# Reengineering Engineering: A Glimpse of Late Professionalism

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Thesis submitted to the Faculty
of the
Virginia Polytechnic Institute and State University
in partial fulfillment of the Degree of

Master of Science
in
Science and Technology Studies

December 9, 1999
Blacksburg, VA

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Keywords: Professionalism, Late Capitalism, Occupations, Metaphor

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Abstract

The role of the engineer in the late capitalist society of the last half century has been misunderstood at best. The lack of a consistent job description for engineers in various fields, a lack of job security, and a lack of respect from both industry and society have spawned severe angst in the engineering community. A classic remedy for this situation has been the rallying of engineering practitioners under a banner of increased professionalism. If engineers could make themselves more like doctors and lawyers – the respected members of professional society – they would gain similar respect and job satisfaction.

This project analyzes current state of engineering practice as revealed in the self-image of the individual engineer. A survey of popular engineering literature is employed in order to develop a composite self-image of the engineer: the technical hired hand of industry. 'Professionalization' is then demonstrated to be useless in the improvement of this situation and furthermore, undesirable in the late capitalist social and economic climate of the late twentieth century.

Late professionalism – an alternative to a understanding of professionalism – is offered as a means by which to improve the job satisfaction of engineers in contemporary society. Suggesting that each engineer is free to negotiate the terms, conditions, and length of his/her own employment based on a personal understanding of the job requirements, late professionalism empowers the engineer to adopt a comfortable position in the late capitalist economy. A new metaphor – the commissioned engineer – is employed in support of the late professional understanding of the engineer's occupation.

## Acknowledgments

Though it is only my name that appears on the title page of this thesis, anyone who has been down this path knows that the process of completing such an expansive project is, ultimately, a team effort. This is my opportunity to thank publicly the members of my team, those with out whose help this project would have never taken flight and soared to the heights which it has.

The members of my committee have been instrumental not only in the organization and review of this project, but each individually as inspiration and guide down the path of education. Special thanks are due both Gary Downey and Barbara Reeves for making time in busy schedules and putting up with the myriad of illnesses, changes in employment, set-backs and excuses that have drawn out the process. Further, I am bound to thank them for being mentors, models, constructive critics, and advocates during my entire graduate career.

Interestingly enough, this thesis is the product of and has spanned across three major redirections in my professional life. My thoughts on the subject of engineering professionalism began as the wild musings of a disgruntled engineering student; they further guided my studies as a graduate student in the STS program and they ultimately led me to what I believe is my life's calling as a teacher. In each of these phases I have had the support and camaraderie of dynamic groups of students and educators whom I am proud to call my mentors, colleagues and friends:

- Ron Landgraf and Jack Lesko: for making time for me and encouraging me to follow my heart in the pursuit of knowledge. You have both shown me what it means to be both an educated engineer and a concerned member of society.

- The Materials Response Group: for your support (both emotional and monetary) and for being sounding boards for my sometimes off-the-wall ideas.
- Both of my STS cohorts: for forcing me to 'think out of the box' and seriously examine the sometimes too conservative moorings of my thoughts and ideas.
- The faculty of the St. James School: for giving me a new home and a place to continue my work in engineering education. Special thanks to Miss Amy Andrews for her patience and diligence in proofing my final draft.

Last but not least I must thank my parents, Arnold and Ruth Anne Callaham for their support and guidance throughout the years. It is said that one who knows the student also knows the teacher, and further that one who that knows the child also knows the parent. I hope that in all I do I can live up to those words by providing a true and positive reflection of my parents and the love and respect they have always given me.

There is not room here to thank everyone, but this has indeed been a team effort and ultimately reflects the work of countless people working in harmony. To all of you I say, "Good Job, Team!" and "Thank You!"

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# 1 - Introduction

> "Engineering, as we come to the turn of the century, is undergoing drastic change. Your experiences as an engineer will be significantly different from when I first entered the field."

It is impossible for me to count or even recall the number of times that I heard the preceding statement – or variations on the theme – during my experience as an engineering student. While it was obvious – even before my graduation – that the use of computers and advances in pure and applied science had indeed changed the nature of engineering practice, my work in the social studies of technology has shown me that the professors' comments were at best incomplete.

Though my professors astutely recognized that the practice of engineering would be different at century's end, they did not comment on whether or not engineers themselves would be any different as a result. Would engineers see their role in society differently in light of the changes in technology and culture, or would they continue on filling the same niche with different tools?

Taken at face value, I suppose both situations follow logically. On one hand, the engineer can be seen as simply one who makes use of engineering skills. Thus, as the engineering skills change – as a result of changes in technology – so the engineer changes. On the other hand, engineers can be understood as more than simply users of certain skills or tools. Thus, they should be able to retain some occupational integrity in spite of the changes in technology and society. While both of these opinions have found popularity in certain sectors of contemporary culture – the former in public opinion and the latter in worlds of engineering education – neither is the result of serious inquiry into the thoughts of practicing engineers.

Through a textual analysis of the semi-popular writings of engineers, this project provides a first step toward incorporating the views of practicing engineers into a general commentary about the state of engineering in contemporary society. Such 'views' of engineers are gleaned from the images of engineering practice as presented in the writings of engineers. I have isolated categories common to the images presented by engineers from a variety of stations within the profession, and combined them under a coherent metaphor for the engineer. In doing so, I develop one answer to the question of whether or not engineers have changed along with – or differently from – their specific standards of practice in the late twentieth century.

The latter sections of this project unpack various facets of the relationship between engineers and their employers – or corporate culture in general – in terms of the popular image/metaphor and further suggest a new image/metaphor that will aid engineers in improving their appreciation for their role in the corporate structure. Throughout the recent history of engineering, this understanding has been discussed in terms of "engineering professionalism." Claims to current state of being, or to rightful position, among the traditional professions, have motivated the engineer's search for understanding of self and corporate role. Through analysis of both current and classic engineering texts, this project shows that the concept of professionalism is not the same for an engineer as it is for a physician or a lawyer, and further that the classic, professional tenets to which engineers claim to aspire are not desirable, or even plausible, in contemporary society. I, then, reestablish the concept of engineering professionalism in a framework more useful to both historians of engineering and current practitioners by asserting that it is not a goal, but a process of conversation between employee (specifically engineer) and employer about the proper role and respect that the employee deserves.

To develop plausible arguments for an alternative image of the engineer in the late twentieth century, I show not only that the images are acceptable across a representative section of the engineering community, but also that they are rooted in changes in the current socio-economic climate. To that end, I offer the following section as a cultural anchor for my project.

## 1.1- Background

While it may seem an understatement for engineers to speak of engineering practice changing in the late twentieth century, it is a far greater understatement for a citizen of the capitalist Western world to say that capitalism has changed in the past twenty years. Globalization and the development of multinational corporations, the rise of the service industries, the exploitation of so-called “information technology” and the transient nature of the contemporary work force are all signs that the capitalist model under which the culture operated in the early part of this century is no longer completely accurate or descriptively useful.

Peter Drucker characterizes the recent dramatic change in the socio-economic and technical character of American society as a *divide*, the development of which has changed the worldview, basic values, social and political structures, arts and even our perceptions of which institutions are to be considered ‘key’ (1993, p.1). Further, he considers this *divide* as a paradigm shift, suggesting that looking back from the lee-side – some fifty years later – people would not be able to fully understand "the world in which their grandparents lived and into which their parents were born."

Drucker may have been a bit hasty in his claim that the nature of the *divide* is such that it causes some sort of Kuhnian incommensurability between the members of cultures represented on the two sides. It is well within the purview of socio-economic history and cultural studies not only to remind us of the character of the former culture, but also to aid us in understanding the path taken during the intervening period. The purpose of this section will be to outline some of those changes and to employ them as framework for my project. I will begin by taking a brief look at the social and economic changes that characterize late capitalism. Further, I will locate the engineer as an actor in this history as a means by which to frame my future arguments about the engineering profession.

Though much has been written about the state of the capitalist enterprise in the post-World War II era, I will follow principally the model offered by David Harvey in his 1990 book *The Condition of Postmodernity*. Of the authors that I have read on the subject, he provides not only one of the clearest discussions of the transition between the modes of accumulation that define early and late capitalism, but develops his discussion of the social ramifications of this change in architectural and artistic terms that I believe appeal more to the engineering mind. My addition to his characterization will be commentary from other – and in most cases, more recent – sources which are of significance to the engineering practitioner.

The significance of Harvey's interpretation of both late capitalism and postmodernity as 'historical conditions' bears mentioning here. In using this characterization, he attempts to capture the blurriness of the temporal boundary of these concepts and their dynamic nature. The historical condition is not a historical era (like the Renaissance or the Middle Ages) having characteristic cultural norms and contexts, but is the activity of changing these cultural norms over a period of time.[1] Late capitalism and the associated postmodernity are simply the latest in a recent series of such changes (Harvey 1990, p.328).

In spite of the fact that Harvey seems loath to pin down his 'condition' to any specific time frame, he does hint about the fact that much of the character of late capitalism developed in the wake of a serious recession in the U.S. economy that began in 1973 (Harvey 1990, p. 122). The first major failure of the post-World War II era economy marked the first significant change in the U.S.'s regime of

[1] It is a failure to appreciate the dynamic nature of the historical condition (thus making it an historical era) that is at the heart of much of the criticism of postmodern thought. In treating postmodernity as a specific time frame, one must deal with the question of the amount by which we have deviated from the values and cultural signifiers of the *modern* era (Harvey 1990, p.42). Answers to this question cover the entire spectrum. In offering postmodernity as a dynamic system, the question becomes 'are we changing?' thus leaving analysis of significance for later discussion.

accumulation and political regulation[2] since the Great Depression of the interwar years.[3]

The economic system called capitalism has existed in relatively isolated pockets of both Eastern and Western culture throughout most of civilized history. Stark divisions between the owners of capital and the owners of specific means of production can be represented, in small scale, within any of the other major economic trends throughout history. Technological advances associated with the Industrial Revolution, along with the development of Enlightenment idealism, allowed capitalism to spread and be adopted as a popular, large-scale economic system: Capitalism[4] (Drucker 1993, pp. 20-21).

Developments in industrial technology – especially production, transportation, and communications – along with revisions of the political systems of the West, aided in the development of modes of production, and organization, that characterize Capitalism, as Harvey first addresses it. He securely anchors the 'Capitalism' that he wants to ultimately contrast with 'late capitalism' in Fordist-Keynesian modes of

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[2] For Harvey a regime of accumulation "describes the stabilization over a long period of the allocation of the net product between consumption and accumulation; it implies some correspondence between the transformation of both the conditions of production and the conditions of reproduction of wage earners" (1990, p.121). Political regulation includes the country's monetary policy and general attitude toward business and labor, usually summed up in a broad economic 'policy' like Keynesianism or 'top-down economics.'

[3] It is important here to note that, unlike the Great Depression, which effectively forced a change in the government regulation of business, and thus in the overall regime of accumulation, the recession of the mid 70's was a result of the changing capitalism, providing a witness to the effects of attempts by either capitalists or government, to alter the momentum of a engrained regime.

[4] I use here a capital and lower-case 'c' to distinguish between capitalism as simply a relationship between the owners of capital and the owners of production means, and the widespread economic and

production and regulation (Harvey 1990, p. 120). It is the association of new modes of production based on improvements in technology with the classic roles of the industrial employee that makes the role of the engineer an interesting object for study in this timeframe.

While the mode of accumulation eventually known as Fordism is intimately linked to the River Rouge introduction of assembly line technology in 1913, it is far more descriptive when seen in relation to Ford's vision for capitalist culture:

> What was special about Ford (and ultimately separates him from Taylor) [was] his vision, his explicit recognition that mass production meant mass consumption, a new system of reconstruction, of labor power, a new politics of labor control and management, a new aesthetics and psychology, in short, a new kind of rationalized, modernist and populist democratic society (Harvey 1990, p. 126).

Ford intended that his workers be given sufficient remuneration (via the revolutionary $5/day wage) and leisure time (work days limited to eight hours) to become mass consumers of mass-produced goods.

This change in cultural and consumer mentality dictated the adoption of new social (i.e. governmental) controls to maintain both political and economic stability in the face of the swelling Capitalist enterprise. "The problem, as an economist like

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cultural changes associated with the adoption of this relationship by entire social entities – Capitalism.

Keynes saw it, was to arrive at a set of scientific managerial strategies and state powers that would stabilize capitalism, while avoiding the evident repressions and irrationalities, all the warmongering and narrow nationalism that national socialist solutions implied" (Harvey 1990, p.129). The state adopted these Keynesian roles in the post-World War II era through the development of new institutional powers, the encouragement of corporate capitalists to trim their sails in certain respects (thus allowing them to move smoothly and secure wider profitability) and through the development of an oft-times tedious relationship with organized labor. Social security, the national minimum wage, social health care, and occupational education are all facets of Keynesian governmental policy.

Once again, the rise of engineers as an occupational group is interesting within the framework of developing late capitalism. Although employed by the company, and therefore employees, engineers could not completely relate to labor. For that reason, engineers struggled during this time period with their role in the organization, their need for unionization, and ultimately their role in society.

Because of the inherent contradictions in Capitalism,[5] no operationalized set of government controls can be expected to last indefinitely. The post-World War II boom in the U.S. economy pushed the limits of the Keynesian governmental and social control. The constant stretching of these controls forced the mid-century

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Comments throughout this project will refer to the situation of the engineer in Capitalism.

[5] Harvey 1990 p172.

government to adopt a position concerning Capitalism which Harvey characterizes as 'rigid' (Harvey 1990, p.142).

The rapid increase in mass production/consumption precluded any thought of significant changes in the mode of accumulation through the end of the 1960's. This inertia, coupled with the degree of control exerted through Keynesian governmental policies and an 'over-empowered' organization of union labor, provided few outlets for the pressure derived from the inherent problems in Capitalism. "The only tool of flexible response lay in monetary policy, in the capacity to print money at whatever rate appeared necessary to keep the economy stable" (Harvey 1990). These inflationary tactics eventually led to the mid-seventies recession that marked the significant change in America's economic policies from capitalism to late capitalism.

An attempt to describe or analyze the exact development of late capitalist thought and economics is not within the purview of this project. It will suffice, for my efforts, to suggest that changes in the economy did occur that altered both the *regime of accumulation* and the *modes of social and political regulation.* Harvey characterizes these changes as a switch from 'rigid' to 'flexible' modes of accumulation, outlining the latter as follows:

> *Flexible accumulation*, as I shall tentatively call it, is marked by a direct confrontation with the rigidities of Fordism. It rests on flexibility with respect to labor processes, labor markets, products, and patterns of consumption. It is characterized by the emergence of entirely new sectors of production, new ways of providing financial services, new markets, and, above all, greatly intensified

> rates of commercial, technological, and organizational innovation. It has entrained rapid shifts in the patterning of uneven development, both between sectors and between geographic regions, giving rise, for example, to a vast surge in so-called ‘service sector’ employment as well as to entire new industrial ensembles in hitherto underdeveloped regions (Harvey 1990, p. 147).

Terms such as globalization, service industry and ‘just-in-time’ manufacture along with business practices like Total Quality Management are the catch phrases of the flexible mode of accumulation.

To this point, the effects of changes in the capitalistic mode of accumulation (from rigid to flexible) have dealt strictly with the proliferation of business, economics, management and production. These changes have not existed in a vacuum; they are intimately mated to changes in the social structure and worldview of the world community in which late capitalism operates. As Drucker mentions, changes in economic structure cause a *divide* not only in economics, but also in culture, worldview and other facets of culture. Thus is the case with the change occurring (in the late seventies on Harvey’s reading) from rigid to flexible accumulation. The resultant social changes (together with the economic ones) are packaged in what Harvey terms the *historic condition of postmodernity*.[6]

As ‘Fordism . . . built on and contributed to the aesthetic of modernism . . .” (Harvey 1990, p.136) with its appreciation for the routinized processes, hierarchical structures, and efficient design, late Capitalism has helped in the development of the late twentieth-century culture – Harvey’s postmodernity.

## 1.2 - Engineering Professionalism and Conflict – Late Professionalism

While the preceding section has outlined various changes in both society and the capitalist mode of economic production, I suggest that the engineer, as a professional, is in at least one respect the same now as he/she ever was. Professionalism – for the engineer – is the embodiment of the tension between the status quo for engineering practitioners and their desires to be more than they are. This conflict model of professionalism is what I shall from here forward term *late professionalism* because I feel that while, for the engineer, it has been the dominant model of professionalism throughout the second half of this century, it fits well with the new developments in mode of accumulation and social control in late capitalism.

[6] In contrast to *postmoderity*, *postmodernism* refers to a style in theorizing (as well as art and architecture) which attempts to employ various aspects of the historical condition of postmodernity. An appreciation of the self as fragmented and knowledge as situated within experience, along with the analysis of metaphor and discourse, characterize a postmodern mode of theorizing. This thesis will employ the terminology as follows: The goal of this project will be to characterize the actions of engineers IN postmodernity. While much stands to be gained by understanding such a description through the lens of postmodernism, such an of analysis is beyond the scope of this project.

Edwin Layton analyzed this conflict for the engineers of the early part of this century in his 1971 book *The Revolt of the Engineers*. The engineering professional in the first half of this century struggled to be something more than the Organization Man that the Fordist regime of accumulation demanded. By claiming necessity for freedoms such as autonomy, licensure, societal influence, and education, the engineer sought to improve his/her place in the rapidly growing industrial society. In the following chapter, I will address both the historicity and usefulness of Layton's book and will, further, offer a presentation of exactly how concepts of professionalism bear upon the current regime of accumulation. For the moment, however, it will be enough to say that where the bureaucratic organization of industry demanded loyalty, homogeneity and predictability, the engineering profession sought to establish itself as a collective of autonomous, creative, self-governed individuals in the employ of industry.

It is important here to note that the professional movement did not run totally against the grain of modernist industrial society. Although the engineer as professional was struggling to break free of the hierarchical and authoritarian structure of the early industrial manufacturing community, he fought for the development of unions and, later, professional societies – both hierarchical organizations that would have some governing authority over the actions of engineers across corporate lines. In effect, the professional was still trying to be an Organization Man; it was simply a question of the organization that he/she served. Further, the routinized, codified and specialized forms of knowledge integral to the fifties understanding of professionalism had much to do with the Fordist/Taylorist modes of industrial development popular at the time. Thus, it is not surprising that the audience for which Layton was writing – his contemporaries in the world of engineering – found sentiments in common with the revolutionary society on which he was reporting.[7]

According to Layton, the engineering revolt was eventually quashed by the "reformer's inability to 'produce goods and their own retreat into conservatism in the complacency of the prosperous 20's'" (Meiksins 1988).

The position popular among engineers during the first three-quarters of this century is characterized by Layton in his introduction to *The Revolt*:

> Engineers are unlikely to become revolutionaries because such a role would violate the elitist premises of professionalism and because revolution would not eliminate the underlying source of difficulty. The engineer would still be a bureaucrat (Layton 1971, p.1).

It is important to see that while Layton may be correct in saying that engineers, as a social group, are unlikely to revolt fully against the bureaucratic, industrial status quo, there has been sufficient argument (or even *bona fide* conflict) between engineers and employers, over the past fifty years, to suggest that the question of engineering professionalism is not simply a lost cause. The fact of the matter is that it may be

[7] In this respect, *The Revolt* can easily be read less as an accurate portrait of the state of engineering in the 1920's and more as an apology for the state of engineering in the fifties, sixties and early seventies. It is with this is mind that I offer my interpretations of Layton, and feel justified in

different from what was originally expected.  As I will attempt to demonstrate in the next section, professionalism, for the engineer, may follow the old axiom concerning the good life . . . it may, in fact, be a process and not a goal.

If Layton is correct about the integral relationship between the engineer and the bureaucratic, corporate organization, then it stands to reason that as the nature of corporate culture has changed, so has the role of the engineer.  It may be argued that the influence of bureaucratic rationalization inherent in codified 'engineering knowledge' may outweigh the changing influence of any specific culture – thus leaving the engineer as a bureaucrat looking for a home in a late capitalist corporation.  On the contrary, I think that the role of engineer as 'organization man' is much stronger, and therefore the engineer of the late twentieth century is something different from what he/she was in the fifties and sixties.

The concept of the current era's being the home of an engineer of a different sort is not unique.  Bucciarelli (1996) offers a similar thought in a speech concerning the current state of engineering education.  He characterizes the impact of the changes in world corporate culture in terms of changes between the Weberian *ideal types* of engineer.  Bucciarelli's "fifties type" engineer shares much with Layton's bureaucratic engineer – "a staff employee within a large, well equipped, authoritarian organization; he toils within a bureau defined by its technical focus and his expertise" (Bucciarelli 1996).

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using *The Revolt* as a representation of the historical status with which I wish to contrast the current

The direction in which the engineer is heading in Bucciarelli's account is toward what he terms "nineties type" engineering. Far from a bureaucrat lost in the late capitalist world, the "nineties type" is an involved member of a small, highly diversified workforce. With her own customers, technicians and goals, the "nineties type" engineer exists in a world defined by the services she performs and participates in on a daily basis, not by a rigid and unchanging job description and hierarchy.

If the engineer in the late twentieth century is performing the same role of 'organization man,' but now for a radically different organization, then what is to be said of the concept of engineering professionalism during the current age? I suggest that today's engineers are locked in the same professional struggle that they were in Layton's era. While the engineer is no longer torn between the elitist dreams of the more well-known professionals and the requirements of the corporate bureaucracy, he/she is still engaged in conflict.

The 'just in time' mentality of the service-rich corporate culture in the late eighties and nineties has changed the focus of the conflict between engineers and their employers. The contemporary engineer still desires a position of influence and responsibility within the corporate structure, but the worry is no longer that he/she will be absorbed into the corporate bureaucracy – thus losing the autonomy and respect associated with the societal rank of 'professional.' Instead, there is fear of

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images of engineers.

marginalization and a loss of status by being considered merely a 'gun for hire' or, worse yet, a 'hired hand.'

Professionalism, for engineers, therefore, remains principally the same as when Layton described it. It is not simply about gaining social status and distancing practice from the influences of lower, corporate enterprises – this would not provide the 'hands on' experience that is integral to the engineering mentality. Engineering remains the only 'profession' that is intimately linked with the national economic structure – not only providing services, but also actually creating and producing.

Engineering professionalism in the late capitalist era – an example of what I will further call late professionalism – is the state of dynamic and often heated dialogue with employers concerning the position the individual engineer occupies within the company and ultimately the worth of his/her services. For a late professional relationship to be viable and to provide the necessary job satisfaction for all participants, both the current state of employment (assumed to be suitable for the employer) and the ideal state of the employee must be viable within the cultural and economic framework of the conversation.[8]

The main theme of this project will be to develop new descriptive tools for the current state of engineering. I will examine the images used by engineers to talk about their roles in contemporary, corporate society and then demonstrate that by

[8] This is to say that the late professional dialogue will not ultimately satisfy either participant if either of the 'goals' held by the participants is unachievable in the current socio-economic state. For instance, it would not benefit an engineer of the late twentieth century to enter into a late professional dialogue with his/her employer in an attempt to negotiate a socialist framework for employment.

developing a new root metaphor the same images can be adopted in a late professional model for the engineer to increase job satisfaction. An understanding of both late professionalism and the alternative metaphor for the engineer will then be shown to have the potential for an as yet undetermined change in the contemporary engineering educational system.

# 2 - Situating the Problem

## 2.1 - Writings about Engineers

In spite of the unbalanced approach given the question with which I opened my introduction – "What is the nature of engineering at the turn of the century?" by engineering educators – certain members of the engineering and social science communities have, in fact, seriously addressed the nature of the engineering practice.[9] I have characterized these writings into three groups: historical, social, and philosophical (or design).[10]

One significant genre of writings about engineering practice has come in the form of histories about the engineering profession. These histories may seem mundane, but in fact they offer much insight, because many of these stories fit the mold of modern history and can therefore be read for their underlying social commentaries.

In 1971, Edwin Layton wrote a history of the interwar and early post-World War II period of engineering in the United States. Calling it *The Revolt of the Engineers*,

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[9] I specifically and purposefully restrict my discussion here to engineering practice. Especially in the genre of history, there are a number of works dedicated to engineering projects, specific engineers and engineering institutions. As my project deals only indirectly with these topics and is ultimately about engineering practice, I will limit my review to those pieces of history, sociology, and philosophy that deal, at least ostensibly, with engineering practice.

[10] Upon reflection, and re-reading, it became obvious that the development of a three-part classification for writings about engineers is probably an artifact of the specific STS training that I have received (a core curriculum divided into three sections – history, sociology and philosophy). It will become obvious to the reader that there is much topical, analytical and methodological overlap

he attempted to characterize this era of change both in the industrial direction of the US and in the changing nature of the engineering profession in terms of an insurrection among engineers. He suggests that the engineering community was tired of being considered and labeled as 'organization' men, the hired lackeys of Taft-era big business and the harbingers of progressivism in the Hoover era.

While it is questionable whether or not Layton's assertions concerning history are completely accurate, it is obvious that the social phenomenon that he is trying to explain is necessary to legitimate the actions of his engineering contemporaries. Layton uses his *Revolt* to motivate the cries for professionalism that he was hearing from engineers in the early seventies. By outlining the interwar *Revolt*, Layton describes a historical precedent for the cries for professional status made by engineers in the late sixties. Engineers in the twenties began a battle with industry that had not been brought to a close by the seventies. Layton reminded his contemporaries of this throughout the pages of his book.

The apologetic style of Layton seems to pervade much engineering history. Contemporary authors, like the civil engineer-turned-historian Samuel Florman, have continued to make apology for engineering through an appeal to history. His series of short, anecdotal engineering histories: *The Civilized Engineer* (1968), *The Existential Pleasures of Engineering* (1976), *The Introspective Engineer* (1996a) provide narrative histories of engineers and engineering projects meant to inspire his

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among the various categories. For the sake of organization, however, I have decided to leave this contemporaries. As with Layton's, the historical accuracy of Florman's account is not the question to ask in understanding his work. His books' goal is the motivation of engineers to a certain course of action: civic duty, professionalism, and job satisfaction.[11]

Social studies of engineers and engineering practice are limited in both number and scope. As Gary Downey and his colleagues point out in their "The Invisible Engineer" (1989), throughout the development of contemporary Science and Technology Studies, engineers as a social group and engineering as a distinct social practice had become marginalized because of their close ties to industry:

> Feats of engineering came to be seen as efficient organizational realizations of scientific probabilities rather than craft genius. Engineers lost their visibility as individuals and become instead corporate men buried within organizations somewhere between labor and management, with identities increasingly structured by intraorganizational relationships (Downey, Donovan, and Elliott 1989, p. 190).

For these reasons, engineering practice was marginalized and lumped together with studies of organizational behavior and general professionalism. Serious studies of

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categorization intact.

[11] The above descriptions are not meant to suggest that all engineering histories are essentially social commentaries. Historians of technology often include engineering practice as a facet of the development of technological artifacts.

engineering knowledge and the social processes associated with the design of technological artifacts were essentially lost.

Recently, however, social studies of engineering have resurfaced. The principal setting for these works has been in the realm of engineering education. Anthropologists like Downey have found fruitful ground for research on traditional sociological and epistemological topics in the analysis of engineering education. The breakdown of the scientific model for engineering design, as well as the prevalence of technology in the training and practice of engineering, have opened new questions of exactly what it means to do engineering.

Another large body of writings about engineers and engineering practice has come from a tradition of philosophy of science and technology. So-called ‘design philosophies’ are accounts of the process of developing technological artifacts.

In 1983 Donald Schon constructed a means by which to understand the faltering public confidence in the technical professions in his book entitled *The Reflective Practitioner*. He claimed that the public was quickly seeing through the veil of specialized knowledge that had protected the professions for so long. He suggested that the technical professions should in response begin the process of understanding the nature of what had been characterized as ‘tacit’ knowledge. This understanding lay principally in the development of a concept that he called ‘reflection in action.’

Reflection in action was the process by which the engineer (or in many of Schon’s examples, the architect) called upon previous experience to aid in the understanding of the proper application of technical knowledge. Reflection in action was not necessarily a new means by which design was accomplished, but a means through which standard cognitive science models of design could be mediated in actual practice.

This characterization of reflection in action may lead one to question how Schon fits into the ‘social’ school of design philosophy. Implicit in Schon's work is a sense of the engineering profession functioning as a community in which the professional experiences of almost any member can become part of the reflection of any other. The most obvious example of this is in Schon’s characterization of the teaching method for reflection in action that involves the sharing of the teacher’s design experience with the student during the development of a student’s own design project.

Schon outlines his understanding of the design process:

- The practitioner conducts an experiment in re-framing the problematic event.
- The practitioner judges his [sic] problem-solving effectiveness in terms of an objective function.
- When he cannot apply familiar categories of theory or technique . . . he bring[s] prior knowledge to bear on the invention of new frames, theories and strategies of action.
- Reflection in action is a sort of experimenting (Schon 1985, p.135).

The next step in the development of social design philosophy is the local, social interaction developed by Louis Bucciarelli in his *Designing Engineers* (1994). Although Bucciarelli acknowledges the fully social nature of practicing engineers, he limits the interactions influential upon the design process to those that happen within a specific engineering firm. The firm, on his reading, is the group of engineers and non-engineers who work most closely with a specific artifact. This on a small scale may be an actual engineering firm, but in many larger cases may simply be the department of a large corporation that is responsible for a specific artifact.

The firm is made up of many people, not all of whom are engineers. Thus, Bucciarelli suggests that engineering firms develop 'object worlds' in which discussions of the artifact are held and understood by all members. These 'object worlds' are developed from the experiences of the different members of the firm and are paradigmatically different from those associated with other projects from other firms. In Bucciarelli's words, the design process is

> more than the dressing up of a scientific principle, more than the hidden handed evolution of optimum technique to meet human needs, and more than the playing out of the bureaucratic 'interests' of participants seeking power, security or prestige. In the affirmative, this hypothesis takes the form: *Designing is a social process.*
>
> Executive mandate, scientific law and marketplace needs – all are ingredients of the design process, but more fundamental are the norms, and practices of the subculture of the firm where the object serves as icon . . . . Design is best seen as the social process of negotiation and consensus, a consensus somewhat awkwardly expressed in a final product. (Bucciarelli 1994, pp. 20-21)

Critics of Bucciarelli comment that he makes headway in the understanding of design as a social process, but stops short when he limits the meaningful social interaction to the boundaries of the firm. In support of Bucciarelli's work, I would suggest that a careful application of his methodology – to include a flexible understanding of the boundaries of the firm – would reveal much about the true nature of the design process.

Joseph C. Pitt offers the final view of design that will be tackled here. In some respects taking the next step in socialization of the design process, but in a very real way coming up short of the definition offered by Bucciarelli, Pitt offers design (and all of technology for that matter) as simply a social phenomenon. Couching design as a facet of his overall model of technology as 'humanity at work,' Pitt suggests that "just as there is no scientific method *simpliciter* there is no design process pure and simple" (1998, p.20). Thus design can only be understood as the facet of humanity at work that is the "realistic understanding of the negotiation process" (Pitt 1998, p.74). He elaborates his explanation thus: "The emphasis of the model is on decision making. It stresses continual integration of new knowledge into the knowledge base of the decision makers and continual reassessment of that knowledge base and the values in light of new knowledge" (Pitt 1998, p.74). By simplifying design into two basic components – negotiation and integration of new knowledge – Pitt at the same time frees himself from any claims of routinized design, and opens up his design process to the influences of any social forces the designers might encounter.

## 2.2 - Writings about Other Groups

The preceding section offered an outline of various directions that engineering studies have taken in the last fifty years. Though not exhaustive, the outline demonstrates that engineering and specifically engineers can be the subject of both humanistic and technical studies. While writings like those in the previous section have done much to reveal and analyze the social, historical, and cognitive underpinnings of the engineering enterprise, the methodologies that they represent are not sufficient to advance my project. The purpose of this section will be to review literatures from other fields of study and glean from them certain conceptual and analytical frameworks from which I will ultimately develop my methodology.

Though much of the historical writing of engineers and writers concerned with the engineering discipline has to do with the concept of professionalism and its meaning for the engineering practitioner, they are not often considered part of the larger body of more traditional sociological works focused on the sociology of work.

The sociology of work is associated with many of the other fields of inquiry that make up the conglomerate study of socio-economic culture. For Western – and specifically American – culture, these include the studies of capitalism and labor relations, organizational theory, studies of management, and profession and career studies. These fields of study are neither all-inclusive nor existing in an intellectual vacuum. As I hope to show in this section, the study of engineers as professionals, the study of professionals as occupational groups, and the study of occupations in general are well situated within and related to many of the more dominant and over-arching themes in twentieth century sociology.

The roots of the functionalist sociology of professions lie in the early works of those like Howard Volmer and Donald Mills. In their collection *Professionalism* (1966), they outlined a number of essential criteria with which the overall professionalization of occupational groups could be compared. Central to their argument was the assumption that the occupations historically considered ‘professional’ -- i.e. doctors and lawyers -- could be considered archetypical.

Both the professionalism and the overall efficacy of any group could be determined by how doctor- or lawyer-like the group was. Vollmer and Mills also effectively set the language for professional studies when they outlined a number of basic criteria that could be used in analyzing professionalism. Concepts such as professional autonomy, professional education, professional society, professional opinion, and professional ethics/duties are a part of the specialized knowledge that ultimately defines Vollmer and Mills’ concept of the professional.

The popularity of the functionalist definition of professionalism can be seen in its widespread acceptance among various occupational groups. During the cold war, most major occupational groups made some claim for professional status and the requisite organization and social recognition that it required. In 1968, Richard Hall aided these claims significantly by creating a quantifiable scale based on the Vollmer and Mills approach to professionalism (Hall 1968).

The limited approach to the study of the profession that functionalism offered was popular among occupational groups seeking legitimacy, but it quickly ran out of intellectual steam and became simply a tool for social scientists. This waning of interest in the functionalist approach among scholars prompted Hall to pronounce the death of professionalism studies in 1983 (MacDonald 1995, p. xi). As Keith McDonald explains, Hall may have been a bit hasty in his pronouncement, as the decline in the functionalist approach to sociology was not necessarily a sign of a decline in the overall studies of professions. Conversely, professional studies have expanded their scope to meet the pluralistic nature of modern sociology, finding their niche in each of the multiple ‘other-studies.’

The central work in the new ‘professional project’ is Magali Larson’s 1977 *The Rise of Professionalism* which builds on the work of Victoria Freidson and her departure from the traditional ‘power approach’ to the sociology of occupations (MacDonald 1995, p.2). In a near Marxist turn, Larson suggests that the professional ranks, considered separate and privileged in the functionalist model, are better studied within the wider social, or at least occupational, milieu. That being the case, professional claims for special social standing based on their position in the occupational stratum are debased and the quests of occupational groups – such as engineers – for such status become fruitless. My development of a post-professional model for the engineer, specifically one that is based on a certain level of communication, and on the needs of employer and employee rather than on social standing, will stem from this tradition of professional studies.

My project differs significantly from more traditional occupational studies in that it deals less with the actual practices of the occupation of engineering and more with the ideas and opinions of the engineers themselves. In that respect, I tend to associate my work less with traditional sociology and more with later social psychology practice.

George Lakoff and Mark Johnson, have provided a model for my project in their work on the significance of metaphor and image in contemporary culture. Their 1980 *Metaphors We Live By* suggests that an efficient way of determining the conceptual framework within which an individual or group operates can be analyzed by studying the metaphors they use to describe their situation:

> The concepts that govern our thought are not just matters of the intellect. They also govern our everyday functioning, down to the most mundane details. Our concepts structure what we perceive, how we get around in the world and how we relate to other people (Lakoff and Johnson 1980, p.3).

In the contemporary late capitalist setting, what reality more readily defines individual human experience than the occupation? One attempt at such an analysis of the linguistic and cognitive aspects of contemporary occupations is Young and Collin's collection, *Interpreting Career* (1992). Richard Young and Audry Collin characterize their group's approach to the study of career as "ecological, biographical and hermeneutical" as opposed to "objective and intraindividual" (Young and Collin 1992, p.1). This mode of thinking draws heavily on the early works of linguistic and metaphor studies to provide an analytical tool that sees the career as contextualized by the metaphorical interpretations of the actor. This style of analysis is in itself a novel approach and is similar to that which I will take in the study of a specific career group: engineers.

## 2.3 - Methodology

What I attempted to do above was to situate my proposal among the categories widely accepted in the literature of both STS. However, there is precedent to suggest that such synthetic and academic endeavors would not be sufficient in the eyes of my engineering audience to prove my case.

Gauging from the lack of popularity of non-technical literature among engineers, and, further, drawing from my personal experiences as an engineering student, I suggest that the key to making my proposed thesis acceptable -- or at least palatable -- in engineering circles will be to draw my arguments from practical, experiential, and even somewhat anecdotal, sources. The goal of this section will be to define various sources of pragmatic data and then to narrow the types of data into a set useful to this project. En route, I hope to elucidate, or at least to illuminate, some of the methodological pitfalls that I encountered during my data collection progress. My hope, in doing this, will be to provide not only motivation for my actions but to till the intellectual soil somewhat and thus aid those who may follow similar paths in the future.

While the goal of incorporating the experiences and thoughts of practicing engineers into a coherent statement that addresses the engineer's image of engineering may seem straightforward, it is fraught with problems. As George Lakoff suggests in his *Moral Politics*, the connections between the worldview of a certain group of people and the exact statements made by its members are not entirely clear. Specifically, he claims that the worst way of figuring out the various facets of a person's worldview is simply to ask (Lakoff 1996).

Compounding the difficulty in extracting the worldview from a subject group is perhaps a more basic problematic -- the assumption that all members of a test group are of the same sort. Engineers, though not particularly unique among social groups, represent individuals from various backgrounds and experiences whose work also varies widely. It stands to reason, therefore, that there may exist significant fluctuations among the worldviews of engineers 'on the whole.' Near the end of this chapter I will outline, briefly, some of these differences in the hope of taking account for them in the future development of my analytical models. For the moment, I will focus on developing a methodology for uncovering, gathering, reducing, and refining the experience-based commentary of engineers.

A number of avenues for data collection are available to the researcher whose goal is categorizing the self-images of a large and diverse group of people. Among these are the development of both closed- and open-ended ethnographic surveys and the analysis of archival information for trends in group action. While both of these methods have significant historical precedent and acceptance in worlds of sociology and anthropology, neither is well suited to this project.

The skillful application of either of the above methodologies has much to do with the researcher's access to both time and information. Given that my goal is to understand the development of images about practice across a wide sector of the engineering profession, employing ethnographic survey techniques would require that I have access to a large and diverse group of engineering practitioners. While the university community in Blacksburg is full of trained engineers, most of them are either students or faculty and thus represent merely the fringes of my intended study. Further, even if it were possible to develop a suitable list of engineering practitioners who were willing to participate, the time requirement of developing, administering, and analyzing a suitable survey instrument does not fit into the rather short time frame in which I have situated this project.

The second classic approach to socio-historical projects of this type would be the analysis of archival collections. Internal and external business communications as well as public correspondence could be used to develop a commentary on the actions and opinions of engineering practitioners. These types of data, however, prove to be multiply problematic for my particular study. Principally, it is questionable whether such archives contain the kind of personal statements that are required for a study of this kind. While the records of conversations among practitioners would be very helpful to my project, the types of topics that I wish to pursue are generally reserved for the water cooler and therefore are usually lost to posterity. The further difficulty of finding archives that contain data recent enough to be considered relevant to this project motivates my avoidance of archives in general.

A third vector of inquiry that represents a somewhat novel approach to uncovering the worldviews of a certain group is the thematic, textual analysis of appropriate writings produced by the group in question. While there may be concerns about the effects of editorial bias and the true bounds of the sample in quantitative terms, there are significant benefits in the accessibility of these data and the time commitment necessary for its analysis. Compared with the development of a methodologically sophisticated survey tool, or the finding and reducing of archival data, the time necessary for the thematic literature review is miniscule. Further, the time commitment is controlled fully by the motivation of the researcher, as it does not involve the coordination of schedules between researcher and subjects or distant archives.

A further advantage of this sort of a literature review is the general ease of accessibility of the material. Unlike archival data, which are often holed away and poorly catalogued/organized, published literature is widely available and easy to access. For this reason, the researcher should be able to complete all necessary, foundational research at a single site.

The principal mode of analysis for the data set shares much with certain interpretations of the ethnographic interview.[12] The goal of reading any text is to allow the author to speak for him/her self. The role of the researcher is, therefore, that of transparent sorter of the data – sorter in as much as he/she will be responsible for the isolation of themes or categories from the authors' comments and then the grouping of like passages along those thematic, categorical lines. The 'transparency of the analyst' refers to the analyst's attempt to avoid imposition of preconceived categorization based on personal experience.[13] Using the 'sociology as social science' rhetoric of many philosophers, the analyst aims to ensure that his/her observations are not theory laden.

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[12] Here I specifically refer to the methodology offered in Briggs' *Learning How to Ask* (1986).

[13] Feminist standpoint theorists, such as Donna Haraway, would argue that this type of transparency, especially in a literary analysis, is impossible. In her 1987 discussion at UCSC entitiled "Reading Buchi Emecheta: Contests for 'Women's Experience' in Women's Studies", Haraway argues: "Readings must be engaged and produced; they do not flow naturally from the texts." Readings and analysis of texts often have as much to do with the situation of the reader as they do with that of the author. In the absence of an interactive mode of the interview setting -- where both the interviewer and the interviewee are at liberty to explore the influences of situated knowledges that each

The key assumption in this methodology – as it is in other limited surveys and ethnographies -- is that the opinions expressed in the written works of a certain group are not those of the authors alone. Assuming that, in most cases, the opinions of a population are influenced heavily by their professional and personal experiences, the researcher can map the opinions of the authors of a group of literature onto its readership. In this way, significant categories extracted from the writings of a few authors can be taken as representative of the worldview held by the wider group of readers. These assumptions, coupled with the ready accessibility of published literature in the university setting, make the development of a suitable sample much more feasible.

While the survey of widely read literature can provide insight into the ideas and opinions of both authors and readers, it is limiting in a number of important areas. Primarily, any published work is subject to editorial bias. This is most particularly the case with magazines popular in engineering societies. Although the goal of each magazine is to provide a venue for members of the society to voice opinion, the editorial boards must balance the appeal to readers with the idea of keeping the society's best foot forward. Further, since these magazines do not fall into the realm of 'scholarly works,' they are not held to the same standards as peer-reviewed publication. Articles and commentaries are often published as written or reviewed by

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brings to the table -- all readings become "mis-readings, re-readings, partial readings, imposed readings, and imagined readings, of a text that is originally and finally never there."

the editorial staff. The merits of the works are seldom determined by the author's peers prior to the works' publication.

Another limitation of the literature review method of data collection is the inability of the researcher to dissect specific categories of interest. Unlike the interview setting, where direction of conversation can be altered slightly to help the respondent explain better certain facets of his/her experience, analyses of an author's writing are limited to the content of the article. While claims that are more profound can be inferred from a synthesis of multiple works from a single author, or from his/her personal background, it is nearly impossible for the researcher to find answers to specific questions of interest.

Compared to social scientists, and despite their stereotype of illiteracy, engineers are extremely prolific writers. This does not mean, however, that the wider public appreciates or even reads their work. Further, only a very small percentage of their writing is of the reflexive[14] nature that would be useful in this project.

Of the over 2600 journals and conference proceedings listed in the Ei COMPENDEX®, less than one-quarter of one percent are dedicated to the reflexive study of engineering.[15] Further, the scholarly journals listed have a readership and

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[14] Reflexive is here taken to includes writings concerning the many non-technical aspects of engineering. Appendix B lists (by topic) the number of articles published in each year by each of the magazines in the study. While topics listed there are by no means exhaustive, they should provide the reader with sufficient context from which to develop an appreciation for my definition of reflexive.

[15] Notable among these titles are *The Journal of Engineering Ethics, The Journal of Management in Engineering,* and *Ethical Problems in Civil Engineering.* For the most part, every major engineering professional society publishes, or contributes to, a journal of this type. However, when compared to the massive number of journals published by these groups on technical subjects, the reflexive journals tend to get carried away in the flood.

editorial staff that is principally academic – once again, representative of only the fringe of my proposed study group.

An often overlooked but substantially more fruitful source of information on the opinions of engineers is what I call 'popular' engineering writing. I am here referring to the various magazines published by the national engineering societies. Most of these magazines are the literary descendants of the local newsletters that chapters circulated among society membership in the early part of this century. I term them popular because these magazines provide a venue for members from all stations within the profession to write articles and columns of presumably general interest to the rest of the professional society.

In recent decades, more and more societies have adopted the magazine format as a means by which to disseminate information to a national audience. This rise in the number of magazines published by traditional societies has been coupled with the last decade's boom in the founding of new, more specialized societies such that there are now no fewer than thirty-five monthly popular engineering periodicals.

**Table 1: Titles included in the review of popular engineering literature.**

| Title | Society[16] | Initial Publication | Readership | Period | Availability |
|---|---|---|---|---|---|
| Aerospace America | AIAA | 1962 | 50,000 | Monthly | 1984 - |
| The Bent of Tau Beta Pi | TBPi | 1900 | 89,000 | Quarterly | 1997 - |
| Chemical Engineering Progress | AIChE | 1903 | 58,000 | Monthly | 1970- |
| Civil Engineering | ASCE | 1930 | 100,000 | Monthly | 1980 - |
| Engineering Times | NSPE | 1978 | 60,000 | Monthly | 1997 - |

[16] See Appendix A for a list of Societal Abbreviations.

| | | | | | |
|---|---|---|---|---|---|
| IEEE Spectrum | IEEE | 1963 | 95,000 | Monthly | 1980 - |
| Mechanical Engineering | ASME | 1919 | 115,000 | Monthly | 1966 - |
| Prism | ASEE | 1991 | 11,000 | Bimonthly | 1991 - |

This project will examine a disciplinarily representative cross-section of popular engineering literature. Table 1 presents circulation, publishing, and availability data on the magazines that will be used in this study. This grouping contains the primary popular publications of the principal society in each discipline.

Fields included in the study represent the major historical landmarks in engineering disciplinarity. Certainly, Civil and Mechanical are the two principal traditions upon which much of what we know of modern, Western engineering is founded. While it can be said that all engineering disciplines are merely spin-offs of these originals, and therefore, my study could be limited ultimately to these few, the Electrical and Chemical disciplines are the result of major re-evaluations of the purview and practice of engineering, and thus must be included.

The inclusion of Aerospace, alone among third-generation disciplines,[17] was intentional and the result of a hunch that this group of engineers would have more to

[17] A 'generational' approach to the development of engineering disciplines suggests that Civil and Mechanical are the two roots of all modern engineering practices. Advances in science near the turn of the century led to the development of second-generation disciplines, including: Chemical (ME + chemistry), Electrical (ME + Physics), and Mining (CE + geology). Third-generation disciplines are the twentieth century result of the splintering and reorganization of other disciplines to answer the call of the public or industry. Notable among third-generation disciplines are Aerospace and Ocean (from ME), Materials Science (from ME and ChE), and Industrial (from ME). Dr. Gary Downey developed this model for use as a tool for explaining the development of engineering disciplinarity in the United States. My paraphrasing appears here with permission of, and is informed by a number of personal discussions with, Dr. Downey. A similar yet less refined sentiment is echoed in Tiedman (1990) where he suggests that "each new technology and national need spawned a new engineering discipline."

say than others about the differences between Cold War and post-Cold War engineering practice.

The final two societies in the list were drawn from a number of cross-disciplinary societies that have developed during the history of American engineering. These groups represent special and sometimes unique interests that are nonetheless the concern of engineers from a variety of backgrounds. In this case, the organizations that I chose represent those engineers with interests in professionalism and in education. The choice of the National Society of Professional Engineers seemed clear because concepts of professionalism are at the heart of my discussion. Further, the inclusion of the education society had much to do with my own personal experience as a member of the organization, and the idea that what engineering practitioners contribute to the image of their jobs is the result of the socialization that occurs during their educational experience.[18]

A further limit to the data set was constructed along historical boundaries. As was mentioned in the introduction, and hinted at again in the literature review's discussion of postmodernity, the end of the Cold War has been pointed to as a cusp in the development of many disciplines. The same holds for engineering disciplines. For this reason, the end of the Cold War was seen as a proper historical bound for this study. Acknowledging that rapid changes in social thought do not filter to all human

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[18] The data set was further augmented by a small number of articles from alternate sources and time frames. In the development of the data set, I ran across a number of articles that I felt would make significant contributions to the project in general. The number of these articles is sufficiently

endeavors simultaneously, it was thought best to move the bound forward in time to 1990 – thus allowing the momentum of Cold War thought to run its course in the literature.[19]

A search bounded by the list of magazines in Table 1 and only those available and published after 1990 yielded approximately 4200 articles and editorials.[20] Previous analysis of a more limited data set suggested that of the 4200, 420 would be of the type that could be termed 'reflexive.' While this number represents only 10% of the total, it still would have been a daunting task to reduce.

Including only specific topics with direct bearing on this project put further limits on the data set. In those magazines that published yearly indices, only articles that were classified in certain index categories made the cut. Categories of interest to the project included, but were not limited to: education, professionalism, management, career planning, litigation. For the remaining magazines, a quick scan of the title and first paragraph of each article provided the basis for inclusion or exclusion. The target for the reduction was to develop a set of fifty to seventy-five articles, written

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small that they should not contradict or falsify the statements made concerning the importance of limiting the initial study.

[19]It became obvious during the analysis of the data that the opinions of the engineers continued to change well into the nineties. The difference between Cold War and post-Cold War thought was stark enough to all for an easy exclusion of comments that were anachronistic.

[20] This number was arrived at by extrapolating data developed during the competition of a class project from STS 5105, an analysis of the variation in understanding of engineering concepts such as design between worlds of academic and private sector engineers. In this study, articles from the 1990-1997 issues of both Mechanical Engineering and Civil Engineering magazines were reviewed. Approximately 600 articles were published in each magazine over the eight-year period of the study. Since the remainder of the magazines included in this study are of the same type, length, and frequency of publication, it seemed appropriate to offer a multiple of seven times as an approximation of the total number of articles.

from a variety of stations within the engineering profession, from which can be gleaned categories describing the current worldview of engineering practitioners. The actual data set is included as Appendix B.

Using this data set, I attempt to lay out in the following chapters my description of the current self-image of the engineering community. Further, I examine how this image falls short of the engineers' hopes for their profession and is the source of much angst and a general lack of job satisfaction. The final chapter of this project uses the same data set to offer an alternative image of the engineers that can be used to help them assume a more appropriate late professional position in the industrial work place.

# 3- What Engineers Do – The Engineer as Hired Hand

The preceding chapter outlined a unique approach for collecting of data about engineers' images of engineering practice. The first thing that I noticed upon completing a review of the data set is that there are two distinct images embedded in the way engineers talk about what they do. The primary image can be best understood when divided into two descriptions: the first, a serious and sober commentary on engineers' roles in the corporate organization, and the second, a lament about the lack of job satisfaction that their current situation provides.

The current chapter outlines the sober view of engineering practice and examines what it reveals about the engineer's role as a late professional. The next chapter examines comments by engineers that demonstrate how the popular image is insufficient to promote job satisfaction. These, too, are examined in light of what they can add to the description of engineers within a late professional framework.

The second type of image that can be culled from the data set is a much more optimistic description of the engineer. The final chapter presents this additional commentary as the foundation of a new root metaphor for engineering practice, education, and a late professional understanding of occupational dynamics.

The dominant image of the contemporary engineer is developed in the writings of mid-career engineers, their supervisors, and professional journalists.[21] It focuses on the engineer as a problem solver and on the development of the engineer's career. These views are usually couched in terms of 'what young engineers need' to succeed in the corporate world. It is interesting to note the use of the word 'success' here rather than satisfaction. As will become obvious in the next chapter, the successful engineers – those who fit well into the dominant image – are not always the most satisfied with their position.

## 3.1 - Problem Solver

Engineers often describe engineering as the 'design profession.' In stating this, engineers hope to situate themselves, for the non-engineer, in the development and production of new products. Key, then, to the development of a dominant image for engineers is the way in which engineers and engineering employers treat the term 'design.' As I will demonstrate directly, the contemporary understanding of design in industrial parlance has very little to do with any creative or artistic process. Design for the engineer and his/her employer is a methodology employed to solve the problems of industry, especially those where increased technology is seen as a suitable solution.

[21] References to specific authors in the body of the texts are offered in standard format. For information on the stations of specific authors, see the characterization of articles and authors presented in Appendix B.

To understand how this image is developed, it is necessary to begin with the shared educational experience of most engineers. The university curriculum is the place where the majority of future engineering practitioners get their first exposure to the dominant image of the engineer.

Since the 1955 publication of the Grinter Report,[22] the central facet of engineering practice has shifted away from traditional, craft-based skill to more analytical and scientific pursuits. Expansion of the pure science content of undergraduate engineering education and the development of *bona fide* engineering sciences have shifted the emphasis of education from the synthetic and creative to the routine and analytical.

An ironic example of the wide reach of the analytical turn in pedagogy deals with what is traditionally considered the most synthetic facet of engineering practice: design. Considered by some to be the manifestation of pure, creative ingenuity, design has become, in the last forty years, simply another scientized instrument.

An early example of the *design science* movement in engineering education is John Dixon's 1966 design textbook, which has become the standard, or at least a model, for most design coursework in the latter half of this century. For Dixon, design is a science: "an activity that can be researched, analyzed and taught" (Dixon 1966, p.vii), the perfect capstone to the pre-employment experience.

[22] The Grinter Report is the name commonly given to the 1955 American Society of Engineering Education's report on trends in engineering education. It is generally held that this work laid the foundation for many of the changes in engineering pedagogy that occurred during the second half of

Dixon made a statement recently that both summarizes his view of engineering design, and shows how little popular thought on the subject has changed in the past forty years:

> Design is the process of adding to or modifying the information known and recorded about artifacts to be manufactured for human use. Here *design* refers to engineering design: the part of the total process that encompasses determining the physical concept, embodiment and configuration; selecting materials and processes; and assigning dimensions and tolerances (Dixon 1992, p.75).

Noteworthy in this comment is the isolation of so-called ‘engineering design’ from other design pursuits. While engineering design results in the creation of new artifacts, it is not necessarily synthetic or creative. It is not ingenious. “Engineering design is not an art” (Dixon 1991, p.66).

It would be easy to dismiss the scientization of engineering practice a simply an artifact of the necessity of fitting engineering’s tradition of artistry into the mold of a teachable discipline.[23] That, however, is not the case. As early as the beginning of the engineering science movement, it was thought best that engineering practice, as

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this century. Most notably, the report emphasized the need for an increase in the pure science and “engineering science” content of undergraduate engineering education.

[23] By ‘teachable’, I have in mind that a subject fit well into the traditional models of lectures, projects, and grading that are central to the university model of education. In order to evaluate objectively the creative skill of engineering students, all facets of engineering must be reduced to routinized, sequential, and quantifiable parts.

well as education, be altered to reflect order and routine.  Dixon himself outlines an application for his design science in the engineering workplace:

> The objective of courses in engineering design is to help the student develop skill in applying what he has learned in his science, engineering science, social studies and humanities courses to the solution of practical engineering problems (Dixon 1966, p.9).

The role of the engineer in the workplace was preparing practical solutions to technical problems, for Dixon and his contemporaries.  Problem solving remains the primary job description for engineers in the late twentieth century.

From the vantage point of the academy in its role of training young engineers for positions in industry, professors like Eugene Covert of MIT see problem solving as integral to success in the early part of the career.

> The initial and possibly the most important goal of any aerospace engineering program should be to prepare four-year graduates to cope successfully with their first few entry-level technical assignments. Such a program should provide them with the conceptual background and intellectual tools that will enable them to formulate problems properly.  It should also give them the self-confidence and sense of responsibility needed to solve those problems quickly and accurately (Covert 1992, p.21).

Managers, and those who hire and use engineers in industry, make similar points. Daniel Crean, a senior processing engineer for a California chemical engineering corporation, highlights an eerie agreement between industry and academy by suggesting that, “at its purest, engineering is about solving problems.” (1995, p.5)

Linking the need for engineers to solve problems, rather than being generally creative, directly to the profitability of the company, Leland Nicolai, an engineer and program manager for Lockheed, explains:

> Companies are of course in the business of making money. On technology, however, they lose money, since technology, by itself, is not sold. [. . .] Typically less than 15% of industry engineers – or more correctly engineering scientists – are developing new technologies.
>
> Industry does make money by designing, building and selling products. Thus it needs energetic engineers who can solve open-ended problems (Nicolai 1992, p.31).

This is not to say that industry has no need of creative people to discover new ways of doing things (Nicolai’s ‘technologies’); this is the realm of the scientist. He continues his argument by placing the engineer firmly within the traditional roles present in the development of marketable goods:

> Engineers do not discover new technologies – that is the task of the scientist. Nor do they build a product – that is the job of the craftsman or technician. Engineers do apply technologies in designing products (Nicolai 1992, p.30).

It is not only the role that engineers play in the development of products that helps to form the current image of the engineer, but also the connections between the engineer and the other members of the industrial workforce.[24] The subject of the following section will be to add a relational facet to the image that we have so far of the engineer as problem solver.

## 3.2 - Team Member

The classic professional model suggests that the preferred employment situation for an engineer would be self-employment or more likely membership in a small, independent firm. While this may have been the case for certain groups of engineers in the past, it is no longer.

Either in a modern corporate setting or in a small firm, the engineer is a participant in the workplace dialogue that defines working culture:

> In engineering, the day of the brilliant loner, if they [sic] ever existed, is largely over. Engineers have to develop skills and qualities needed to contribute to a group: selflessness, subsystem interface management, interactive design, leadership and followership (Augustine 1994, p.26).

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[24] There is significance not only in the connections between engineers and the other members of the industrial workforce, but also in a recent trend that sees engineering graduates taking jobs in fields other than engineering. Writing about the pervasivness of engineers taking jobs in other non-traditional and often non-technical fields, Beth Panitz states: ". . . engineers bring more to the workplace than an understanding of technology. Engineers also offer the problem-solving and logical-thinking skills that come in handy in many careers. After all, what employer can't use someone who can find workable solutions to the company's problems?"(1996, p.24).

With this in mind, it seems logical that as the last section determined the job function of the engineers, this section would look at how engineers use this job function to deal with their coworkers.

The rise of the late capitalist culture has had marked effects on the workplace dynamic. As lead times and production schedules have been shrinking during the communications and transportation boom of the late twentieth century, industries' ability to maintain huge amounts of overhead – including hierarchical, bureaucratic management structures – has been shrinking as well. 'Just-in-time' manufacturing requires 'stitch-in-time' management.

In order to reduce the human resources necessary to run an organization, industry has been flattening hierarchical management structures by removing middle management. These changes are being effected both internally and externally under the rubric of Quality Improvement, service mentality, and Total Quality Management (TQM).

TQM[25] is not exactly 'managing by teams' or even 'management by removal of middle management.' The concepts of team management and organizational flattening are much older than the TQM revolution of the 1980's, and for the same reason, TQM has much more to do with quality assurance and building customer loyalty than it does with specific management styles. The link between the two,

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[25] The ideas presented here are a synopsis of several exposures, over the years, to TQM concepts and goals. Lesley Muro-Faure provides a complete introduction to concepts of Quality Management in her *TQM: A Primer for Implementation* (1994). Specific application of TQM concepts to engineering organizations is offered by Graves (1993).

however, is unmistakable. Failures in quality and cost efficiency are often linked to inefficiencies in the management structure of the organizations. Further, a proven method for increasing the quality of any process is by gaining 'buy-in' from those who occupy stations along the production process.

The above tenets of TQM have developed a culture that empowers the lower levels of the industrial hierarchy, giving each member of the 'production' or 'quality' team increased influence on the total process. In doing so, it has eliminated middle management and reinforced a collective, or team, mentality within the workplace. This groupthink requires team-minded individuals as participants and is not limited strictly to the business (accounting or finance) and production/technician members of the process. Vilma Barr, summarizing the comments of commercial consultant and engineer Preston G. Smith, speaks to the nature of engineering and production teams in the late capitalist era:

> As new products incorporate a growing number of diverse technologies, engineers from a number of disciplines must work together to meld their expertise. In addition to mechanical engineers, the modern project team often includes electrical, optical and software engineers, as well as specialists in manufacturing, industrial engineering, marketing and purchasing (Barr 1990, p. 48).

The team-based concepts of consultants like Smith have not been ignored. Leaders in the business community have reiterated the need for all members of their organizations, especially engineers, to have skills conducive to working in a team environment. Tommy Hodge, president of Miliken and Co., suggests:

> The first category [of desirable skills] is interpersonal skills. Written and presentation skills head the list here. At Miliken, our engineers have to write about and stand up and explain improvements that they've made. Team skills fall into this category too. The individual out working on a job is a thing of the past. People have to be able to work together and function in teams (quoted in Friday 1995, p.14).

James Heilmeir, president of Bellcore, adds, "We're also looking for students who have the ability to understand the full impact their contributions make. In other words, we're looking for students that have a systems perspective" (quoted in Friday 1995, p.12).

The need for team skills, as defined by those who hire engineers, has also reached the ears of engineering educators. Though not totally incorporated into all facets of engineering pedagogy, engineering educators like Harvey Bernstein of MIT are beginning to come around:

> One of the greatest criticisms of engineering graduates is that they don't understand how to be a contributor to the project team. They have spent too much time studying on their own. Their education doesn't prepare them for a team environment, solving problems as they arise by building upon the expertise and strengths of the various members of the project team (Bernstein and Pillers 1997, p.6).

For TQM to be truly effective, the necessity for team skills must not simply be in the minds of top managers, consultants, and educators of engineers, but also be at the forefront of each member's commitment to the process. Reflecting that sentiment, a 1996 survey conducted by ASME placed 'teaming and teamwork' at the top of the list of *What Emerging Engineers Need to Know*.[26]

In describing how engineers are required to participate in the corporate setting, we are nearer the finish of our characterization of the current image of the engineer in late capitalist culture. It is clear now that in any given corporate situation, the engineer's principal role is that of the problem-solving member of the production team.

<u>3.3 - Career Developer</u>

Probably the most widely written-about subject of any included in this study is career development. It stands to reason that career development, for any member of the industrial community, would be important in a market economy. Working for the majority of one's adult life is central to participation in advanced culture.

A notable difference between the descriptions of engineers now, versus those twenty years ago, is who, specifically, is in charge of maintaining the career of the engineer. Recall Bucciarelli's "fifties type"engineer. He/she joined a corporation immediately after graduation and, barring major life changes, stayed with that company until retirement. During the engineer's tenure, the corporation monitored

[26] The results of this survey were reported in Michael Valenti's *Mechanical Engineering* article "Teaching Tomorrow's Engineers" (listed in Appendix B). The premier place of teaming and teamwork reflects the fact that 94% of industrial respondents and 92% of academic respondents listed teaming as either 'very important' or 'somewhat important' in their responses.

his/her advancement and aided him/her in finding those personal development opportunities that were beneficial to the company.[27]

The “nineties type”engineer has no such opportunity. Chris Tagone of Oxychem explains:

> Most companies today focus heavily on short-term profitability. In some firms, therefore, professional development is not a high priority because it is perceived as not directly impacting the bottom line in the short term (Tagone 1994, p.83).

While the services that engineers provide are seen as assets to be used in the productions of goods, they, themselves are expendable, quickly outdated and transitory. Ultimately it does not benefit a company to keep the traditional ‘stable of engineers’ ready for use in any project. Engineers are assigned to projects for which they have the necessary skills. Once a solution is developed, the engineers are released to another, similar problem, or to fend for themselves. “It has been said that the half-life of our learning may be as little as seven years,” suggests Tony Huff, a professional engineer in Kentucky. “To stay up-to-date and competitive in today’s technological world, we must continually educate ourselves as individuals and as a profession” (1996, p.72).

Continuing education, especially self-initiated and self-funded coursework, has become the new measure for how well one is guarding his/her career and bolstering

[27] This type of company loyalty and job security – offering personal development as a part of the

his/her career potential.[28] The near narcissistic importance of bettering one's own career value is reiterated by Merle Likins, a P.E. at Johnson Yokogawa:

> The individual engineer practicing in industry today must actively promote his or her own career just as those in private practice have done all along. As one works on the current assignment, one must also be actively pursuing the next assignment. This evolving paradigm will inevitably lead to a different relationship between the company and the individual engineer (1996, p. 5).

The new relationship of which Likins speaks is one of temporary employment and a lack of loyalty on the part of either employer or employee. "Career advancement seems to be a mystery to most companies that I worked for," explains Dan Bradshaw, a reader of *Chemical Engineering Progress*. "One thing that is amazing is how much more you're worth to another company than your current one" (Mascone 1995, p. 108). Another participant in the same survey writes: "Changing employers gave me diverse experience that varied from plant engineering and management to consulting project engineering." These are the opportunities once provided by employers, but

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in-house career path – reminds me of a softer version of Henry Ford's programs to develop his work-force by requiring each worker to be clean living and of good character.

[28] As is his style, Samuel Florman offers an interesting twist on the question of continuing education in an *Engineering Times* article (1996b). He suggests that while engineers of the past decade have been scrambling and using up all of their free time accruing continuing education, they have missed out on valuable opportunities to better themselves both as engineers and as human beings. His remedy for this state is for engineers to make an honest attempt to take a more active role in their companies, communities, and families, assuring ensuring the reader that this will provide for a much more rewarding career than any retooling could.

now left to the engineers to find for themselves, in an attempt to make themselves more attractive for their next change in employment.

Cynthia Tagone provides a summary to the comments of nearly all of the engineers' comments on the subject of career development:

> The bottom line, then, is that each of us needs to recognize that professional development is our own responsibility. No one will ever have as much interest in your career on a daily basis as you do. This may seem cold, but it is the sad reality. You are the one constant within a climate of changing bosses, owners, economic times, and management trends. *You* need to develop a plan that assures your long-term satisfaction and security, particularly in an economic downturn (Tagone 1994, p.83).

## 3.4 - How Are These Late Professional?

The previous sections set out what I have gleaned from my data set of engineering writings. The material describes the role that engineers occupy in the late capitalist world of the late twentieth century. The presence of commentary by engineering employers and educators in the above section suggests that the position that I describe is widely accepted in both the business and the educational communities. In this way, the image provides the first half of a late professional dialogue.

What is missing is the dialogue itself. While the majority of comments presented are from engineers, they are not totally representative. As mentioned before, they summarize only about half of the comments that I read. They provide a sober, considered reflection of the current state of being for engineers. Much of the remainder of the data set deals with what I will call a feeling of angst among engineers. These engineers speak of a lack of job satisfaction that stems from a mis-understanding of what it means to be an engineer. Additionally, the engineers feel that they do not receive the respect they deserve from either employers or peers. The next chapter outlines these desires and further determines whether or not they comprise a suitable position from which engineers can enter into a late professional dialogue with their employers.

# 4- What Engineers Lack and What They Desire

As we have seen, the dominant image of the engineer is insufficient to analyze his/her role as a late professional.  While the image is acceptable to both the industrial and academic worlds, it has yet to be determined if it is perfectly acceptable to the engineer.  If that should turn out to be the case, then the situation that best describes engineering as an occupation is that of a typical worker, a skilled laborer at best, not deserving of professional status within the community.

On the other hand, and central to this project, this image is not totally acceptable to the majority of engineers.  In fact, the major categories of commentary offered by engineers in the data set were of a sort that could best be described as a group longing.  Engineers in public forums like those included in this study are anxious about their positions in industry and have specific comments on how things could be better.  This chapter examines the angst-ridden commentary of engineers and analyzes the way in which these comments bear upon the situation of engineers as late professionals.

## 4.1 – Respect on the Job

By far the most commented-upon anxiety that engineers have is that of respect within the workplace.  Along with respect in the wider community, the respect that engineers receive, or do not receive, from their coworkers and employers makes up the core of the traditional drive among engineers to be counted among the professional ranks.  Sadly for engineers and their job satisfaction, they are not getting, or at least perceiving, the kind and amount of respect that they would like. Says one engineer (a participant in a 1993 IEEE survey on job satisfaction):

> I'd encourage someone to go into engineering today for the technical rewards – it's very satisfying that way. Nevertheless, as far as the personal satisfaction, forget it – engineers get no respect. Upper management in most companies I've worked for have treated engineers sort of like high-priced plumbers (Wolff 1993, p.28).

The most popular characterization of this lack of workplace respect is similar to the image of the temporary employee that I used as a dominant metaphor in the previous chapter. An anonymous respondent to Cynthia Mascone's 1993 Survey of Chemical Engineers sums up this attitude best: "Engineers are generally paid as hired hands at no more than the minimum dictated by the market rather than as professionals paid for our talents and contributions" (quoted in Mascone 1993, p. 90), a thought echoed by Mascone herself when she explains: "The current attitude of general management toward most engineers is that they are a commodity to be hired when needed and fired when not" (Mascone 1993, p.93).

It should be noted that these are simply the opinions of engineers and that engineers, along with many other occupational groups, are suspicious of management practices. This is especially common when workers are directed by managers who are not members of the occupational group. In this case, however, the engineers' suspicions are borne out by employment figures. Increasingly, engineers occupy a transient position in the corporate hierarchy; they are hired as problem solvers, often for specific problems, and then they have their usefulness for the company frequently re-evaluated. The resulting feeling among engineers is that of an utter lack of job security and company loyalty.

> Engineers today will work for as many as seven different companies during their careers. And even if they have chosen to work for a large company, they will be told very early in their employment period: 'The company cannot guarantee that you will always have a job here. You are responsible for your own development and growth' (Bar-Cohen 1995, p.70).

While this employment pattern is not necessarily odd in light of the late capitalist developments discussed in the first chapter, it goes against the grain of what engineers have been hoping for themselves since the fifties. Interestingly enough, the engineers sampled in this study were silent about the kind of job security that they were seeking. It is my considered opinion that the traditional model of the television fifties (fifty years with the same company and a gold watch upon retirement) would be equally angst-provoking for engineers. Finding a median position will be the topic of the next chapter. For the moment it will suffice to reiterate the comments of most of the engineers sampled: "The most important determinants of career satisfaction are interesting and challenging work, personal fulfillment and job security" (Mascone 1993, p.89).

An interesting facet of the discussion about job security and hiring practices among engineering employers is the current debate in the engineering community about the difference between engineers and technicians. An artifact of the problem-solver image of the engineer is the fuzziness in engineering job descriptions. In many cases, the solutions to industry's problems are applications of existing technologies rather than the creation of new technologies or the application of technologies from other fields. Whichever the case may be, problem solving is the purview of the engineer in contemporary society. The results of this situation have been the confusion, in the minds of the engineers in the data set, of the role of the engineer with that of the technician. On their account, engineers are being hired to do jobs that are below their level, suited for technicians, while at the same time, technicians, insufficiently trained[29] in the practice of engineering, are taking jobs away from engineers. Some of the authors sampled go to great lengths to examine the differences between engineers and technicians, in an attempt to guide industry back into correct hiring practices.

> The difference – a significant one – is that the engineer applies his or her knowledge with judgment; the technologist simply applies his or her knowledge. One renders a professional opinion, the other does not. The engineer develops new technology, the technologist applies current technology (Pennoni 1997, p. 6).

A confusion of roles in the workplace is symptomatic of a general confusion in contemporary society about the role of the engineer. The following section will

[29] The American Board of Engineering and Technology (ABET) – the accrediting body for engineering and technical programs at the post-secondary level – has, over the past ten years, gone to great lengths to ensure that Engineering degree programs and Engineering Technology programs have remained distinct entities.

examine the ramifications of this confusion: a perceived lack of respect for engineers by their peers.

### 4.2 – Respect in the Society

"In the U.S., there is no profession with which the public has greater, albeit indirect, interface than engineering" (Medcalf Jr. 1995). However, there is also no profession in the U.S. of which society has such a great misunderstanding. Although nearly every corporation in America has an engineer in its employ, and the Dilbert comic strip continues to be one of the favorites among the reader of the daily news, the wider community has little idea what engineers actually do on a day-to-day basis. Further, even fewer people have an idea of where engineers fit into the production process that develops the technologies that they use everyday. While this ignorance is by no means a malicious ignoring of the engineering profession, engineers interpret it as a lack of respect for their occupation – respect without which they forfeit their professional status.

As is the case with most of the other images that engineers have developed about themselves in recent times, the ideal social status for the engineer is derived from the static, state-of-being centered, classic professional model. In short, engineers want to be doctors or lawyers. Unfortunately, that cannot be the case – as Norman Augustine points out.

> In the Socioengineering[30] Age, engineers' many achievements are largely taken for granted and our occasional failures draw intense criticism. If we were doctors, we would be given credit for the prolonging of life, even if we could not, in the end, banish death (Augustine 1994, p. 25).

Because technology pervades contemporary culture, while at the same time being far beyond the practical understanding of the average user, engineers are doomed to failure. The average user of technology feels comfortable approaching the engineer and complaining about failures in technology without realizing the complexities and unpredictabilities of technological systems. This is completely different from the case of doctors or lawyers who basks in near immunity from criticism because the systems with which they deal are recognized as far beyond the reach of the average person.

Engineers' reaction to the treatment that they receive in the work place is often displaced onto the wider community. While there is little similarity between the engineer at the end of his/her career in industry and the slow sinking into retirement that is experienced by the medical or legal professional, comments of the following sort are still published for the placation of disgruntled engineers:

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[30] Augustine defines the Socioengineering Age as the latest era in the development of technology and its relationship to society. For him, the accident at Three-Mile Island, March 28, 1979, ushered in a new age which has shaken "the American public's willingness to accept on faith every innovation engineers unleash" (Augustine 1994).

> I am continually amazed at how U.S. corporations toss away older technical talent in the engineering field. Why is a 55-year-old MD or lawyer a valued member of society but a 55-year-old engineer not worth keeping on the payroll? (quoted in Mascone 1993, p.91).

Whether or not engineers during any part of their careers are respected as upstanding members of the community is not within the scope of this project to determine. What is evident, however, is that engineers in the workforce feel that they do not get the respect that they deserve either from their coworkers, or from the members of their community. In many respects, the lack of job security and the transient position which engineers experience are unfortunate, but are to be expected in the current economic and social climate. Therefore, it is important for engineers to begin to re-evaluate their anxiety within this new framework. The following section deals with that specific question: Are the worries/requirements of engineers late professional?

### 4.3 - Making Things

In the preceding chapter, I explained the way in which contemporary industry representatives (engineers included) developed the job description for the engineer based on a notion of engineering design. This popular image understands design as a process of developing technology-based solutions to technical problems, thus defining the engineer as nothing more than a problem solver for industry.

A wider reading of the articles in the data set reveals that many practicing engineers would prefer a different understanding of the engineer's role in technology development.  Interestingly enough, the central term for these engineers' ideal definition is the same as for the popular one – design.

Kenneth Waldron, engineering professor at Ohio State University and part-time engineering contractor/consultant, characterizes the feeling as follows:  "I'm here to tell you that the most satisfying experience as an engineer is doing design" (1992, p.60).  The design of which Waldron speaks is not, however, the same as that described by authors like John Dixon.  Where Dixon's design is systematic, a process for process' sake, Waldron describes a design that is more productive, less routinized, and subject to criticism based upon its ends rather than its means:

> I like to use an aphorism that is basically a distillation of something written by Herbert Simon in his book *The Sciences of the Artificial.* 'Science is the study of what is.  Engineering is the creation of what is to be.'
>
> Notice the critical role of the word 'creation' in making this distinction.  The parts of engineering practice are devoted to synthesis, or creation, design and manufacture.  Design is planning for manufacture.
>
> You cannot be an engineer and participate in the creation of tomorrow's technologies without participating in design.
>
> Engineers study the world in order to obtain knowledge that can be used in design.  However, we must always remember that this knowledge is a tool.  To an engineer, science is a means to an end, not an end in itself (Waldron 1992, p.60-61).

For Waldron, the process of design – the design science – is simply that, a science and therefore a means to the end that can be called design. Sidney Guralnick reiterates this sentiment in a comment delivered to colleagues and students at the Illinois Institute of Technology in 1991:

> Good engineering implies imagination, the imagination to conceptualize actual things that are to be manufactured. That is the essential feature that distinguishes engineering from science. Far from being merely applied science, engineering design is a separate and wholly distinct intellectual activity (Guralnick 1992).

Note here the overtone of dissatisfaction with the status quo in engineering practice. Guralnick speaks of 'good engineering' practice rather than simply engineering practice. Though subtle,[31] this dissatisfaction permeates the data set on the question of whether engineering is a process- or goal-driven activity. The importance of the goal, and of creativity in general, to engineering is both a throwback to the craft and

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[31] It is important here to comment on the subtlety with which the engineers in this study express their dissatisfaction. While the magazines and other publications polled are written with the engineering community as an audience, it is well understood by both the writers and publishers that the articles cannot be of an inflammatory nature. It is interesting to juxtapose the opinions of engineers expressed in this data set with those expressed in more engineer specific/private venues. During the early phases of research for this project, I reviewed a large number of postings to internet newsgroups (specifically sci.eng.civil and sci.eng.chemical). Though these venues did not pan out as suitable data sources for this specific project, my exposure was sufficient to draw the conclusion that many engineers in general are willing to express their dissatisfaction with the profession more vehemently in such relatively private arenas than in those more public ones in the engineering magazines.

construction traditions of engineering[32] and a representation of the American spirit of industry and work ethic. Steven Ashley quotes Freed on this subject:

> When asked about their jobs, most veteran engineering managers call themselves engineers, according to Freed. 'They identify more with being engineers, because somehow, management is not considered an honorable profession in their eyes,' he said. This seems to be related to the cultural norms that say that those who produce are valued. 'It is no surprise that engineering managers often find themselves asking – What did I produce today?' (John Freed, management analyst, quoted in Ashley 1993, p.62).

Though the industrial spirit is a cultural norm, it is ingrained in the engineering student throughout his/her experience, and comes from all levels. D. Allen Bromley, Assistant to President Bush for Science and Technology in the Executive Office, included the following comment to his 1991 commencement address at Polytechnic University: "We need more engineers who are not afraid to get their hands dirty, who get their satisfaction from actually making things work, who appreciate evolutionary as well as revolutionary changes" (1991).

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[32] Eugene Ferguson offers a similar analysis of engineering design in his *Engineering and the Mind's Eye* (1994). He suggests that what the engineer has lost in the high tech, process-driven age of design is an appreciation for visualization skills. His development of visualization bears a resemblance to the tactile experience that many engineers claim is the satisfactory part of making things.

Not only are engineers being told the values of personal industry, but also they are responding. In a recent survey conducted by IEEE, engineers spoke out about the intimate link between making things and their level of job satisfaction.

> On design, about an equal number (ranging from 23% to 26%) said they were spending more, less, or about the same time, compared to five years ago. Again, the level of job satisfaction increased for more than 80% of those spending more time on design, and decreased for about 70% of those spending less time (Wolff 1993, p.27).

Wolff summarizes this trend: "Then [1988], as now, the most important element in job satisfaction is the opportunity to be creative" (1993, p.25).

Though engineers are willing to work in an industrial setting that appreciates their skills as nothing more than refined problem solving, they yearn for an earlier time in which they would have been give the opportunity for 'hands-on' product development and the satisfaction associated with 'making things.' Not only, according to these engineers, would this create a heightened sense of industry and job satisfaction, but it would begin to develop the respect among their peers that they feel is their right. The remainder of this chapter addresses two different issues that can be loosely incorporated under the rubric of respect: respect in the workplace and respect in the wider community.[33]

[33] Engineers have, for a long time, been exceedingly conscious of their role in society. An interesting example of this near paranoia is Michael Valenti's article in *Mechanical Engineering*, "Engineers on the Silver Screen"(1991). In this article, Valenti tracks the image of the engineer in film through the ages.

## 4.4 - How Are These Complaints (Not) Late Professional?

Central to the development of my model of late professionalism has been the active dialogue between engineers and their employers over the specific nature of the work relationship. This being the case, concern on the part of the employee – if not both the employer and the employee – is necessary, or else the conversation would not proceed.[34] However, as I explained at the end of the preceding chapter, all parts of the conversation between employer and employee must also fit within the conditions of late capitalism in order for any resolutions to be satisfactory or even possible. The focus of this section will be to analyze the complaints registered in this chapter for their ability to promote late professional dialogue.

The desire of engineers to be the makers of things is a good example of the seed of a post professional dialogue. Whereas industry has adopted an image for the engineer that is of one sort, the engineering community has determined that the image is unacceptable, and thus needs to be altered.

It is important to note here what I failed to mention earlier for the purpose of developing my argument. Proponents of both dominant images were drawn from across the spectrum of engineers, managers, and journalists. This is to say that neither opinion is held solely by one group rather than another. Now, it is clear that the maker image is more popular in the engineering community, while that of the

[34] This is what I earlier referred to as the situation of the skilled laborer.

problem solver is more common to the managers. Nevertheless, each group has developed its own opinions concerning these images.

The danger that has been avoided here is the essentialist grouping of engineers under images. While it is useful to develop categories for groups of people as tools for unpacking traits common to many, it is dangerous to be too specific about exactly how many within the group are defined by the image. It is wrong, under the framework of contemporary social thought, to claim that either all engineers are of a sort, or that there are sets of traits that are necessary and common to all engineers. The globalization and diversification of industry in the late twentieth century should demonstrate the importance of flexibility. As the image to be developed in the next chapter demonstrates, it is up to each individual engineer to develop a role acceptable to both him/herself and his/her employer, based on any of a number of not necessarily pre-determined categories.

Essentialist thinking is also the central problem in the engineers' argument concerning respect. For engineers to claim that all professionals – centering their image on a specific state of being – are deserving of respect, and therefore defined by the respect they receive, is to challenge against late capitalist thinking. Once again, flexibility, individualism, and a respect for the dynamic, multiple nature of the self is important to developing the proper image of the engineer.

It seems to me that the central issue addressed in this chapter has been the concept of job satisfaction. For engineers, satisfying work is centered on three things: stimulating endeavors, job security, and deference from the community. The first of these has already been addressed in this section. Perhaps the latter two are better commented upon separately.

Job security, for any worker in late capitalism, should be a non-issue. To put it bluntly, there is none. The same corporate culture that defines TQM has also been dictating the transitory status of many professionals. High employee overhead, with its requisite benefit packages and payrolls, is not well suited to the high-paced service economy of today. Neither should a life-long commitment to a single employer be desirable to the employee whose goal is to raise and provide for a family in the spatially compressed world of the late twentieth century.

Community deference for the engineer is an equally questionable concept in late capitalism. Proactive social groups have, in many respects, filled communities' needs for saviors from the ills of technology. Moreover, as I mentioned before, the average person's familiarity and comfort with technological artifacts has destroyed the mystique of expert knowledge upon which professionals have built their respect for years.

The next chapter outlines a new core metaphor for the engineer: one around which I develop a number of images which the engineer can use to anchor his/her late professional dialogue. Each image drawn from the new metaphor succeeds where the 'hired hand' metaphor has failed as both generally acceptable but open for discussion in a late capitalist framework.

## 5 – Late Professionalism: A New Commission for the Engineer

The previous two chapters have outlined and examined what I think is the dominant image of the engineer expressed in the data set. I have also shown that both industry's image of the engineer and engineers' specific desires for improvement fall short of what is necessary for the development of a late professional dialogue.

While both engineers and their employers have a good idea of what engineers do in their current, industrial role, this alone is not enough to be considered a dialogue. A one-sided approach to understanding an occupational group places the members of the group in a position of little organizational power, not a position that one would call 'professional.' On the other hand, the image of the professional that is at the root of the engineers' angst about their current situation is anachronistic at best; and furthermore, it is unsuitable for a discussion of professionalism that is limited socio-historically to late capitalism.

The current chapter offers a new image for the engineer that is both late capitalist and dialogic. It addresses many of the points listed as central to engineers' job satisfaction, while allowing enough room for active discussion and negotiation between engineers and employers. The various facets of this image can be taken in whole or in part as a central metaphor for a specific engineer's late professional dialogue, thus making it acceptable to those active in developing current social thought.[35]

Following the development of the new image, I examine various applications for such an image. First, a late professional understanding of Layton's *Revolt* is offered in order to demonstrate the usefulness of the framework across a temporarily wider data set for this project. Secondly, the new image for the engineer is operationalized in the late professional framework to redefine the role of the professional society in the contemporary social milieu. Finally, I comment on the role that a late professional understanding of engineering can play in the new engineering educational system.

## 5.1 - The New Image

As a late professional, the engineer is at his/her leisure to negotiate a position with a potential or current employer. The engineer is, certainly, an employee, but his/her employment now carries with it a larger amount of personal responsibility. Employer and employee are free to negotiate both the nature of work to be performed and the terms and conditions of employment. In developing these images, I struggled to find a guiding metaphor with which engineers might govern their development.

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[35] Here I am referring, again, to the changes in social thought that have accompanied, or at least developed alongside, late capitalism. Feminism, post-colonial studies, black studies and other standpoint theories of social analysis stress the concepts of multiple dynamic identity and situated knowledge. In allowing for the engineer to adopt multiple roles in the late-professional model, I hope to locate my study within contemporary social thought.

Ultimately, I settled upon a metaphor which linked up well with the traditional model for the current state of engineering, industry as an army.[36]

Within the current image, the engineer is seen as the GI of industry, called up during periods of national crisis and kept on for a predetermined period of time with an option to continue service based solely upon the needs of the country. While it is often considered an honor to be called upon by one's country to serve, the role of the GI is looked upon as menial labor, a position lacking in respect. Though GIs are remunerated for their service and self-sacrifice, the brevity of their tenure limits the level at which they can avail themselves of the benefits of membership in the armed forces. In the eyes of the national government, draftees and conscripts are cheap and disposable and neither worthy of respect nor expected to possess a high degree of loyalty.

Another status of employment in the military, and one that I believe has much in common with the late-professional, is that of the commissioned officer.[37] While both the officer and the GI are soldiers, have the same basic job description (defense of

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[36] I realize that a military image may not suit every reader. By the simple fact that in many cultures the image of the Soldier is a masculine one, I run the risk of alienating about half my audience. I hope to demonstrate though that this image was chosen not because I have any wish of transferring the gender bias of the military to engineers, or to suggest that only those engineers that have a latent desire to emulate military service can better themselves as engineers. I simply draw upon my own situation, experience and desires to motivate my explanations.

[37] By using the term commission as a base for my distinction between the roles engineers can play in the industrial setting, I hope to draw not only upon the military metaphor, but also on a relatively obscure portion of engineering history. During the infrastructure boom of the early parts of this century, engineers responsible for the great public works projects were often 'commissioned' (i.e. hired on extended contract) by municipalities for a certain period of time or number of projects. While neither this, nor the military meaning of commissioning, captures entirely my meaning for late

national interests) -- the commissioned officer occupies a different niche within the military culture. Not only are the officers in a military hierarchy given the responsibility of leadership, but they also serve under vastly different conditions. In the historical military, as well as the modern setting, commissioned officers are soldiers contracted by the government to serve at the convenience of both parties. They are salaried employees of the government, in many cases functioning more like private citizens in the service of the government rather than conscripts. Unlike an enlisted person, who at the end of a tour of duty is discharged from service (basically a one-sided decision on the part of the government); the commissioned officer resigns his/her commission – a civilized parting of ways between employer and employee.

Engineers in the contemporary industrial setting are suffering from a lack of job satisfaction because they are appreciated by both their employers and wider society as nothing more than hired hands -- enlisted personnel in the service of industry. Seasonal with respect to projects and transient in their own mentality, they are of little continuing worth to the company. When their services are no longer needed for the current project, they are discharged to find other work on their own.

Engineers stand to gain job satisfaction by adopting and promoting, among their employers, the commissioned officer/engineer metaphor as that which guides their employment relationship. Increased loyalty and provisions for 'buying in' on projects, along with an appreciation of the retained transitory nature that accompanies

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professionalism, I believe the use of this double meaning for commission will aid in my overall the concept of ‘career’ in late capitalism, would give the impression of the needed respect to engineers. The following are some categories that that have fallen out of the data set as popular among current engineering professionals. They all, furthermore, can be related to the root metaphor of the engineer as late capitalist commissioned engineer.

As the title indicates, the commissioned officer/engineer is commissioned by an authority to fulfill a single, yet nebulous role: to be responsible for the progress and welfare of a certain number of projects/people and to use the recourses at hand to advance the overall cause of the employer. In the same manner, a general job description can be developed for the engineer that encapsulates both the desire of the engineer to be a ‘maker of things’ and industry’s desire for the engineer to be a ‘solver of problems.’ The responsibility of the engineer in contemporary industry can be interpreted as that of a creative designer.

The opportunity to be truly creative, meaning to develop ‘that which has not been before,’ is central to the engineer’s angst about current job situations. A wider understanding of the meaning of creativity as important to both tangible artifacts and the solutions to industry’s problems would help engineers to appreciate work in a number of circumstances as more satisfying.

While the teamwork mentality of TQM strives to flatten hierarchical organizational structure, it does not exactly become communal in nature. Each

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argument.

member of the production team is empowered to make a contribution to the betterment of the overall production process. In this happy, empowered situation, there must exist a voice of reason, arbitration, and vision that guides the team to the ultimate goal of serving the customer. In the new image of the engineer, and specifically for teams where design is a goal, the engineer is the logical choice as leader.

Standard commentary on the nature of teamwork and the selection of people and their roles within the team begins with a standard disclaimer:

> The first requirement in filling this key spot [team leader] is to disregard the name of the department from which he or she comes. Since project teams typically include members drawn from engineering, marketing, manufacturing, and purchasing, representatives of these departments should have equal shot at the top job, based on ability (Barr 1990, p.49).

This may in fact be the case, but in developing the role of the engineer in the late professional design role, we must keep two things in mind: the job satisfaction of the engineer, and his/her specific training as it pertains to the design process as a whole.

When it comes to job satisfaction, the preceding chapter demonstrated what Freed is saying when he comments: “The research base says that engineers have high needs for control over their own activities, and therefore the results that they produce” (Ashley 1993, p.62). The activities of engineers that Freed has in mind include but are not limited to[38] the design process and the ultimate production of goods and processes.

In much the same manner, the officer/engineer is the local authority in the field. Although his/her superiors are ultimately in control of the movements and condition of the force, as far as the GIs know, the officer is the boss. For the commissioned officer, authority stems not simply from his/her rank, but because he/she possesses a certain set of skills that include leadership and management.[39]

Those who have analyzed the team process in the production setting have commented on the qualities that make up a good team leader:

> The most vital member of the product development team is a gutsy generalist, a person who's not afraid to dream, not afraid to create something at the conceptual level and then ask, 'Why not?' (Bar-Cohen 1995, p.69).

The assertion here, as elsewhere, is that the engineer fits perfectly into this mold. Not only has he/she been trained to create things 'on the conceptual level,' but he/she is

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[38] A 1993 AIChE poll reinforces and expands the role of leadership in job satisfaction. Not only do some engineers feel the need to be directly in control of the design process, but they want their presence to be felt in other areas. "Respondents seemed pleased at having more supervisory responsibilities, paying more attention to quality and being more involved in financial affairs" (Mascone 1993).

[39] The combination of rank and ability into respect is what separates the commissioned officer from the warrant officer in military culture. The warrant officer program was developed to reward those enlisted men that had proven themselves through mastery of a certain set of skills with positions of responsibility. In many respects this is a complementary metaphor for the position that engineers have desired under the classic model of professionalism, that being one where respect and job security have come simply from mastery of a certain body of codified knowledge rather than from an ability to act both within and apart from the corporate structure.

respected in the industrial community as one who can solve problems in the production process.

The mystique of the soldier across ages and cultures runs the gambit of social roles and stereotypes. For the purposes of this paper, however, I will focus on the actions of the soldier associated with the maintenance of chivalry in the West. Though rooted in the concept that a good soldier – especially a commissioned officer who, ostensibly gave up some position in private life -- would give his/her life for his/her country, soldiers in general gained the respect in their communities as self-sacrificing models of duty and honor. In much the same way, the late professional engineer must negotiate public opinion concerning engineers in general.

> The lesson of this new [socioengineering] age is increasingly evident: Engineers must become as adept in dealing with societal and political forces as they are with gravitational and electromagnetic forces (Augustine 1994).

The societal forces of which Augustine speaks are incident upon the engineer in the form of public opinion, which in the past few decades has become increasingly informed about the developments and workings of technology.

> We technical people have begun to share more and more of the pros and cons of technology with the rest of society, and that's a positive undertaking. But we need to be good at it because technology make many people increasingly uneasy. We need to find ways to help them better understand what the risks and benefits of specific

> technologies are ( Dick Balhiser of the Electric Power Research Institute, quoted in Friday 1995, p.12).

At the risk of stretching a metaphor too far, I suggest that the role of guide and protector suits the image of the commissioned officer/engineer as well. In what has become a vast wilderness of technology and information, the engineer, along with other technically trained professionals, can be seen as an advocate for a society that is sometimes ill-prepared to deal with, and often taken advantage of by, the technology-rich capitalist enterprise.

The role of the engineer in the late capitalist enterprise is not as one-sided as the previous comment may have suggested. While both engineers and the public may desire the advocacy relationship that I just mentioned, most contemporary engineers realize that they cannot adopt this understanding wholeheartedly and without consideration of the relationship that they have with their employer. As mentioned in the preceding chapter, the main complaint of engineers about their current status is the lack of job security that they perceive in their positions. If engineers were to fully become customer or public advocates, especially to the detriment of employer-employee relationships, they might jeopardize their already transient position.

Therefore a balance must be struck between the classic mode of the ‘organization man’ – wholly committed to the success of the company and long term service to one industry – and both forms of the current mode of near-temporary employment. I say ‘both’ meaning the ‘hired hand’ model which pervades engineers’ complaints about lack of employer loyalty and the free-lance, consultant engineer which has operated on the fringe of industry for the past half a century.[40]

The engineers of the late twentieth century need to accentuate their importance to the companies that they currently work for, while constantly preparing for a change in career. This mentality need not be seen as a lack of loyalty on the part of either employer or employee, but as each realizing that there is benefit to both dynamic and static modes of employment.

Benefits of the static mode of employment include the opportunity of both the industry and the engineer to take advantage of the experience gained on any particular project, and the similarity that is often found between successive projects. On the other hand, the opportunity for the engineer to work for a number of different employers over the course of a career, and the related opportunity for the employer to take advantage of the skills of a number of engineers at the low prices for which new engineers are willing to work, are the benefits of the late capitalist economy.

Throughout this re-evaluation of the role of engineers in the economy, it is important to remember that it is ultimately the engineer's responsibility to enact the

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[40] The free-lancer, job-shopper, or consultant is a specific job role that I have purposefully ignored during this discussion for the reason that these represent a near static minority in the engineering community and that they are the subject of mixed reviews among the majority. While their job status is far more transient than that of the average engineer, and their role within the corporate structure is the recipient of far less respect, they are basically happy in their roles. This is because these engineers are highly self-selected and pre-socialized to their role in industry. For this reason, their numbers are small, and they have realized a relatively high level of success in the contemporary setting. Laura Mackail, Executive Director of the National Technical Services Association, reports "We have individuals working in our industry who have chosen a career working on a contract by contract basis. Of our contract employee universe, 44 percent report that their average downtime is less than 30 days, and 70 percent report that their average downtime is less than three

changes that I have mentioned. The momentum and relative success of industry in the past ten years preclude any chance of willful change in the way that it views the engineer. Each individual engineer must take responsibility for his/her own image in the new economy. "It is the responsibility of the young engineer to understand the context of the job so that the knowledge gained from it is portable" (Bar-Cohen 1995, p.70).

### 5.2 - How the New Images Are Late Professional

The previous section outlines an image for the engineer that is useful for helping the engineering community both to realize its role as a late profession, and at the same time to aid engineers in gaining the job satisfaction that the previous chapter demonstrates that they lack. It is necessary here to criticize my own image in light of the late professionalism in order to add to it the necessary validity for adoption. To that end, this section answers the questions that I have asked of all previous models: 1) is the 'commissioning' image of the engineer consistent with the economic and social underpinnings of late capitalism, and 2) does this image of the engineer provide sufficient conflict to foster late professional discourse?

In both cases I would say yes! The commissioning image for the engineer makes use of much of the language and new modes of thinking associated with the late capitalist movement. Further, it applies this language within a framework that

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months" (Bell 1996, p.23).

promotes a respectful tension between employer and employee. The utilization of late capitalism in the development of the commissioning metaphor can most readily be seen in the flexibility offered to the 'gutsy generalist' understanding of the engineer as team leader. Further, the ability for this model to be applied while leaving intact certain aspects of the late capitalistic workplace[41] suggests that the metaphor may be a good representation of more than an idealized state of affairs.

While a return to commissioning for the engineer may provide the perfect description of the professional in the last decade of this century, it does not particularly provide for a blissful existence in the workplace. The transience associated with the engineer's role remains in spite of the new image. On this side, however, the ultimate brevity of employment is a function not of the whim of employers, but of the discourse between engineers and managers. Engineers, under this model, become the guardians of their personal careers and make decisions with their employers that are mutually beneficial to both parties. The idea of a career as being within one company or among a number of companies becomes less of an issue. In its place will be the question of how relationships between engineers and their employers can be mutually beneficial no matter what the length of the engineer's tenure.

It is important to remember that the late professional engineer need not be all of the above things, or even any of them. In a society that is gaining comfort with the

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[41] Here I have in mind teamwork and just-in-time labor and production practices.

concept of dynamic multiples, the engineer must also be comfortable with being unique among his/her peers.  Thus, it is  for the engineer and employer to decide which of the images presented above to include in their late professional negotiation.

Respect for the late professional will come from the wider society's desire to be in a similar position of mediation.  Where formerly the lack of job security was seem as an albatross for the engineer, industry value placed on the engineer's skill coupled with a late capitalist feeling of mobility will now give the impression of respect for the late professional.

## 5.3 – The Ramifications of Late Professionalism

Up to this point, I have developed my concept of a late professional in relative isolation.  I have confined myself to the role of the late professional engineer in the last decade of the twentieth century and sought to explicate how a late professional understanding would alter the relationships among engineers, employers, and the wider society.  It stands to reason, though, that a proper analysis should at least comment briefly on the broader ramifications of the new model.  Is the late professional understanding fixed temporally or socially to engineers in the late twentieth century?  Would such a change in worldview for engineers affect their life outside of the work place, their organizations, or the community functions they find important enough to fill?  How would one go about training young engineers to fill better their roles as late professionals?  These are the questions that I will suggest abrief answer to in this final section.

Since the end of the Second World War, the guiding force for social change in the engineering community has been the desire of engineers to ‘earn their place’ among the professional ranks.  As I have repeatedly demonstrated, concepts central to classical understandings of professionalism are not well suited to understanding engineers in contemporary job relationships.  Could it be the case then that engineers would have been better served throughout this century by a late professional understanding of their occupational role?

With the preceding image of the engineer as a tool, it is possible to reanalyze the conflict portrayed by Layton in his *Revolt*.  As I mentioned in the opening chapter, the revolt that Layton talks about is the general feeling of angst on the part of engineers in the postwar period.  The worry of engineers was that they were being cheated out of their public standing by being co-opted by their employers into positions of  ‘organization men.’  In reaction to this, Layton suggests (or describes) aan earlier push by engineers to develop the same type of professional stature as doctors and lawyers.

The ensuing conflict between engineers and their employers can be seen as one form of late professional conflict.  Engineers began to take the liberty to negotiate their own job descriptions either by taking the organization jobs offered them by their employers or by venturing out on their own as consultants.  Further, both the ‘organization’ and professional models were viable during the capitalist timeframe that Layton was describing; thus the late professional dialogue was legitimate.

Layton’s revolt can, therefore, be interpreted as an early form of late professional dialogue, and the engineers who took part in it, the first late professionals.  This statement is a reversal of the traditional thinking which places the engineer as merely the most recent among professionals. Seeing engineers as the first among late professionals should provide engineers in the contemporary setting some needed pride and motivation to make the most of their current situation.

As if in response to Layton's call for a professional revolt, engineering professional societies have marched under a banner of 'increased professionalism' for the better part of this century. Reforms in ethical standards, community service, advocacy for members, and codification of specific knowledge have been the major facets of society life. While all of these things are important to a group centered around a 'state of being' model of the professional, the dynamics of late professionalism call into question the role of, or even the need for, professional societies.

As long as engineering, like doctoring or lawyering, was considered to be a professional goal, the role of the professional society was simple and integral: to outline the behaviors and categories of knowledge without which one could not be considered a part of the profession. Unfortunately, this type of society is of little help to the commissioned officer of late capitalist industry.

As I mentioned before, the defining characteristic of the late professional is the flexibility to negotiate his/her own job description. Under this framework, it is illogical to think that engineers would require, or even desire, a rigid structuring and codification of 'engineering knowledge.' The engineer under late professionalism makes use of any and all information and knowledge made available to him/her, but resists an organization that tries to dictate the knowledge that is/is not important to his/her personal dialogue with an employer. Further, as the late professional framework gains wider acceptance, an engineer's personal experiences – the type that can be readily applied to new problems with different companies – will become more useful than any codified sources of knowledge.

Alternative roles for the engineering professional society would include that of repository for the collective experiences of its members. This would be especially useful if the amassed material were then made public so that engineers from a variety of backgrounds and disciplines could access it for their unique and private uses.

Another feasible role would make important steps toward the realization of collective social action which could be managed by the well-defined organizational structure of the society. The existing conference structure as well as the well-defined channels for disseminating information would allow for rapid development of positions of advocacy and collective opinions on current social issues.

With a changing understanding of the role of engineer in the late capitalist workplace, and a drastic change in the ways in which engineers organize for their own good, must also come a change in the ways we teach our young people about engineering. Much of the recent movement among American colleges and universities to redesign their engineering curricula is being driven by the realization among educators that their students are leaving the university setting ill-prepared to assume roles in the industrial community.

Traditional means of preparing students for the workplace – especially those that emphasized rigorous scientific analysis over communication and design skills – are no longer consistent with the desires of engineering employers. While these teaching methods were adequate for the development of good engineering problem solvers, and thus kept engineering graduates from the unemployment lines, they do not help develop the personal and communication skills that are necessary for the engineer to play the part of team member. Furthermore, the highly specialized degree programs did not give students the types of exposure to other fields that allowed them either to move easily between positions or seek to better themselves through career development.

Not only have engineering employers found the traditional means of engineering education inadequate, but engineering students have also been dissatisfied. While many thrived in and enjoyed the rigorous setting of engineering school, others did not. In both cases, however, upon entering the workplace, students have been disgruntled. For those who enjoyed the science and mathematics rigor of college, the workplace is providing insufficient opportunities to apply the knowledge that they gained over the years. For those whom the rigor did not suit – who may ultimately have a better understanding of what it means to be an engineer in late capitalism – the workplace has been frustrating in the same way that it is for all engineers.

Beginning in 1995, the American Board of Engineering Technologies (ABET) reexamined their accreditation processes based on the desires of engineering educators and employers. The ABET 2000[42] guidelines were developed for implementation by engineering colleges and universities in the fall of the year 2000.

The general rubric under which these guidelines were developed is expressed best by Beth Panitz's comments from a 1996 article on the movement of people trained in engineering to alternate career paths:

> Many engineering educators tout that engineering is the liberal-arts education of the 21st century because it provides students with the strong technical and problem-solving skills that are needed in many fields (Panitz 1996, p.25).

In this way, the engineer becomes the consummate late professional, able to adopt and adapt to any role required by his/her employer and able to negotiate a myriad of delicate possibilities for employment.

My goal in this project has been to outline a different way of thinking about the role that engineers play in the contemporary workforce. Somewhere between labor and independent industrialist, engineers need industry as much as industry needs engineers. That is not to say, however, that the relationships between engineers and their employers are by any means homogeneous. The beauty of a late professional understanding of the relationship is that it provides the flexibility necessary to satisfy all involved.

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[42] A complete description, motivation and analysis of the ABET 2000 guidelines for accreditation can be found on the website of the ASEE: www.asee.org

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# Appendix A – Engineering Professional Societies

Dates indicate the society's date of founding

AIAA – 1963 – American Institute of Aeronautics and Aerospace

AIChE – 1908 – American Institute of Chemical Engineers

ASCE – 1852 – American Society of Civil Engineers

ASEE – 1893 – American Society of Engineering Education

ASME –1880 – American Society of Mechanical Engineers

IEEE – 1884 – Institute of Electrical and Electronic Engineers

NSPE – 1934 – National Society of Professional Engineers

TBPi – 1885 – Tau Beta Pi, National Engineering Honorary

# Appendix B – Data Set of Popular Engineering Writings

Articles listed here represent all of those that I read during the data analysis phase of this project. Not all of those included here were finally referenced in the text, but all were influential in helping me to develop my understanding of the current state of engineering practice. They are listed here by magazine and author. Below each reference is a brief, keyword description of the contents of the article as well as a description of the station of the author.

*Aerospace America* – AIAA

Covert, Eugene E. 1992. Engineering Education in the '90's: Back to the Basics. *Aerospace America*, April 1992, 20-26, 46.
Problem Solving, Respect, Licensure, Respected Social Advocate
Junior Professor

Grey, Jerry. 1991. Coping with a Different World. *Aerospace America*, October, 1991, 4.
Government Official

Lopez, Virginia C. 1995. Aerospace Employment Trends, 1962 - 1995. *Aerospace America*, July 1995, 14 - 16.
Senior Engineer

Nicolai, Leland M. 1992. Designing a Better Engineer. *Aerospace America*, April 1992, 30 - 33, 46.
Problem Solving
Senior Engineer

Vadas, David. 1995. Aerospace after the Cold War: A Blueprint for Success. *Aerospace America*, October 1995, 18 - 21.
Senior Engineer

*ASEE Prism* – ASEE

Augustine, Norman. 1994. Preparing for the Socioengineering Age. *ASEE Prism*, February 1994, 24 - 26.
Societal Influence, Respected Social Advocate
Company President

Bromley, D. Allen. 1991. Engineering's Renaissance. *ASEE Prism*, December 1991, 14.
Making Things
Government Official

Burton, Lawrence, Linda Parker, and William K. Lebold. 1998. U.S. Engineering Career Trends. *ASEE Prism*, May/June 1998, 18 - 21.
Career Development
Government Official

Ercolano, Vincent. 1997. Dual-Career Couples. *ASEE Prism*, April 1997, 28 - 32.
Career Development
Journalist

Friday, William. 1995. Educating Tomorrow's Engineers. *ASEE Prism*, May/June 1995, 10 - 15.
Career Development, Respected Social Advocate, Creative Design
Senior Professor

Guralnick, Sidney A. 1992. In the Details. *ASEE Prism*, May/June 1992, 48.
Creative Designer, Making Things
Junior Professor

Meade, Jeff. 1991. Engineering Coalitions Find Strength in Unity. *ASEE Prism*, September 1991, 24 - 26.
Journalist

Panitz, Beth. 1996. Evolving Paths. *ASEE Prism*, October 1996, 22 - 26.
Career Development
Journalist

Peterson, George D. 1997. Engineering Criteria 2000: A Bold New Agent for Change. *ASEE Prism*, September 1997, 30 - 34.
Education Reform
Journalist

Wenk Jr., Edward. 1996. Teaching Engineering as a Social Science. *ASEE Prism*,

December 1996, 24 - 28.
Respected Social Advocate, Respect
Senior Professor

<u>*Chemical Engineering Progress* – AIChE</u>

Mascone, Cynthia Fabian. 1993. ChE Job Satisfaction: Good, But . . . . *Chemical Engineering Progress*, November 1993, 89 - 98.
Job Security, Team Leader, Respect, Career Development, Societal Influence
Journalist

_____. 1995. Career Advancement: What Works for ChE's. *Chemical Engineering Progress*, November 1995, 108 - 112.
Career Development
Journalist

Panos, Jean Baglione. 1995. Relocating as a Dual Career Couple. *Chemical Engineering Progress*, January 1995, 74 -- 78.
Career Development
Senior Engineer

Tagone, Chris. 1994. Take Charge of Your Professional Development. *Chemical Engineering Progress*, May 1994, 83 -- 85.
Career Development
Junior Engineer

<u>*Civil Engineering* – ASCE</u>

Arnesen, Tore O. 1992. Surplus Promotes Price Competition. *Civil Engineering*, December 1992, 6.
Respected Social Advocate, Societal Influence
Principal in Firm

Bernstein, Harvey M., and William R. Pillers. 1997. Reengineering the Profession. *Civil Engineering*, July 1997, 6 -- 8.
Team Work, Team Leader
Senior Engineer, Senior Professor.

Haratunian, Michael. 1991. Engineers Need a Wider View. *Civil Engineering*,

February 1991, 8.
Respected Social Advocate, Societal Influence, Team Leader, Creative Design
Senior Engineer

Huff, Tony. 1996. Does ASCE Have a Responsibility to Mandate Continuing Education? *Civil Engineering*, 72 -- 73.
Career Development, Professional, Licensure, Role of Professional Society
Professional Engineer

Kaplan. 1997. It's Practice Periodical Time. *Civil Engineering*, May 1997, 6.
Making Things,
Professional Engineer, Principal in Firm

Khanna, J. 1993. Holistic Engineering: Beyond the Code of Ethics. *Civil Engineering*, October 1993, 6.
Respected Social Advocate, Societal Influence
Professional Engineer, Principal in Firm

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Societal Influence, Respected Social Advocate
Junior Professor, Junior Engineer

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Professional, Respect, Problem Solving, Making Things
Principal in Firm

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Respect, Professional
President of ASCE

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Respect, Career Development
Employee of ASCE

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Readership
Journalist

Scalzi, John B. 1996. Research Relevance: Communication Is the Key. *Civil Engineering*, August 1996, 6.
Professional, Respect
Government Official

Tarricone, Paul. 1992. Portrait of a Manager. *Civil Engineering*, August 1992, 52 - 55.
Team Leader, Career Development

Tiedman, Jane L. 1990. Do Current Practices in Continuing Education Fulfill the Ethical Needs of the Profession and Society? *Civil Engineering*, March 1990, 73 - 75.
Respected Social Advocate, Societal Influence
Student

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Team Leader

*Engineering Times* – NSPE

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Professional Engineer

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Career Development, Respected Social Advocate
Professional Engineer, Principal in Firm

Likins, Merle R. 1996. Licensure and the 'Free Agent' Industry Engineer. *Engineering Times*, January 1996, 5.
Career Development, Respected Social Advocate
Professional Engineer, Senior Professor

Medcalf Jr., W.E. 1995. The Real Reason to License Industry Engineers. *Engineering Times*, July 1995, 5.
Making Things, Respected Social Advocate
Professional Engineer, President of Company

*IEEE Spectrum* – IEEE

Bell, Trudy. 1996. Employment Roundtable: Survival Calls for More Than Technical Fitness. *IEEE Spectrum*, March 1996, 20 -- 31.
Job Security, Career Development
Journalist

Wolff, Howard. 1993. How Engineers View Themselves. *IEEE Spectrum*, April 1993, 24 -- 28.
Respect, Creative Designer, Making Things, Societal Influence
Journalist

Youst, David B. 1990. The Technical Ladder Gets Harder to Climb. *IEEE Spectrum*, September 1990, 46 -- 47.
Team Leader
Senior Engineer

*Mechanical Engineering* – ASME

Ashley, Steven. 1993. The Making of an Effective Manager. *Mechanical Engineering*, January 1993, 61 --63.
Team Leader, Making Things,
Journalist

Bar-Cohen, Avram. 1995. Mechanical Engineering in the Information Age. *Mechanical Engineering*, December 1995, 66 -- 70.
Problem Solving, Mobile Corporate Asset
Senior Professor

Barr, Vilma. 1990. Six Steps to Smoother Product Design. *Mechanical Engineering*, January 1990, 48 -- 51.
Team Work
Journalist

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Making Things
Senior Professor

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Senior Professor.

Dixon, John R. 1991. The State of Education. *Mechanical Engineering*, February 1991, 64 -- 67.
Making Things
Senior Professor

Valenti, Michael. 1996. Teaching Tomorrow's Engineers. *Mechanical Engineering*, July 1996, 64 -- 69.
Team Leader, Team Work
Journalist

Valenti, Michael. 1991. Engineers on the Silver Screen. *Mechanical Engineering*, August 1991, 30 -- 37.
History, Respected Social Advocate
Journalist

Waldron, Kenneth J. 1992. Secret Confessions of a Designer. *Mechanical Engineering*, November 1992, 60 -- 62.
Making Things
Senior Professor

Davis, Michael. 1996. Defining 'Engineer' -- How to Do it and Why it Matters. *The Bent of Tau Beta Pi*, Fall 1996, 13 - 17.
Professional History
Senior Professor

*The Bent* – Tau Beta Pi

Florman, Samuel C. 1997. The Introspective Engineer. *The Bent of Tau Beta Pi*, Winter 1997, 16 - 18.
Societal Influence, Career Development
Professional Engineer, Principal in Firm

Hickling, Ronald M. 1996. Teamwork, Leadership and Growth -- Three Tales of Entrepreneurship. *The Bent of Tau Beta Pi*, Fall 1996, 11 - 12.
Team Work, Team Leader
Senior Engineer, President of Company

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## Curriculum Vitae

**Address:** St. James School
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**Education:** **MS** Science and Technology Studies
Thesis Title: "Reengineering Engineering: A Glimpse of Late Professionalism"
**BS Magna Cum Laude** (1997), Engineering Science and Mechanics;
Minor Curricula: Mathematics, Religion Studies

**Study Abroad:** FH Mittweida, Germany (Summer 1995)
Language School
Technical University of Vienna, Austria (Fall 1995)
Department of Mechanical Engineering

**Employment:** **Physics and Mathematics Master;** 1999 – Present, St. James School, St. James, MD
**Graduate Research Assistant**; 1995-1999, Materials Response Group, Virginia Tech; Dr. John J. Lesko, Advisor.

**Written Work:**

"Iterative Design Modeling of Hybrid Composites." Senior Thesis, Engineering Science and Mechanics Department, Virginia Polytechnic Institute and State University. April 1997

**Conference Presentations:**

"Extra-curricular Influences on the Student Image of the Engineer." NSF Research Tomorrow Project Symposium. Roanoke, VA, 22 August 1999

"Design is What Engineers Do: Examining the Gap Between Engineering Education and Practice in the Late 20$^{th}$ Century." 2$^{nd}$ Place Award – Social Sciences and Humanities Division, 1999 Virginia Tech GSA Student Research Symposium, 29 March 1999

"A Design Guide for FRP Composites in Civil Infrastructure Applications" with David C. Haeberle (ESM). 1999 Virginia Tech GSA Student Research Symposium, 29 March 1999

"Oh the Webs We Weave: Increasing Organization With Web Pages" with M. Bigley, C. Craft and M. Ross. 1999 SAA/SF District III Conference, Myrtle Beach SC, 27 February 1999

**Professional Development:**

Introduction to Teaching Physics, Taft Education Center, Summer Program, Watertown CT, July 1999
AP Calculus, Taft Education Center, Summer Program, July 1999
CASE District III Annual Conference. "Creativity in Institutional Advancement," Charlotte NC, February 1999

**Associations:**

National Association of Physics Teachers
National Association of Mathematics Teachers
Maryland Association of Science Teachers
Tau Beta Pi, National Engineering Honorary
Omicron Delta Kappa, National Leadership Honor Society
Society of Engineering Sciences
Society of Experimental Mechanics
National Eagle Scout Association
American Society of Engineering Education

**Awards:**

J. Ambler Johnston Award for Outstanding University Service
Who's Who Among American College and University Students
Engineering Science and Mechanics Departmental Scholar
Eagle Scout Award