	2	3	4
(e) Chance to evolve new ideas and methods	1	2	3	4	1	2	3	4
(f) Opportunity to achieve personal goals	1	2	3	4	1	2	3	4
(g) Chance for personal advancement and growth	1	2	3	4	1	2	3	4
(h) Chance to achieve your full potential	1	2	3	4	1	2	3	4
(i) Chance to use your abilities and skills	1	2	3	4	1	2	3	4
(j) Chance to do the kind of work you do best	1	2	3	4	1	2	3	4

23. Please indicate the extent of your disagreement or agreement:	Strongly Disagree		Neutral			Strongly Agree	
(a) I am willing to put in a great deal of effort in order to help my organization be successful	1	2	3	4	5	6	7
(b) I would accept almost any assignment in order to keep working for my organization	1	2	3	4	5	6	7
(c) I find that my values and my organization's values are very similar	1	2	3	4	5	6	7
(d) I am proud to tell others that I am part of my organization	1	2	3	4	5	6	7
(e) My organization really inspires the very best in me in the way of job performance	1	2	3	4	5	6	7
(f) For me this is the best of all possible organizations for which to work.	1	2	3	4	5	6	7

- 24 (a) On average how much time do you actually spend working at the office each week? _____ Hrs./ Week
- (b) If you regularly work overtime, how much on average is: (1) unpaid overtime? _____ Hrs./ Week
- (2) paid overtime? _____ Hrs./ Week
- (c) How much additional time on average do you spend at home each week on work-related matters? _____ Hrs./ Week

25. (a) How do you feel about your workload? ☐ 1 I almost always prefer to do more work
☐ 2 I often prefer to do more work
☐ 3 It is neither too light nor too heavy
☐ 4 It is often too heavy
☐ 5 It is almost always too heavy

- | | Extremely
<u>Light</u> | Slightly
<u>Light</u> | About
<u>Right</u> | Slightly
<u>Heavy</u> | Extremely
<u>Heavy</u> | | |
|---|---------------------------|--------------------------|-----------------------|--------------------------|---------------------------|---|---|
| (b) How would you rate the <u>time demands</u> of your present job? | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| (c) How would you rate the <u>intellectual demands</u> of your present job? | 1 | 2 | 3 | 4 | 5 | 6 | 7 |

- | | To a Small
<u>Extent</u> | To a Medium
<u>Extent</u> | To a Great
<u>Extent</u> | | | | |
|--|-----------------------------|------------------------------|-----------------------------|---|---|---|---|
| 26. Is your authority adequate for your assigned responsibilities? | 1 | 2 | 3 | 4 | 5 | 6 | 7 |

27. A Canadian engineer suggests that there are five basic parts to any organization:

1. The *Operating Core* includes employees who perform the basic work related to the production of goods and services
2. The *Strategic Apex* includes the top-level managers who have overall responsibility for the organization,
3. The *Middle Line* includes the managers who connect the Operating Core with the Strategic Apex,
4. The *Technostructure* includes the analysts who establish the procedures and practices for the organization,
5. The *Support Staff* provide indirect services for the organization.

- (a) In which of the five parts would you place yourself? 1 2 3 4 5
- (b) In your organization which is the dominant part? 1 2 3 4 5

28. (a) Do you have, or share, an assistant
 (e.g. a secretary or administrative assistant)? No ☐ 1 Yes ☐ 2
- If yes, (b) What percentage of their time is devoted to your work? %
- (c) By how much is your work effectiveness increased? by %
- (d) If he or she had better training would effectiveness increase more? (1) No ☐ 1 Yes ☐ 2, (2) % more
- If no, (e) Could you justify an assistant? (1) No ☐ 1 Yes ☐ 2, (2) % of the time
- (f) By how much could your work effectiveness increase? by %

29. (a) Approximately what percent of your total work time do you devote to keeping up-to-date in your field of work? _____ % of the time

(b) Have you completed any job-related training by your organization in the past TWO YEARS? (1) No _____, Yes _____, (2) _____ days in total

30. To what extent have the following improved your work effectiveness?	<u>To No Extent</u>		<u>To an Average Extent</u>			<u>To a Great Extent</u>	
(a) Job-related training courses	1	2	3	4	5	6	7
(b) External general education courses	1	2	3	4	5	6	7
(c) Conferences and professional meetings	1	2	3	4	5	6	7
(d) Reading of publications	1	2	3	4	5	6	7
(e) On-the-job colleague interaction	1	2	3	4	5	6	7
(f) On-the-job problem solving	1	2	3	4	5	6	7
(g) New computer software	1	2	3	4	5	6	7

31. To what extent does your organization provide you with support:

(a) With technical (e.g. computer) problems?	1	2	3	4	5	6	7
(b) With administrative or personnel matters?	1	2	3	4	5	6	7
(c) With routine clerical (e.g. filing) work?	1	2	3	4	5	6	7

32. (a) What percent of your work time is spent on work that could be done by someone with less training? _____ % of my work time

(b) How much of your work time is spent doing work which you have not done before? _____ % of my work time

33. How subjective or objective is the measurement of:	<u>Fully Subjective</u>		<u>Both Equally</u>			<u>Fully Objective</u>	
(a) your work performance?	1	2	3	4	5	6	7
(b) your work productivity?	1	2	3	4	5	6	7

If you are a direct supervisor only:

(c) your staff's work performance?	1	2	3	4	5	6	7
(e) your staff's work productivity?	1	2	3	4	5	6	7

34. In your organization:
	<u>To a Small Extent</u>		<u>To an Average Extent</u>			<u>To a Large Extent</u>	
(a) is the reward system fair and equitable?	1	2	3	4	5	6	7
(b) are promotions based on competence?	1	2	3	4	5	6	7
(c) Is job performance evaluated in writing?	(1) No ____ 1 Yes ____ 2, (2) every ____ mnths						

35. Would you like your career to be:
	<u>Strongly Disagree</u>		<u>Neutral</u>			<u>Strongly Agree</u>	
(a) A progression up the technical professional ladder to a higher-level position?	1	2	3	4	5	6	7
(b) A progression up the managerial ladder to a higher-level position?	1	2	3	4	5	6	7
(c) A progression of challenging activities and projects, irrespective of promotion?	1	2	3	4	5	6	7

36. What is the most likely form of reward in your job?
(a) High performance leads up the technical-ladder	1	2	3	4	5	6	7
(b) High performance leads up the managerial ladder	1	2	3	4	5	6	7
(c) High performance leads to more interesting project assignments	1	2	3	4	5	6	7

37. Some people are completely involved in their job - they are absorbed in it night and day. For other people their job is simply one of several interests. How involved are you in your job?

- ____ 1 Very little involved in my job; very strongly involved in my other interests
 ____ 2 Slightly involved in my job; strongly involved in my other interests
 ____ 3 Moderately involved in my job; my other interests are equally absorbing to me
 ____ 4 Strongly involved in my job; slightly involved in my other interests
 ____ 5 Very strongly involved in my job; it is the most absorbing interest in my life

38. How satisfied are you with:
	<u>Very Dis-satisfied</u>	<u>Dis-satisfied</u>	<u>Neutral</u>	<u>Satisfied</u>	<u>Very Satisfied</u>	<u>Extremely Satisfied</u>
(a) Your career choice	1	2	3	4	5	6
(b) Your career progress	1	2	3	4	5	6
(c) Your present employer	1	2	3	4	5	6
(d) Your present job	1	2	3	4	5	6
(e) Your present pay	1	2	3	4	5	6

39. At this point in your professional life how succesful do you think you are?

- Very unsuccessful ____ 1 Somewhat unsuccessful ____ 2 Neutral ____ 3 Somewhat succesful ____ 4 Very succesful ____ 5

40. How many professional societies other than PEO are you a member of? ____ society(ies)

41. During the past TWO YEARS have you Number of
times if yes

(a) Attended PEO branch or committee meetings? (1) No ____ , Yes ____ , (2) ____

(b) Attended other professional society meetings? (1) No ____ , Yes ____ , (2) ____

42. Have you ever:

(a) Written a technical article(s) and had it (them) published in a professional journal? (1) No ____ , Yes ____ , (2) ____

(b) Made a major contribution to a device, product or process innovation? (1) No ____ , Yes ____ , (2) ____

(c) Disclosed, applied for, or received a patent? (1) No ____ , Yes ____ , (2) ____

43. During the past TWO YEARS have you completed any of the following university or college courses: Number of
courses if yes

(a) Non-degree-credit technical? (1) No ____ , Yes ____ , (2) ____

(b) Non-degree-credit non-technical? (1) No ____ , Yes ____ , (2) ____

(c) Technical leading to a graduate degree? (1) No ____ , Yes ____ , (2) ____

(d) Non-technical leading to a graduate degree? (1) No ____ , Yes ____ , (2) ____

(e) If any yes, did your organization pay for tuition? No ____ , Yes ____ ,

(f) If any yes, did your organization pay your salary while attending a course? No ____ , Yes ____ ,

44. (a) Year of Bachelor degree (or degree accepted for registration) 19 ____

(b) OR year of admission to PEO by exam (if applicable) 19 ____

(c) Did you obtain a Bachelor's degree in Canada? No ____ , Yes ____ ,

45 Any graduate degrees? (a) MASc, MEng No ____ , Yes ____ ,

(b) MBA No ____ , Yes ____ ,

(c) PhD (Engineering) No ____ , Yes ____ ,

(d) Other (specify) _____ No ____ , Yes ____ ,

46. What was your basic annual salary in 1994 (i.e. excluding non-cash benefits)? \$ _____

47. What was your total cash income from employment in 1994 (i.e. basic salary plus bonuses, overtime and commissions)? \$ _____

48. In what year were you born? 19 ____

49. Are you: Female ____ , Male ____ ,

APPENDIX 5

ENGINEERING UTILIZATION INDEX

List of Engineering Utilization Scale Items, Response Weights
and Percentage of Total Sample Selecting each Response.

ITEM NO.	RESPONSE CATEGORIES [1]					
	MB	VI	I	SI	LI	UN
7. RELEVANCE TO PRESENT OR LAST JOB (Weight)	(6)	(5)	(4)	(3)	(2)	(1)
1-Engineering Experience.....	46%	26%	18%	7%	2%	2%
2-Educational Background.....	39	26	24	9	2	*
	RESPONSE CATEGORIES [2]					
	EX	VY	SO	NO		
13. EMPLOYER CHARACTERISTIC DESCRIPTION (Weight)	(4)	(3)	(2)	(1)		
21-Excellent utilization of engineering personnel is common.....	5%	29%	54%	13%		
	RESPONSE CATEGORIES [2]					
	EX	VY	SO	NO		
14. CURRENT JOB CHARACTERISTIC FACTORS (Weight)	(4)	(3)	(2)	(1)		
6-Utilization of education and training.....	10%	41%	44%	5%		
7-Sufficient supporting technical personnel....	8	37	46	9		
8-Sufficient supporting non-technical personnel	6	34	52	9		
9-Utilization of experience engineers.....	11	44	41	5		
10-Utilization of talented young engineers.....	8	38	44	10		
11-Match between job requirements & capabilities	11	44	40	5		
14-Good working environment.....	12	46	36	6		
15-Challenging work assignments.....	14	42	38	5		
18-Opportunities for on-the-job training.....	9	34	46	11		
19-Opportunities to work on long-term goals.....	5	27	50	17		
21-Adequate motivation to perform well.....	11	34	43	12		
[1-Use of overall technical competence.....	15	44	38	3]		

[1] Key

MB = Must Have

VI = Very Important

I = Important

SI = Some Importance

LI = Little Importance

UN = Unnecessary

[2] Key

EX = Extremely

VY = Very

SO = Some

NO = None

American Association of Engineering Societies, Engineering Manpower Commission
(1986). Toward the More Effective Utilization of American Engineers: The
National Utilization Survey. Appendix F, Table F1, p. 193. Washington, D.C.:
American Association of Engineering Societies.

APPENDIX 6

1. What is your current occupational status? **81** 1 Full-time permanent employee **6** 3 Owner-manager NA = 0
2 2 Full-time contract employee **1** 4 Unemployed
1 3 Part-time employee **2** 7 Retired
7 4 Self-employed **8** Other _____
2. What functional area best describes your principal activity at work? **5** 1 Research - basic or applied **7** 13 Business management NA = 0
7 2 Development - product/ system **14** Corporate planning
20 3 Design - product/ system **2** 15 Project planning
4 4 Computer services and systems **17** 16 Project management
2 5 Manufacturing **4** 17 Administration
8 6 Plant operation/ production **18** Economics
1 7 Quality control **9** 19 Marketing, sales
4 8 Construction **1** 20 Purchasing
1 9 Exploration **21** Legal Services
2 10 Teaching **22** Personnel
1 11 Finance **23** Accounting
12 Public relations **4** 24 Other _____
3. What industry do you work in? (If you work in a Crown corporation please mark the relevant industry category rather than the government category.) **15** 1 Durable manufacturing **8** 11 Resources industry NA = 1
4 2 Non-durable manufacturing **7** 12 Construction industry
4 3 Educational institutions **1** 13 Research laboratories
7 4 Federal government **12** 14 Engineering consulting
4 5 Prov'l/ Terr'l governments **1** 15 Health/ Social services
4 6 Municipal/Reg'l governments **5** 16 Transportation
7 7 Telecom or computer services
10 8 Utilities (electrical, gas, water, telephone)
6 9 Commerce, Finance, Insurance or Real estate
5 10 Other (please specify) _____
4. What is the discipline of: (a) your under-graduate education (b) your graduate education (c) your current work (a) NA = 0
Not Applicable **1** 0 **56** 0
Chemical **4** 1 **1** 1 **2** 1 (b)
Civil & construction **27** 2 **11** 2 **21** 2 NA = 19
Systems & computers **1** 3 **2** 3 **10** 3
Electrical & electronics **27** 4 **7** 4 **18** 4 (c)
Petroleum & geological **2** 5 **3** 5 **2** 5 NA = 11
Industrial **3** 6 **6** 6 **2** 6
Mechanical & aerospace **21** 7 **3** 7 **16** 7
Mining & metallurgical **13** 8 **4** 8 **7** 8
Business administration **9** 9 **10** 9 **13** 9
Other **4** 10 **6** 10 **10** 10
5. Would you say your work function is.... **6** 1 Entirely technical NA = 2
33 2 Primarily technical
37 3 Half technical and half non-technical
22 4 Mainly non-technical with some technical background needed
3 5 Mainly non-technical and no technical background needed
6. Since becoming a P.Eng.: (a) in how many organizations have you worked? **1** - **16** NA = 0
(M = 2.9)
(b) in how many functional areas (Quest. 2 above) have you worked? **1** - **14** (M = 3.5) NA = 0

7. (a) How many years have you worked in your present organization? 1 - 34 Years NA = 0
(M = 10.8)
- (b) How many years have you been in your current position? 1 - 31 Years NA = 5
(M = 5.8)
- (c) How many years were you in your previous position? 1 - 43 Years NA = 10
(M = 6.4)
8. (a) Is your organization a multinational corporation? No 61 : Yes 39 : NA = 1
- (b) If yes only, is the head office in Canada? No 42 : Yes 58 : NA = 85
9. How many persons are employed in your organization? 0 1 - 5 6 - 25 26 - 100 101 - 500 501 - 1000 1001+
- (a) Total outside Canada 36 : 2 : 7 : 5 : 10 : 4 : 31 : NA = 46
(M = 4.6)
- (b) Total in Canada 10 : 6 : 10 : 15 : 7 : 54 : NA = 10
(M = 3.7)
- (c) Total in your plant or office 12 : 15 : 14 : 31 : 12 : 17 : NA = 8
(M = 1.6)
10. In the past TWO YEARS has your Canadian organization:
- 22 : Grown in number of persons NA = 2
29 : Stayed about the same size
49 : Decreased in number of persons
(M = 2.3)
11. In your work unit or group approximately how many persons in total, and with engineering degrees, are employed
- (a) Persons in Total 1 - 800 (M = 97.1)
- (b) Persons with Engineering Degrees 1 - 250 (M = 30.3)
- (a) NA = 4
(b) NA = 3
12. In your work unit or group, to what extent: (please circle one number per item)
	To a Small Extent			Average Extent		To a Great Extent		
	1	2	3	4	5	6	7	
(a) are rules, procedures and standards used? (M = 4.7)	7	7	8	22	19	20	16	NA = 3
(b) is there freedom to use one's discretion? (M = 5.2)	1	3	8	19	22	26	20	NA = 3
(c) is there standardization of the work? (M = 4.4)	4	8	11	23	28	17	7	NA = 3
(d) are the important decisions made by top executives? (M = 5.1)	1	4	12	20	12	27	24	NA = 3
(e) do persons perform highly specialized tasks? (M = 4.8)	4	8	10	17	22	25	14	NA = 3
(f) are personnel with whom you deal with regularly, geographically dispersed? (M = 4.2)	16	10	11	13	13	19	17	NA = 3
(g) is there regular, trustworthy feedback on your group performance? (M = 4.0)	10	10	20	22	16	16	6	NA = 3
(h) is there free communication downward from more senior management to you? (M = 4.5)	6	11	14	20	13	20	17	NA = 4
(i) is there free communication upward from you to more senior management? (M = 4.9)	3	3	12	20	23	25	13	NA = 7
13. What is the management style of your organization? (M = 4.1)
	Highly autocratic					Highly democratic		
	1	2	3	4	5	6	7	
	7	12	17	22	19	16	7	NA = 3

14. What is your present *PEO (APEO) Level of Professional Responsibility?*

0 : Level A: Engineer-in-Training, 1 - 2 yrs. experience as P.Eng. NA = 3

1 : Level B: 2 - 3 yrs. P.Eng. experience, work under close supervision

9 : Level C: Min. 3 - 5 yrs. P.Eng. experience, fully qualified level, make independent studies

24 : Level D: Min. 5 - 8 yrs. P.Eng. experience, first level of full specialization or of direct supervision of other engineers, decisions accepted as accurate

32 : Level E: Min. 9 - 12 yrs. P.Eng. experience, specialist in field or knowledge of more than one field, authority over small group of professionals in complex applications or supervision of large groups, make responsible decisions except those involving large sums of money or long range objectives

28 : Level F: Broad experience, including administrative duties or recognized authority in an engineering field, conceive programs and problems to be investigated, make responsible decisions on all matters, including establishment of policies and expenditure of large sums of money

7 : Level F+: High degree of originality, skill and proficiency, plan and approve projects requiring the expenditure of large amounts of human resources and financial investment, long range planning and far-reaching management decisions

(M = 5.0)

15. If direct supervision is defined as having direct and principal responsibility for staff performance reviews and salary reviews, what is your responsibility? (One only)

NA = 2

22 : No direct supervisory responsibility

29 : No direct supervisory responsibility, but project or team leadership

15 : First level of direct supervision (i.e. those you supervise do not supervise others)

13 : Direct supervision of first level management

10 : Direct supervision of middle management

11 : Direct supervision of senior management

(M = 2.9)

16. (a) How many levels of direct supervision are there between you and the chief executive?

0	1	2	3	4	5	6	7+
1	34	17	17	16	11	1	3

 NA = 2

(M = 2.7)

(b) How many levels of direct supervision are there below you in your organization?

0	1	2	3	4	5	6	7+
48	19	16	13	2	1	.	.

 NA = 2

(M = 1.1)

17. How many persons, and engineers only, do you directly supervise? (0 = None) (1) Persons 1 - 54 (2) Engineers 0 - 30 NA1 = 16
(M = 9.0) (M = 1.4) NA2 = 15

18. (a) In a matrix structure, individuals have two bosses, a functional department manager, and a project manager. Do you work as a project leader or manager, or member of a matrix team?

Never 24 : Seldom 7 : Sometimes .9 : Often 13 : Almost Always 25 : Always 11 : NA = 3
(M = 3.4)

(b) If you are a project leader or manager only, but not a direct supervisor, how many persons', and (M = 6.4) (M = 3.3) NA1 = 74
engineers' work do you personally direct? (1) Persons 0 - 40 (2) Engineers 0 - 10 NA2 = 84

19. (a) Does your organization have a dual career ladder structure, in which specialist professionals and administrative managers are rewarded equivalently? No 70 : Yes 30 : NA = 10

(b) If yes only, are you rewarded in this manner? No 33 : Yes 67 : NA = 97

20. If you report to a direct supervisor (i.e. who has principal responsibility for your performance and salary reviews), please continue. If not, please check here 26/137 and skip to Question 21. NA = 111

(a) How many persons, and engineers only (including you) report to your supervisor? (1) Persons 1 - 50 (M = 9.1) (2) Engineers 0 - 20 (M = 3.7) NA1 = 34 NA2 = 33

(b) How would you rate your direct supervisor:

	Well Below Average	Below Average	Average	Above Average	Well Above Average	
(1) as a manager of people?	1 9 (M = 3.2)	2 10	3 39	4 35	5 7	NA = 28
(2) as a technical leader?	12 (M = 3.0)	21	34	24	9	NA = 28

(c) Is your direct supervisor an engineer? No 41 : Yes 59 : NA = 29

(d) Does your direct supervisor:

	Never	Seldom	Sometimes	Often	Almost Always	
(1) ensure that you receive credit for your work?	1 4 (M = 3.6)	2 13	3 28	4 33	5 25	NA = 28
(2) provide you with opportunity to broaden the scope of your work?	2 (M = 3.6)	17	25	34	22	NA = 28
(3) allow you to make the decisions which you feel are necessary?	3 (M = 4.0)	6	16	41	34	NA = 28
(4) delegate enough authority to match your assigned responsibility?	6 (M = 3.8)	6	17	37	33	NA = 28
(5) exercise general (rather than close) supervision of your work?	2 (M = 4.3)	6	10	25	58	NA = 28
(6) allow you to participate in establishing your work responsibilities?	5 (M = 4.0)	6	19	28	41	NA = 28

21. If you are a direct supervisor (i.e. who has principal responsibility for your staff's performance), please continue. If not, please check here 62/137 and skip to Question 22. NA = 75

Do you:

	Never	Seldom	Sometimes	Often	Almost Always	
(1) ensure that your staff receive credit for their work?	1 -	2 -	3 14	4 43	5 43	7 NA = 74
(2) provide your staff with opportunity to broaden the scope of their work?	-	2 (M = 4.2)	19	38	41	NA = 74
(3) allow your staff to make the decisions which they feel are necessary?	-	-	13 (M = 4.2)	52	35	NA = 74
(4) delegate enough authority to match your staff's assigned responsibility?	-	-	10 (M = 4.4)	44	46	NA = 74
(5) exercise general (rather than close) supervision of your staff's work?	-	3 (M = 4.2)	13	41	43	NA = 74
(6) allow your staff to participate in establishing work responsibilities?	-	2 (M = 4.1)	24	40	35	NA = 74

22. Please indicate the importance to you personally, and the extent it is characteristic of your work environment, of the following descriptions:	(1) Importance to You Personally				(2) Characteristic of Your Work Environment				
	None	Some	Very	Extremely	None	Some	Very	Extremely	
(a) Use of your overall professional competence	1	9	46	44	2	32	47	20	NA1 = 4 NA2 = 4
(b) Proper utilization of your education and training	3	28	47	23	4	47	40	10	NA1 = 4 NA2 = 4
(c) Match between job requirements and your capabilities	2	15	52	31	6	35	47	13	NA1 = 4 NA2 = 4
(d) Challenging personal work assignments	2	7	46	46	5	27	45	23	NA1 = 4 NA2 = 4
(e) Chance to evolve new ideas and methods	2	12	47	39	7	36	44	14	NA1 = 4 NA2 = 4
(f) Opportunity to achieve personal goals	3	5	50	42	11	41	35	14	NA1 = 4 NA2 = 4
(g) Chance for personal advancement and growth	5	15	40	41	14	48	28	11	NA1 = 4 NA2 = 4
(h) Chance to achieve your full potential	3	9	43	45	11	45	32	11	NA1 = 4 NA2 = 4
(i) Chance to use your abilities and skills	-	8	45	47	5	26	53	15	NA1 = 4 NA2 = 4
(j) Chance to do the kind of work you do best	1	12	46	41	6	41	38	15	NA1 = 4 NA2 = 4
23. Please indicate the extent of your disagreement or agreement:	Strongly Disagree		Neutral		Strongly Agree				
	1	2	3	4	5	6		7	
(a) I am willing to put in a great deal of effort in order to help my organization be successful (M = 5.8)	1	3	1	7	20	35	32	NA = 3	
(b) I would accept almost any assignment in order to keep working for my organization (M = 4.0)	7	20	12	20	18	15	9	NA = 4	
(c) I find that my values and my organization's values are very similar (M = 4.6)	5	11	13	15	26	17	14	NA = 4	
(d) I am proud to tell others that I am part of my organization (M = 5.2)	4	4	8	15	21	23	26	NA = 4	
(e) My organization really inspires the very best in me in the way of job performance (M = 4.4)	5	10	14	23	26	11	12	NA = 4	
(f) For me this is the best of all possible organizations for which to work. (M = 4.3)	10	6	14	22	22	16	11	NA = 4	
24 (a) On average how much time do you actually spend working at the office each week?	0 - 65 Hrs./ Week (M = 43.0)							NA = 4	
(b) If you regularly work overtime, how much on average is:	(1) unpaid overtime?							0 - 25 Hrs./ Week (M = 5.0)	NA = 4
	(2) paid overtime?							0 - 70 Hrs./ Week (M = .32)	NA = 9
(c) How much additional time on average do you spend at home each week on work-related matters?	0 - 17 Hrs/ Week (M = 4.0)							NA = 4	

29. (a) Approximately what percent of your total work time do you devote to keeping up-to-date in your field of work? 0 - 50 % of the time NA = 1
(M = 11.2)
- (b) Have you completed any job-related training by your organization in the past TWO YEARS? (1) No 32, Yes 68, (2) 1 - 50 days in total NA1 = 2 (M = 10.0) NA2 = 50
30. To what extent have the following improved your work effectiveness?
	To No Extent		To an Average Extent			To a Great Extent		
	1	2	3	4	5	6	7	
(a) Job-related training courses
(M = 3.8)	13	13	7	31	19	13	4	NA = 3
(b) External general education courses
(M = 2.9)	30	19	7	19	16	4	4	NA = 7
(c) Conferences and professional meetings
(M = 4.2)	8	12	7	19	16	4	4	NA = 3
(d) Reading of publications
(M = 4.4)	4	12	10	23	23	16	7	NA = 3
(e) On-the-job colleague interaction
(M = 5.0)	2	3	7	19	27	31	11	NA = 3
(f) On-the-job problem solving
(M = 5.5)	1	2	1	13	27	40	16	NA = 3
(g) New computer software
(M = 4.1)	9	10	16	20	25	13	7	NA = 3
31. To what extent does your organization provide you with support:
	1	2	3	4	5	6	7	
(a) With technical (e.g. computer) problems?
(M = 4.5)	6	10	11	16	26	22	8	NA = 3
(b) With administrative or personnel matters?
(M = 4.0)	8	10	16	28	22	10	5	NA = 3
(c) With routine clerical (e.g. filing) work?
(M = 3.5)	17	18	14	23	11	11	5	NA = 5
32. (a) What percent of your work time is spent on work that could be done by someone with less training? 0 - 100 % of my work time (M = 25.5) NA = 2
- (b) How much of your work time is spent doing work which you have not done before? 0 - 100 % of my work time (M = 23.5) NA = 1
33. How subjective or objective is the measurement of:
	Fully Subjective		Both Equally			Fully Objective		
	1	2	3	4	5	6	7	
(a) your work performance?
(M = 4.0)	8	9	11	42	11	13	5	NA = 5
(b) your work productivity?
(M = 3.9)	10	11	16	32	14	13	5	NA = 5
- If you are a direct supervisor only:
(c) your staff's work performance?
(M = 4.4)	2	8	8	43	13	23	2	NA = 77
(d) your staff's work productivity?
(M = 4.9)	3	7	8	42	12	28	-	NA = 77

34. In your organization:
	To a Small Extent		To an Average Extent			To a Large Extent		
	1	2	3	4	5	6	7	
(a) is the reward system fair and equitable?	11	15	12	33	18	7	5	NA = 2
(M = 3.7)								
(b) are promotions based on competence?	13	11	12	31	21	4	7	NA = 3
(M = 3.8)								
(c) Is job performance evaluated in writing? (1) No 26; Yes 74; (2) every 3 - 36 mths								NA1 = 8
NA2 = 48
(M = 11.9)								
35. Would you like your career to be:
	Strongly Disagree		Neutral			Strongly Agree		
	1	2	3	4	5	6	7	
(a) A progression up the technical professional ladder to a higher-level position?	8	4	8	40	14	19	5	NA = 3
(M = 4.3)								
(b) A progression up the managerial ladder to a higher-level position?	9	4	6	29	16	24	12	NA = 2
(M = 4.6)								
(c) A progression of challenging activities and projects, irrespective of promotion?	3	3	5	20	27	30	16	NA = 3
(M = 5.1)								
36. What is the most likely form of reward in your job?
(a) High performance leads up the technical-ladder	17	8	15	42	12	5	2	NA = 5
(M = 3.5)								
(b) High performance leads up the managerial ladder	9	5	7	30	20	18	11	NA = 4
(M = 4.4)								
(c) High performance leads to more interesting project assignments	5	4	10	24	23	23	11	NA = 4
(M = 4.7)								
37. Some people are completely involved in their job - they are absorbed in it night and day. For other people their job is simply one of several interests. How involved are you in your job?
1	1	Very little involved in my job; very strongly involved in my other interests	NA = 2
2	2	Slightly involved in my job; strongly involved in my other interests	
3	9	Moderately involved in my job; my other interests are equally absorbing to me	
4	9	Strongly involved in my job; slightly involved in my other interests	
5	8	Very strongly involved in my job; it is the most absorbing interest in my life	
(M = 3.6)			
38. How satisfied are you with:
	Very Dissatisfied	Dissatisfied	Neutral	Satisfied	Very Satisfied	Extremely Satisfied	
	1	2	3	4	5	6	
(a) Your career choice	1	4	7	27	44	19	NA = 2
(M = 4.6)							
(b) Your career progress	4	12	14	34	26	10	NA = 2
(M = 3.9)							
(c) Your present employer	3	10	16	30	24	18	NA = 2
(M = 4.2)							
(d) Your present job	2	4	16	30	30	17	NA = 2
(M = 4.3)							
(e) Your present pay	4	12	18	34	22	10	NA = 2
(M = 3.9)							
39. At this point in your professional life how successful do you think you are?
Very unsuccessful 2;	Somewhat unsuccessful 7;	Neutral 13;	Somewhat successful 60;	Very successful 18;	NA = 1
(M = 3.8)					

40. How many professional societies other than PEO are you a member of? 0 - 10 society(ies) NA = 5
(M = 1.2)
41. During the past TWO YEARS have you
- Number of times if yes
- (a) Attended PEO branch or committee meetings? (1) No 84 : Yes 16 : (2) 1 - 24 NA1 = 0
(M = 3.2) NA2 = 1
- (b) Attended other professional society meetings? (1) No 61 : Yes 39 : (2) 0 - 20 NA1 = 0
(M = 4.1) NA2 = 8
42. Have you ever:
- (a) Written a technical article(s) and had it (them) published in a professional journal? (1) No 69 : Yes 31 : (2) 1 - 46 NA1 = 1
(M = 5.1) NA2 = 9
- (b) Made a major contribution to a device, product or process innovation? (1) No 52 : Yes 48 : (2) 1 - 15 NA1 = 1
(M = 4.1) NA2 = 8
- (c) Disclosed, applied for, or received a patent? (1) No 89 : Yes 11 : (2) 1 - 12 NA1 = 1
(M = 3.1) NA2 = 1
43. During the past TWO YEARS have you completed any of the following university or college courses:
- Number of courses if yes
- (a) Non-degree-credit technical? (1) No 81 : Yes 31 : (2) 1 - 4 NA1 = 3
(M = 1.6) NA2 = 1
- (b) Non-degree-credit non-technical? (1) No 87 : Yes 13 : (2) 1 - 3 NA1 = 3
(M = 1.3) NA2 = 1
- (c) Technical leading to a graduate degree? (1) No 99 : Yes 1 : (2) 4 NA1 = 5
(M = 4) NA2 = 1
- (d) Non-technical leading to a graduate degree? (1) No 98 : Yes 2 : (2) 3 - 10 NA1 = 6
(M = 6.5) NA2 = 1
- (e) If any yes, did your organization pay for tuition? No 43 : Yes 48 : NA = 93
- (f) If any yes, did your organization pay your salary while attending a course? No 57 : Yes 43 : NA = 95
44. (a) Year of Bachelor degree (or degree accepted for registration) 19 44 - 89 (M = 73) NA = 4
(b) OR year of admission to PEO by exam (if applicable) 19 53 - 93 (M = 77) NA = 10
- (c) Did you obtain a Bachelor's degree in Canada? No 23 : Yes 77 : NA = 5
45. Any graduate degrees? (a) MAsC, MEng No 80 : Yes 20 : NA = 3
(b) MBA No 95 : Yes 5 : NA = 4
(c) PhD (Engineering) No 95 : Yes 5 : NA = 4
(d) Other (specify) No 96 : Yes 4 : NA = 20
46. What was your basic annual salary in 1994 (i.e. excluding non-cash benefits)? \$ 15,000 - \$200,000 NA = 5
(M = \$73,156)
47. What was your total cash income from employment in 1994 (i.e. basic salary plus bonuses, overtime and commissions)? \$ 31,255 - \$650,000 NA = 7
(M = \$84,679)
48. In what year were you born? 19 23 - 66 NA = 3
49. Are you: Female 4 : Male 96 : NA = 4

APPENDIX 7
DICTION. OF QUEST. ITEMS

302

Q. NUM	VARIABLE LABELS	VAR#	VARNAME	RANGE	MISS	SCA	NEW	NVA
PAGE 1								
1	Current occupational status	1	Q 1	1 to 8	- 9	NOM	Dem	
2	Functional Area of Work	2	Q 2	1 to 24	- 9	NOM	Dem	
3	Industry of occupation	3	Q 3	1 to 16	- 9	NOM	Dem	
4(a)	Discipline of undergraduate education	4	Q 4 A	0 to 10	- 9	NOM	Dem	
4(b)	Discipline of graduate education	5	Q 4 B	0 to 10	- 9	NOM	Dem	
4(c)	Discipline of current work	6	Q 4 C	1 to 10	- 9	NOM	Dem	
5	Work function	7	Q 5	1 to 5	- 9	NOM	Dem	
6(a)	Number of organizations worked in	8	Q 6 A	1 to 20	- 9	INT	CA1	
6(b)	Number of functional areas worked in	9	Q 6 B	1 to 24	- 9	INT	CA1	
	TOTAL VARIABLES ON QUEST. PAGE 1 =	9						
PAGE 2								
7(a)	Years in present organization	10	Q 7 A	1 to 70	- 9	INT	OP2	
7(b)	Years in current position	11	Q 7 B	1 to 40	- 9	INT	OP2	
7(c)	Years in previous position	12	Q 7 C	1 to 25	- 9	INT	OP2	
8(a)	Multinational corporation?	13	Q 8 A	1,2	- 9	NOM	Dem	
8(b)	Head office in Canada?	14	Q 8 B	1,2	- 9	NOM	Dem	
9(a)	Employees outside Canada	15	Q 9 A	1 to 6	- 9	OFD	Dem	
9(b)	Employees in Canada	16	Q 9 B	1 to 6	- 9	OFD	Dem	
9(c)	Employees in plant or office	17	Q 9 C	1 to 6	- 9	OFD	Dem	
10	Canadian organization growth	18	Q 10	1 to 3	- 9	NOM	Dem	
11(a)	Group employees in total	19	Q 11 A	1 to 90	- 9	INT	Dem	
11(b)	Group employees w. enrg degrees	20	Q 11 B	1 to 90	- 9	INT	Dem	
12(a)	Group rules, proced and standards	21	Q 12 A	1 to 7	- 9	OFD	For	182
12(b)	Group freedom to use discretion	22	Q 12 B	1 to 7	- 9	OFD	For	182
12(c)	Group standardization of work	23	Q 12 C	1 to 7	- 9	OFD	For	182
12(d)	Group decisions made by top executives	24	Q 12 D	1 to 7	- 9	OFD	Cen	183
12(e)	Group performs specialized tasks	25	Q 12 E	1 to 7	- 9	OFD	Hcm	180
12(f)	Group persons dealt with dispersed	26	Q 12 F	1 to 7	- 9	OFD	Scm	181
12(g)	Group rec. reg. trustworthy feedback	27	Q 12 G	1 to 7	- 9	OFD	Cen	183
12(h)	Group has free comm. downward	28	Q 12 H	1 to 7	- 9	OFD	Cen	183
12(i)	Group has free comm. upward	29	Q 12 I	1 to 7	- 9	OFD	Cen	183
13	Management style of organization	30	Q 13	1 to 7	- 9	OFD	Cen	183
	TOTAL VARIABLES ON QUEST. PAGE 2 =	21						
PAGE 3								
14	PEO level of responsibility	31	Q 14	1 to 7	- 9	OFD	PR1	201
15	Direct supervision level	32	Q 15	1 to 6	- 9	OFD	PR2	201
16(a)	Levels of direct supervision above	33	Q 16 A	0 to 7	- 9	INT	com	179
16(b)	Levels of direct supervision below	34	Q 16 B	0 to 7	- 9	INT	com	179
17(1)	Number of persons directly supervised	35	Q 17 1	0 to 50	- 9	INT	OS1	
17(2)	Number of eng grads directly supervised	36	Q 17 2	0 to 50	- 9	INT	OS1	
18(a)	Extnt of work in matrix struct.?	37	Q 18 A	1 TO 6	- 9	OFD	OS3	205
18(b1)	Numb. of persons' work directed only	38	Q 18 B1	0 to 50	- 9	INT	OS3	
18(b2)	Numb. of engineers' work directed only	39	Q 18 B2	0 tp 50	- 9	INT	OS3	
	TOTAL VARIABLES ON QUEST. PAGE 3 =	9						

Q.NUM	VARIABLE LABELS	VAR#	VARNAME	RANGE	MISS	SCA	NEW	NVA
PAGE 4								
19(a)	Organization has dual career ladder?	40	Q 19 A	1,2	-9	NOM	op4	
19(b)	If yes only, rewarded in this manner?	41	Q 19 B	1,2	-9	NOM	op4	
20	Report to a direct supervisor?	42	Q 20	1,2	-9	NOM	SC1	211
20(a1)	No. of pers. reportg to direct superv.	43	Q 20 A1	0 to 50	-9	INT	sc1	
20(a2)	No. of engs. reportg to direct superv.	44	Q 20 A2	0 to 50	-9	INT	sc1	
20(b1)	DS as a manager of people?	45	Q 20 B1	1 to 5	-9	OFD	SC1	211
20(b2)	DS as a technical leader?	46	Q 20 B2	1 to 5	-9	OFD	SC1	211
20(c)	DS an engineer?	47	Q 20 C	1,2	-9	NOM	sc1	
20(d1)	DS ensures credit given?	48	Q 20 D1	1to 5	-9	OFD	SC3	212
20(d2)	DS provides for work broadening?	49	Q 20 D2	1 to 5	-9	OFD	SC3	212
20(d3)	DS delegates DM?	50	Q 20 D3	1 to 5	-9	OFD	SC3	212
20(d4)	DS delegates authority for resp.?	51	Q 20 D4	1 to 5	-9	OFD	SC3	212
20(d5)	DS exercises general supervision?	52	Q 20 D5	1 to 5	-9	OFD	SC3	212
20(d6)	DS allows participation in work resp?	53	Q 20 D6	1 to 5	-9	OFD	SC3	212
21(d1)	You ensure credit given?	54	Q 21 D1	1to 5	-9	OFD	SC3	
21(d2)	You provide for work broadening?	55	Q 21 D2	1 to 5	-9	OFD	SC3	
21(d3)	You delegate DM?	56	Q 21 D3	1 to 5	-9	OFD	SC3	
21(d4)	You delegate authority for resp.?	57	Q 21 D4	1 to 5	-9	OFD	SC3	
21(d5)	You exercise general supervision?	58	Q 21 D5	1 to 5	-9	OFD	SC3	
21(d6)	You allow participation in work resp?	59	Q 21 D6	1 to 5	-9	OFD	SC3	
	TOTAL VARIABLES ON QUEST. PAGE 4 =	20						
PAGE 5								
22(a1)	Import.: use of profess'l competence?	60	Q 22 A1	1 to 4	-9	OFD	up1	
22(a2)	Charact.: use of profess'l competence?	61	Q 22 A2	1 to 4	-9	OFD	UP1	184
22(b1)	Import. utilization of education?	62	Q 22 B1	1 to 4	-9	OFD	up1	
22(b2)	Charact. utilization of education?	63	Q 22 B2	1 to 4	-9	OFD	UP1	184
22(c1)	Import. match job and capabilities?	64	Q 22 C1	1 to 4	-9	OFD	up1	
22(c2)	Charact. match job and capabilities?	65	Q 22 C2	1 to 4	-9	OFD	UP1	184
22(d1)	Import. challenging assignments?	66	Q 22 D1	1 to 4	-9	OFD	up1	
22(d2)	Charact. challenging assignments?	67	Q 22 D2	1 to 4	-9	OFD	UP1	184
22(e1)	Import. chance to evolve new ideas?	68	Q 22 E1	1 to 4	-9	OFD	up1	
22(e2)	Charact. chance to evolve new ideas?	69	Q 22 E2	1 to 4	-9	OFD	UP1	184
22(f1)	Import. opportunity to achieve goals?	70	Q 22 F1	1 to 4	-9	OFD	up1	
22(f2)	Charact. opportunity to achieve goals?	71	Q 22 F2	1 to 4	-9	OFD	UP1	184
22(g1)	Import. chance for personal growth?	72	Q 22-G1	1 to 4	-9	OFD	up1	
22(g2)	Charact. chance for personal growth?	73	Q 22-G2	1 to 4	-9	OFD	UP1	184
22(h1)	Import. chance to achieve potential?	74	Q 22-H1	1 to 4	-9	OFD	up1	
22(h2)	Charact. chance to achieve potential?	75	Q 22 H2	1 to 4	-9	OFD	UP1	184
22(i1)	Import. chance to use abilities?	76	Q 22 I1	1 to 4	-9	OFD	up1	
22(i2)	Charact. chance to use abilities?	77	Q 22 I2	1 to 4	-9	OFD	UP1	184
22(j1)	Import. chance to do best work?	78	Q 22 J1	1 to 4	-9	OFD	up1	
22(j2)	Charact. chance to do best work?	79	Q 22 J2	1 to 4	-9	OFD	UP1	184
23(a)	Willing to put effort into organizn.?	80	Q 23 A	1 to 7	-9	OFD	OC1	191
23(b)	Accept any job offered by orgn?	81	Q 23 B	1 to 7	-9	OFD	OC1	184

Q.NUM	VARIABLE LABELS	VAR#	VARNAME	RANGE	MISS	SCA	NEW	NVA
23(c)	Values and orgs similar?	82	Q 23 C	1 to 7	-9	OFD	OC1	184
23(d)	Pride in organization?	83	Q 23 D	1 to 7	-9	OFD	OC1	184
23(e)	Organization inspires best?	84	Q 23 E	1 to 7	-9	OFD	OC1	184
23(h)	Organzn is best of all possible?	85	Q 23 H	1 to 7	-9	OFD	OC1	184
24(a)	Actual office working hrs per wk	86	Q 24 A	30 to 70	-9	INT	oc2	
24(b1)	Unpaid overtime hrs per wk	87	Q 24 B1	0 to 30	-9	INT	OC2	192
24(b2)	Paid overtime hours per week	88	Q 24 B2	0 to 30	-9	INT	oc2	
24(c)	Addtl. time on work at home per wk	89	Q 24 C	0 to 30	-9	INT	OC2	192
	TOTAL VARIABLES ON QUEST. PAGE 5 =	30						
PAGE 6								
25(a)	Amount of workload	90	Q 25 A	1 to 5	-9	OFD	UP2	185
								186
25(b)	Time demands of job	91	Q 25 B	1 to 7	-9	OFD	Ltd	177
							Htd	178
25(c)	Intellectual demands of job	92	Q 25 C	1 to 7	-9	OFD	Ltd	176
26	Authority comm. with responsib.	93	Q 26	1 to 7	-9	OFD	pr1	
27(a)	Where in Mintzberg five parts	94	Q 27 A	1 to 5	-9	OFD	os2	
27(b)	Dominant Mintzberg part in organization	95	Q 27 B	1 to 5	-9	OFD	OS2	204
	TOTAL VARIABLES ON QUEST. PAGE 6 =	6						
PAGE 7								
28(a)	Have or share an assistant?	96	Q 28 A	1,2	-9	NOM	OP1	206
28(b)	If yes, % of time to your work?	97	Q 28 B	0 to 100	-9	INT	op1	
28(c)	% Increase in effectiveness?	98	Q 28 C	0 to 80	-9	INT	OP1	206
28(d1)	Increase further with better training?	99	Q 28 D1	1,2	-9	NOM	op1	
28(d2)	Further % increase in effectiveness	100	Q 28 D2	0 to 30	-9	INT	op1	
28(e1)	If no, justify having or sharing one?	101	Q 28 E1	1,2	-9	NOM	op1	
28(e2)	% of time justified	102	Q 28-E2	1 to 100	-9	INT	op1	
28(f)	% increase in effectiveness	103	Q 28 F	0 to 80	-9	INT	op1	
29(a)	% of time keeping up-to-date	104	Q 29 A	0 to 95	-9	INT	PC4	196
29(b1)	Job related traing. by org in last 2 yrs?	105	Q 29 B1	0 to 7	-9	NOM	op2	
29(b2)	Days job rel. traing. by org in last 2 yrs	106	Q 29 B2	0 to 7	-9	INT	op2	
30(a)	Effectiveness of job related courses	107	Q 30 A	0 to 7	-9	OFD	OP2	207
30(b)	Effectiveness of ext'l gen'l edn. courses	108	Q 30 B	0 to 7	-9	OFD	op2	
30(c)	Effectiveness of conferences and meetin	109	Q 30 C	0 to 7	-9	OFD	OP2	207
30(d)	Effectiveness of reading of publications	110	Q 30 D	0 to 7	-9	OFD	op2	
30(e)	Effectiveness of colleague interaction	111	Q 30 E	0 to 7	-9	OFD	OP2	207
30(f)	Effectiveness of O-T-J problem solving	112	Q 30 F	0 to 7	-9	OFD	OP2	209
30(g)	Effectiveness of computer software	113	Q 30 G	0 to 7	-9	OFD	OP2	207
31(a)	Orgn support with technical problems	114	Q 31 A	0 to 7	-9	OFD	OP1	206
31(b)	Orgn support with admin. problems	115	Q 31 B	0 to 7	-9	OFD	OP1	206
31(c)	Orgn support with clerical work	116	Q 31 C	0 to 7	-9	OFD	OP1	206
32(a)	% of time on work of less training	117	Q 32 A	0 to 50	-9	INT	UP4	187
32(b)	% of work spent on original work	118	Q 32 B	0 to 100	-9	INT	UP5	188
33(a)	Your work perfee. measurement	119	Q 33 A	0 to 7	-9	OFD	op2	
33(b)	Your work prod. measurement	120	Q 33 B	0 to 7	-9	OFD	op2	

Q. NUM	VARIABLE LABELS	VAR#	VARNAME	RANGE	MISS	SCA	NEW	NVA
33(c)	Staff's work perice. measurement	121	Q 33 C	0 to 7	- 9	OFD	op2	
33(d)	Staff's work prod. measurement	122	Q 33 D	0 to 7	- 9	OFD	op2	
	TOTAL VARIABLES ON QUEST. PAGE 7 =	27						
PAGE 8								
34(a)	Reward system fair?	123	Q 34 A	1 to 7	- 9	OFD	OP4	209
34(b)	Promotions based on competence?	124	Q 34 B	1 to 7	- 9	OFD	OP4	209
34(a)	Performance formally evaluated?	125	Q 34	1,2	- 9	NOM	op3	
34(b)	Frequency of evaluation in months	126	Q 34 B	1 to 48	- 9	INT	op3	
35(a)	Tech-Profess'i career advancement?	127	Q 35 A	1 to 7	- 9	OFD	OP3	208
35(b)	Managerial career advancement?	128	Q 35 B	1 to 7	- 9	OFD	OP3	208
								198
35(c)	Challenging project opportunities?	129	Q 35 C	1 to 7	- 9	OFD	OP3	208
36(a)	Performance leads to technical ladder	130	Q 36 A	1 to 7	- 9	OFD	OP3	208
36(b)	Performance leads to managerial ladder	131	Q 36 B	1 to 7	- 9	OFD	OP3	208
36(c)	Performance leads to interesting projec	132	Q 36 C	1 to 7	- 9	OFD	OP3	208
37	Extent of job involvement	133	Q 37	1 to 5	- 9	OFD	CA2	199
38(a)	Satisfaction with career choice	134	Q 38 A	1 to 6	- 9	OFD	js2	
38(b)	Satisfaction with career progress	135	Q 38 B	1 to 6	- 9	OFD	JS2	190
38(c)	Satisfaction with employer	136	Q 38 C	1 to 6	- 9	OFD	JS2	190
38(d)	Satisfaction with job	137	Q 38 D	1 to 6	- 9	OFD	JS1	189
38(e)	Satisfaction with pay	138	Q 38 E	1 to 6	- 9	OFD	JS2	190
39	Professional success	139	Q 39	1 TO 5	- 9	OFD	js	
	TOTAL VARIABLES ON QUEST. PAGE 8 =	17						
PAGE 9								
40	Number of societies except PEO	140	Q 40	0 to 10	- 9	INT	ca3	
41(a1)	PEO meetings attended?	141	Q 41 A1	1,2	- 9	NOM	CA3	200
41(a2)	Number of PEO meetings attended	142	Q 41 A2	0 to 20	- 9	INT	ca3	
41(b1)	Other society meetings attended?	143	Q 41 B1	1,2	- 9	NOM	CA3	200
41(b2)	Number of oth. society mtgs. attended	144	Q 41 B2	0 to 20	- 9	INT	ca3	
42(a1)	Published technical article(s)?	145	Q 42 A1	1,2	- 9	NOM	PC5	197
42(a2)	Number of published technical articles	146	Q 42 A2	0 to 50	- 9	INT	pc5	
42(b1)	Made major innovation?	147	Q 42 B1	1,2	- 9	NOM	PC5	197
42(b2)	Number of major innovations	148	Q 42 B2	0 to 50	- 9	INT	pc5	
42(c1)	Discl., applied for or recd. patent(s)	149	Q 42 C1	1,2	- 9	NOM	PC5	197
42(c2)	Number of patents	150	Q 42 C2	0 to 50	- 9	INT	pc5	
43(a1)	Completed non-degree techl. course	151	Q 43 A1	1,2	- 9	NOM	pc1	
43(a2)	Number of non-degree techl. courses	152	Q 43 A2	0 to 10	- 9	INT	PC1	193
43(b1)	Completed non-degree non-techl. course	153	Q 43 B1	1,2	- 9	NOM	pc1	
43(b2)	Number of non-degree non-tech courses	154	Q 43 B2	0 to 10	- 9	INT	PC1	193
43(c1)	Completed degree techl. course(s)?	155	Q 43 C1	1,2	- 9	NOM	pc1	
43(c2)	Number of degree technical courses	156	Q 43 C2	0 to 10	- 9	INT	PC1	193
43(d1)	Completed degree non-techl. course(s)?	157	Q 43 D1	1,2	- 9	NOM	pc1	
43(d2)	Number of degree non-techl. courses	158	Q 43 D2	0 to 10	- 9	INT	PC1	193
43(e)	If yes, did org. pay tuition?	159	Q 43 E	1,2	- 9	NOM	op2	
43(f)	If yes, did org. pay salary attending?	160	Q 43 F	1,2	- 9	NOM	op2	

Q.NUM	VARIABLE LABELS	VAR#	VARNAME	RANGE	MISS	SCA	NEW	NVA
44(a)	Year of Bachelor degree	161	Q 44 A	20 to 93	- 9	INT	YBa	176
							SeD	172
							PC2	194
44(b)	Year of PEO exam admission	162	Q 44 B	20 to 93	- 9	INT	pc2	
44(c)	Canadian Bachelor degree?	163	Q 44 C	1,2	- 9	NOM	pc1	
45(a)	MASc or MEng?	164	Q 45 A	1,2	- 9	NOM	PC3	175
							OC1	191
45(b)	MBA?	165	Q 45 B	1,2	- 9	NOM	PC3	175
							OC1	191
45(c)	PhD (Engineering)?	166	Q 45 C	1,2	- 9	NOM	PC3	175
							OC1	191
45(d)	Other grad degree?	167	Q 45 D	1,2	- 9	NOM	PC3	
46	Basic annual salary in 1994	168	Q 46	20-900k	- 9	INT	SeD	172
47	Total cash inc. from employt.1994	169	Q 47	20-900k	- 9	INT	D	
48	Year of birth	170	Q 48	01-75	- 9	INT	Age	173
49	Gender	171	Q 49	1,2	- 9	NOM	D	
	TOTAL VARIABLES ON QUEST. PAGE 9 =	32						
	OVERALL TOTAL NUMBER OF VARIABLES=	171						

DICTION. OF DERIVED VARS.

VAR	VARNAME	VARIABLE LABELS	RANGE	MISS	SC	FORMULA
172	SAL_DEC1	SALARY BACH YR DECILE	{+/-5	-9	OR	(New manual entry based on separate table of deciles)
173	AGE	AGE	20 to 8	-9	OR	COMPUTE AGE=(95-Q 48)
174	YR_SBACH	YRS SINCE BACHELOR	2 to 60	-9	OR	COMPUTE YR_FBACH=(95-Q 44 A)
175	HIGH_DEG	HIGHEST DEGREE	1 to 3	-9	OR	COMPUTE HIGH_DEG=1; IF (Q 45 A < 0) HIGH_DEG=0; IF (Q 45 A = 2) HIGH_DEG=2; IF (Q 45 B = 2) HIGH_DEG = 2; IF (Q 45 C = 2) HIGH_DEG = 3
176	LITEINTD	LIGHT INTELL. DEMANDS	0 to 3	-9	OR	COMPUTE LITEINTD = 0; IF (Q 25 C=1) LITEINTD = 4; IF (Q 25 C=2) LITEINTD=3; IF (Q 25 C=3) LITEINTD=2; IF (Q 25 C=4) LITEINTD=1
177	LITETIMD	LIGHT TIME DEMANDS	0 to 3	-9	OR	COMPUTE LITETIMD=0; IF (Q 25 B=1) LITETIMD=4; IF (Q 25 B=2) LITETIMD=3; IF (Q 25 B=3) LITETIMD=2; IF (Q 25 B=4) LITETIMD=1
178	HEAVTIMD	HEAVY TIME DEMANDS	0 to 3	-9	OR	COMPUTE HEAVTIMD=1; IF (Q 25 B=7) HEAVTIMD=4; IF (Q 25 B=6) HEAVTIMD=3; IF (Q 25 B=5) HEAVTIMD = 2
179	VERCOMP	VERTICAL COMPLEXITY	0 to 14	-9	OR	COMPUTE VERCOMP=Q 16 A + Q 16 B
180	HORCOMP	HORIZONTAL COMPLEXITY	1 to 7	-9	OR	COMPUTE HORCOMP= (Q 12 E)
181	SPACOMP	SPACIAL COMPLEXITY	1 to 7	-9	OR	COMPUTE SPACOMP=(Q 12 F)
182	FORMZN	FORMALIZATION	3 to 21	-9	OR	COMPUTE FORMZN=(Q 12 A)+R(Q 12 B)+(Q 12 C)
183	CENTRZN	CENTRALIZATION	5 to 35	-9	OR	COMPUTE CENTRZN=(Q 12 D)+R(Q 12 G) +R(Q 12 H)+R(Q 12 I)+R(Q 13)
184	UPA_1	UTILIZN. OF PROFL. ABILITY	4 to 40	-9	OR	COMPUTE UPA_1=SUM(Q 22 A2) TO (Q 22 J2)
185	UPA_2	NEGATIVE UNDERUTILIZATION	0 to 11	-9	OR	IF Q 25 A = 1 UPA_2=LITEINTD +2.0*LITETIMD
186	UPA_3	NEGATIVE MISUTILIZATION	0 to 12	-9	OR	IF Q 25 A = 2 UPA_2=LITEINTD +1.5*LITETIMD
187	UPA_4	EFFICIENT USE OF TIME	0 to 95	-9	OR	IF Q 25 A GE 3 UPA_2=LITEINTD +1.0*LITETIMD
188	UPA_5	TIME ON ORIGINAL WORK	0 to 95	-9	OR	IF Q 25 A = 5 UPA_3=LITEINTD +2.0*HEAVTIMD
189	JOBSATN1	JOB SATISFACTION	1 to 6	-9	OR	IF Q 25 A = 4 UPA_3=LITEINTD +1.5*HEAVTIMD
190	JOBSATN2	WORK SATISFACTION	3 to 18	-9	OR	IF Q 25 A LE 3 UPA_3=LITEINTD +1.0*HEAVTIMD

DICTION. OF DERIVED VARS.

VAR	VARNAME	VARIABLE LABELS	RANGE	MISS	SC	FORMULA	
191	ORGOOM1	REPORTED ORGANIZ. COMMIT.	8 to 56	-9	OR	COMPUTE ORGOOM1=SUM (Q 23 A) TO (Q 23 F)	8
192	ORGOOM2	UNPAID OVERTIME	0 to 40	-9	OR	COMPUTE ORGOOM2=(Q 24 B1) + (Q 24 C)	9
193	PROOMP1	RECENT ACADEMIC EDUCAT.	1,2	-98	CO	COMPUTE PROOMP1=2; PROOMP1=1 IF (Q 43 A1)=1	10
						IF (Q 43 B1)=1 IF (Q 43 C1)=1 IF (Q 43 D1)=1	
194	PROOMP2	REPORTD. YRS SINCE BACH DEG	0 to 70	-9	OR	COMPUTE PROOMP2=(94 - YR SBACH)	11
195	PROOMP3	HIGHEST DEGREE	1 to 3	-9	OR	COMPUTE PROOMP3=(HIGH DEG)	12
196	PROOMP4	EFFT. KEEP. UP-TO-DATE	0 to 95	-9	OR	COMPUTE PROOMP4=(Q 29 A)	13
197	PROOMP5	PROFL ACHIEVEMENTS	1,2	-99	CO	COMPUTE PROOMP5=2; PROOMP5=1 IF (Q 42 A1)=1	14
						IF (Q 42 B1)=1 IF (Q 42 C1)=1 IF (Q 42 D1)=1	
198	CARASP1	REPORTED MGFL ASPIRATS.	1 to 7	-9	OR	COMPUTE CARASP1=(Q 35 B)	15
199	CARASP2	REPORTED JOB MOTIVATION	1 to 5	-9	OR	COMPUTE CARASP2=(Q 37)	16
200	CARASP3	ATTENDCE. AT PROFL MTGS.	1,2	-9	CO	COMPUTE CARASP3=2; CARASP3=1 IF (Q 41 A1)=1	
						IF (Q 41 A2)=1	
201	PRFRESP1	PEO LEVEL OF RESP.	1 to 7	-9	OR	COMPUTE PRFRESP1=(Q 14)	18
202	PRFRESP2	DIRECT SUPERV. RESP.	1 to 6	-9	OR	COMPUTE PRFRESP2=(Q 15)	19
203	ORGSTRU1	EXTENT OF ORGANIC MGT.	(+18	-99	CO	COMPUTE ORGSTRU1=(ZVERCOMP+Z+ORCOMP	20
						+ZSPACOMP +ZFORMZIN+ZCENTRZN)	
204	ORGSTRU2	MECH VS. ORG. CONFIG.	1,2	-9	OR	IF (Q 27 3)=1 OR (Q 27 3)=5 ORGSTRU2=2	
						IF (Q 27 3)=2 ORGSTRU2=1	
						IF (Q 27 3)=3 ORGSTRU2=1	
						IF (Q 27 3)=4 ORGSTRU2=1	
205	ORGSTRU3	AMT. OF WK. IN MATRIX	1 to 6	-9	OR	COMPUTE ORGSTRU3=(Q 18 A)	21
206	ORGPRA1	AVAILAB. OF SUPPT. SERV.	4 to 28	-9	OR	IF Q 28 A = 1 ORGPRA1=SUM (Q 31 A) TO (Q 31 C)	22
						IF Q 28 A = 2 ORGPRA1=SUM (Q 31 A) TO (Q 31 C)	
						+ RND((Q 28 C*7)/100)	
207	ORGPRA2	EXTENT OF DEVELOPMT. PROGS	0 to 49	-9	OR	COMPUTE ORGPRA2=(Q 30 A)+(Q 30 C)+(Q 30 E)	23
						+ (Q 30 F)+(Q 30 G)	

DICTION. OF DERIVED VARS.

VAR	VARIABLE LABELS	RANGE	MISS	SC	FORMULA	
208	ORGPR3	0 to 7	-9	OR	IF (Q_35_A) > (Q_35_B) OR (Q_35_B) > (Q_35_C)	24
					ORGPR3=(Q_36_A)	
					IF (Q_35_B) > (Q_35_A) OR (Q_35_B) > (Q_35_C)	
					ORGPR3=(Q_36_B)	
					IF (Q_35_C) > (Q_35_A) OR (Q_35_C) > (Q_35_B)	
					ORGPR3=(Q_36_C)	
209	ORGPR4	2 to 14	-9	OR	COMPUTE ORGPR4=(Q_34_A) + (Q_35_B)	25
210	ORGPR5	1 to 6	-9	OR	COMPUTE ORGPR5=SAL DECI	26
211	SUPCMP1	2 to 10	-9	OR	IF DIRSUPVR = 2 SUPCMP1=(Q_20_B1) + (Q_20_B2)	27
212	SUPCMP2	6 to 30	-9	OR	COMPUTE SUPCMP3=SUM (Q_20_D1) TO (Q_20_D6)	28
41	(=TOTAL NON-QUESTIONNAIRE VARIABLES)				TOTAL "Y" AND "X" VARIABLES = 28	

APPENDIX 9

A BRIEF INTRODUCTION TO LISREL MODEL OF UTILIZATION

Most theories and models in the social and behavioral sciences are formulated in terms of theoretical concepts or constructs, which are not directly measurable or observable. However, often a number of indicators of such concepts can be used to study the theoretical variables. The LISREL model, in its general form, consists of two parts: a structural equation model and a measurement model (Jöreskog and Sörbom 1989, Long 1983a, 1983b, Byrne 1989, Hayduk 1987). The structural equation model specifies the causal relationships among the latent variables and describes the causal effects and the amount of the variance. The measurement model specifies how the latent variables are measured in terms of the observed variables, and it describes the validities and reliabilities of the observed variables. LISREL's three basic equations contain four matrices of coefficients and four additional covariance matrices. Random independent variables $\eta_1, \eta_2, \dots, \eta_m$ and random dependent variables $\xi_1, \xi_2, \dots, \xi_n$ are related by the following system of linear structural relations:

$$\eta = B \eta + \Gamma \xi + \zeta,$$

where B ($m \times m$) and Γ ($m \times n$) are coefficient matrices and

$\zeta' = (\zeta_1, \zeta_2, \dots, \zeta_m)$ is a random vector of residuals (errors in equations and random disturbance terms). The elements of B represent direct effects of the endogenous variables on other endogenous variables, and the elements of Γ represent direct effects of exogenous variables on endogenous variables. Vectors η and ξ are not observed, but are related in the measurement equations to the observed vectors $y' = (y_1, y_2, \dots, y_p)$ and $x' = (x_1, x_2, \dots, x_q)$, such that

$$y = \lambda_y \eta + \varepsilon$$

and

$$x = \lambda_x \xi + \delta, \text{ where } \lambda_y \text{ and } \lambda_x \text{ are}$$

coefficient matrices, and ε and δ are vectors of error terms.

The following assumptions are made,

1. ζ is uncorrelated with ξ
2. ε is uncorrelated with η
3. δ is uncorrelated with ξ
4. ζ , ε and δ are mutually uncorrelated
5. $I - B$ is non-singular (i.e., that $1/I - B$ exists), simply meaning that none of the equations in the model is redundant.

The eight matrices specifying the theoretical model contain numerous fixed coefficients (mainly 0's and 1's) and

several free coefficients whose values are to be estimated (primarily the coefficients of B , linking the endogenous variables, and of Γ , linking the exogenous and endogenous variables). With the maximum likelihood estimates (MLE) method, initial estimates for the free structural coefficients are computed by LISREL using two-stage least-squares methods. These values are used to calculate a model-implied covariance matrix among the observed indicators (Σ). Comparison of the model's predictions (S) with the observed reality (the actual observed covariances) provides the fundamental basis for testing a model's adequacy and for obtaining reasonable estimates of the model's coefficients. (Hayduk 1987: 107). The first estimates are progressively improved upon by using first, steepest-descent iterations and then, Fletcher-Powell iterations to fine tune the initial estimates (Hayduk: 138). Maximum likelihood estimates result from a combination of model and data constraints, since the model constrains the estimates by specifying the variables included in the model and the location of the free coefficients linking the variables, while the data constrains the estimates, since the comparison of the model-and-estimate implied Σ with the data S ultimately is used to select the best set of coefficient estimates (Hayduk 1987: 139). The better set of estimates is the set whose Σ provides a higher

likelihood (i.e. probability) that S could appear by random sampling fluctuations if Σ was the population's covariance matrix.

LISREL maximizes the logarithm of the likelihood ratio based on the statistical proof that "minus twice the logarithm of a likelihood ratio is asymptotically distributed as a χ^2 variable with degrees of freedom equalling the difference between the number of free coefficients in the models represented in the denominator and numerator of the ratio. LISREL calculates this likelihood ratio χ^2 , its associated degrees of freedom (d.f.) and its probability. If the chi-square probability exceeds the usual 0.05 criteria, we must accept (or fail to reject) that the differences between the model-implied covariance matrix Σ and the observed S are small enough to be sampling fluctuations. However, Hayduk (1987: 161) suggests that "since accepting the null hypothesis amounts to accepting one's theory (a reversal of the usual role of the null hypothesis), it would seem preferable to use a 0.1 or even a 0.2 level of significance".

Identification and collinearity problems can arise when "the combined force of the theory and the data constraints are insufficient to determine unique estimates of the structural coefficients" (Hayduk 1987: 140). If more than

one set of coefficients result in the same best fitting Σ there is an identification problem. If a coefficient is unidentified, there may be a wide range of acceptable values, and thus large standard errors may signify unidentified coefficients. Very unreasonable estimates also suggest identification problems as do impossible estimates such as negative error variances, negative endogenous variable variances and standardized coefficients exceeding 1.0. Reciprocal effects and causal loops are a common source of identification problems. Problems can be avoided by always fixing at least one of the coefficients linking the measurement variables and its associated concept variable. The solution to an identification problem is to place further theoretical or data constraints on the coefficients, and thus Hayduk recommends that we should "initially build our model with the minimum necessary (free) coefficients and later add coefficients of dubious use or of interest to others" (Hayduk 1987: 148).

END

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FIN