CAN ENGINEERS HOLD PUBLIC INTERESTS PARAMOUNT?

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I. INTRODUCTION

Perhaps the most pervasive issue plaguing every attempt engineers have made to develop a code of ethics for their profession is the continuing controversy over rules stipulating something like "the engineer shall hold paramount the health, safety and welfare of the public in the performance of his professional duties."[1] Most engineering professional societies which have codes of ethics have adopted such rules—hereinafter referred to as "public paramountcy" rules.[2] The American Association of Engineering Societies (AAES), a federation of thirteen major engineering professional societies, is one example.[3] The Institute of Electrical and Electronics Engineers (IEEE), largest of the engineering professional societies, is a noteworthy exception.[4]

Underlying the public paramountcy issue is a sentiment which spans the memberships of the various engineering professional societies, and is apparently shared by most engineers. This sentiment asserts that engineers *cannot assure* the health and welfare of the public because risk-free engineering often cannot be achieved. Thus, a problem is posed for the incorporation of

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The purpose of this paper is to consider the problem of whether public paramountcy rules are consistent with correct conceptions of the fundamental nature of engineering. I will argue that (a) while public paramountcy rules are consistent with conventional applied science conceptions of engineering, these concepts are incorrect; and that (b) ordinary means of public paramountcy are not consistent with the new correct praxiology conception of engineering. Instead of suggesting that public paramountcy rules be repealed from engineering codes of ethics, qualifications for ordinary meanings of public paramountcy are offered that provide consistency between such rules and the correct conception of engineering.

II. THE NATURE OF THE PROBLEM

Unlike many physicians and lawyers, engineers are typically employees in large bureaucracies.[5] Within these bureaucracies one can distinguish two types of engineers: the "line" engineer, whose workload is principally of an engineering nature, and the engineer-manager, whose responsibilities are mainly managerial. Since most engineer-managers evolve from line engineers, a chronological boundary can be drawn between the collectivity of the younger and that of the older engineers that roughly separate the line from the engineer-manager types.[6]

Line engineers can look forward to substantial increases in salary as their evolution across this boundary takes place. The further up the managerial ladder the engineer goes, the less he or she can expect to return to engineering work of the line type since one's technical skills tend to diminish rapidly when not used, and one's efforts to gain new skills are often thwarted by the intensity of the bureaucratic life. Thus, older engineers often have fewer employment options than do line engineers and, therefore, have stronger ties of dependency to their employers. Pressures to conform to bureaucractic demands for loyalty are high in work environments where employees can be fired and blackballed, and alternative employment opportunities are few. Such factors undoubtedly contribute to differences in attitudes characteristics of the line and managerial types about the kinds of relationships that should exist between their profession and the public, and between their profession and their employers.

Layton[7] refers to the younger engineers as the collectivity which, historically, has regarded the promotion of the public interest or the general health and welfare to be a professional responsibility. Younger engineers tend to insist that whenever public interests conflict with business interests, the public welfare should be the paramount concern. Layton refers to the older engineers as the collectivity which contains the politically and economically potent managerial class who, unlike the younger engineers, consider the business interests of engineering to be compatible or not to conflict with the public good. When issues arise that pit profit interests against the public welfare, battle lines within the profession often correspond to a division between youth and age—between line engineer and engineer-manager—between the politically weak and politically strong. Thus, younger engineers have in the past sought to strengthen their position by attempting to unite the profession (across disciplines). Such attempts have repeatedly failed, but their histories fit into a now familiar pattern.

The AAES, a new unity organization, was formed in 1980 and now consists of over thirteen member societies. From its structure one might argue that the AAES was formed to represent a single voice for the engineering profession in the U.S. political arena—possibly for the purpose of advancing business interests. However, there appears to be little reason to suspect that the AAES was formed to meet any solidarity aims of either older or younger engineers. Indeed, the fact that younger engineers are not visible in this debate is a matter of curiosity. Perhaps because engineering professional societies are dominated by the older engineers, this debate has not aroused the political passions of the younger engineers. Instead, the issues being debated are those of concern to the managerial class.

Contemporary engineering managers are no less concerned that the interests of employers or clients be served than has been the case in the past. However, the social context in which these concerns are manifest creates more complex and dynamic public-versus-employer conflicts. Americans more often use the word "public" in an expanded sense that transcends national boundaries so that consideration can be given to conflicts between, on the one hand, world health and welfare interests and, on the other hand, both (a) national security interests of business and military employers in nuclear and space-based or SDI-type defense systems; and (b) business interests of multinational corporate employers or clients in apartheid and in the technological affairs of developing countries, and other interests. Owing to the growing credibility of Gian theory, the notion of "public health and welfare" may soon give way to "stability and integrity of the ecosystem" allowing moral status to be given to nonhuman nature. Thus, these expanded interests on the public side of our debate are pitted against the business side which is grappling with global financial austerity, international competition and the dynamics of technological innovation.

One can observe that the managerial class of engineers uses a strategy to deal with these difficulties that involves (a) the claim that engineering is a science so as to gain the confidence and support of the public for engineering business enterprises; and (b) the claim that engineering is not a science and is laden with risk so as to maintain public confidence in, and support for engineers in the wake of technological failures. The problem addressed in this paper is to resolve these two contradictory claims and formulate a meaning for public paramountcy that is consistent with a correct view of engineering.[8]

III. THE CONVENTIONAL APPLIED SCIENCE VIEW OF ENGINEERING: THE CLAIM TO "KNOW" IS GOOD FOR BUSINESS

Until recently, virtually every definition of the term "engineering" has included something like "the application of science to practical or societal problems."[9] On this view, engineering research is scientific and professional engineers are "applied" scientists (who use science to solve practical problems) as distinct from "pure" scientists (who use science to create more science). Engineers as scientists can thus enjoy the faith Americans have in the scientific method, and can even claim to "know" why and how technology works. When supported by credentials taken from the culture of engineering (e.g., formal education, licensure, experience, membership in professional societies, etc.) such claims enable engineers to narrow the field of competition and gain public sanction of business interests. However, although most engineers probably regard the notion of engineering as an applied science to be appealing, these same engineers share the view that the functioning of engineering products often cannot be deduced from scientific principles alone and that the concept of "risk-free" engineering is a myth.

The inconsistency of believing, on the one hand, that engineering is a science and, on the other hand, that engineering neither helps engineers to "know" exactly how technology will respond to these conditions, gives evidence of confusion about the nature of engineering and provides a clue to the possibility of error in the applied science view.

The error in the applied science conception is that engineering methodology consists not of scientific principles alone, but of scientific principles together with a constellation of non-scientific heuristics.[10] Moreover, the observation that engineering practices are often established and used successfully well in advance of their incorporation within scientific theory suggests that the same arguments used to define engineering as applied science could be used to (incorrectly) define science as some sort of theoretical engineering. Which conception of engineering is correct?

IV. THE NEW PRAXIOLOGY VIEW OF ENGINEERING: A CORRECT CONCEPTION

The Greek term "praxis" has an ordinary meaning that roughly corresponds to the ways in which we now commonly speak of "action" or "doing," and it is frequently translated into English as "practice." Whereas "practice" connotes for some people mundane activities that is not motivated by theoretical considerations, "praxis" takes on a quasitechnical meaning derived from Aristotle. The twentieth century Polish philosopher Kortabinsky,[11] apparently motivated by the Aristotelian usage, introduced the term "praxiology' to mean the theory of efficient action, and more recently the term has been employed, in a slightly different spelling, by Scandinavian philosophers in their contribution to the analytic theory of action.[12] In my modified usage, praxiology is juxtaposed to epistemology, and functions as the basis for a correct understanding of engineering (as a scholarly discipline) in the same way that epistemology does in the philosophy of science.[13]

On the one hand, epistemology may be characterized as the branch of philosophy that analyzes the nature of knowledge—and contains theories that aim to answer questions such as "What is the nature of knowledge?" and "Now is knowledge obtained?" On the other hand, I have defined praxiology as the branch of philosophy that analyzes the nature of change—and contains theories that aim to answer questions such as "What is the nature of the proposed change?" and "How are purposeful changes effected?"

The argument for praxiology as deserving of philosophical attention is based on the natural inclination of people to acknowledge the "engineering" imperative to improve the human condition before all the facts are in that could enable one to predict with certainty or (sometimes) even with regularity the outcome of the change. Moreover, it is natural for people to regard the human condition as one that is complex and important enough to warrant application of their minds to develop theoretical bases for the attempts made to fulfill the engineering imperative.

Since physical science can be defined as a kind of epistemology, i.e., one that consists of theories of knowledge about physical nature, I would define engineering as a kind of praxiology, one that consists of theories about changing physical nature.[14] To illustrate these conceptions, one can consider two different ways in which scientists and engineers might typically view some dispositional property of physical objects.[15]

An object may be said to possess the dispositional property "fragile" if one can observe the object to break when struck in a particular way. The assumption here is that the striking procedure and the method for observing the breaking of an object are well-defined and together constitute a test. If no member of a particular class of like objects has ever been tested, then, the scientist would not claim to "know" whether the object is fragile. However, the engineer, being concerned with making conservative judgments in the absence of scientific facts, would conceivably *assign* the property "fragile" to the object until it is tested, then acknowledge the appropriate property of the object following the test. If the object were tested, then both the scientist and engineer would extend the results of the test to all like objects. However, if two identical objects were similarly tested and different results were observed, then the scientist would abandon the test as a means of obtaining knowledge about such objects, whereas the engineer would not necessarily do so if it exhibited "consistent enough" results. What scientists admit as consistent enough results are those that are controllably predictive. What engineers admit as consistent enough results are those that can be used to obtain acceptable risks.

The literature abounds with conceptions of how these risks are or ought to be assessed, and with the various human populations (e.g., employers, clients, end-users, etc.) actually targeted or who ought to be targeted by engineers for gaining acceptance of these risks. The point being made here is that neither universal acceptability of these risks, nor the acceptance of *all* affected rational persons is sought. Indeed, standards for acceptability of risks and, thus, standards for consistency of engineering test results, are components of the lore of engineering which is established by the profession and maintained by force of law, habit, and the suppression of divergent views during the engineering educational process.

This illustration indicates how scientific and engineering theories are oriented differently to the physical world. The error in the applied science view is that engineering methodology consists not of scientific principles alone, but a blend of these principles with a lore for the purpose of "changing" physical nature at the expense of—at best—attaining "acceptable" risks. "Acceptable to whom?" and "By what method of risk assessment?" are questions that are dealt with in engineering lore which contains a variety of Koen's "engineering heuristics,"[16] together with trial-and-error case histories, organizational means for establishing procedural conventions, institution, etc., which are handed down to engineers from their predecessors. Thus, engineers can only seldom claim on rational grounds to "know" how complex technologies will affect people.

The praxiology view supports the claim that engineering is not a science and is laden with risk. Thus, part of our problem is resolved. What remains is to formulate a meaning for public paramountcy that is consistent with praxiology.

V. MEANINGS OF PUBLIC PARAMOUNTCY

One inference from the idea that engineering is a science is that engineering judgment deserves the faith that people put in scientific judgments. This is not to say that people never observe scientific judgments to be in error. When new facts are discovered that disprove a scientific theory, scientists are known to make public disavowals of prior judgments based on the theory, but to insist that they were correct to *claim* (at the time) that those judgments were scientifically sound. However, engineering judgments can be valued as "good" independently of their scientific soundness. Thus, a person who assumes that engineering is a science may be misled into assuming that engineering judgments are scientifically sound and, thereby, be misled by his assessment of the possibility of risk being associated with engineering work. Furthermore, a person who assumes that engineering is a science could reasonably interpret a public paramountcy rule in an engineering code of ethics to mean that the engineer should not, by forgoing scientific analyses of his work, introduce public risk into engineering work for reasons of expediency, cost, and so forth. Engineers, however, know that scientific analyses of engineering work are typically forgone, and not just because of pressures from an employer or client.

Since applied science views of engineering have been articulated in the literature, and since the new praxiology view is yet obscure to the public eye, the above inference about the meaning of public paramountcy will be considered an "ordinary" meaning. Other ordinary meanings can be identified. The point is that there are ordinary meanings that are not consistent with the correct praxiology view of engineering. How, then, can public paramountcy rules in engineering codes of ethics be qualified so as to make them consistent with praxiology?

Since the praxiology view of engineering suggests that risk is a part of the nature of engineering, this view is also consistent with the "engineering experiment" view[17] which observes engineering works to be experiments involving human subjects (i.e., the public). According to Martin and Schinzinger, originators of this view, moral relationships between engineers and the public should be of the informed consent variety. Thus, a code of ethics should not be contradictory to the notions that (a) affected parties should be aware of the risks associated with engineering works; and that (b) in some reasonable measure, their consent to participate in these works should be obtained. An example of a qualifier for public paramountcy rules that is consistent with these notions is as follows:

> The engineer shall not claim that engineering necessarily assures good public health and welfare. Instead, he shall advise the public of the risks associated with his work and seek to obtain public acceptance of these risks.

In stipulating that engineering does not necessarily guarantee public health, this sort of qualifier eliminates scientific assurances form the scope of ordinary meanings that can reasonably be attached to public paramountcy. Moreover, this qualifier is consistent with the various whistle-blowing provisions which stipulate that the engineer should make the public aware of dangers to the general welfare. This qualifier also clarifies what the engineer can and shall hold paramount.

Instead of holding *assurance* of public health, safety and welfare to be paramount, qualified public paramountcy thereby means that the engineer shall hold *acceptability of risk* to public health, and so forth, to be paramount. Questions like "Acceptable to whom?" "What are appropriate grounds for acceptance?" and "What are reasonable methods of assessing risk?" are answered in the contexts of public law and methodological precedence as existing in the lore of engineering. Thus, the engineer *can* comply with qualified public paramountcy rules.[18]

NOTES

1. This language was first introduced by the Engineers' Council for Professional Development (ECPD, renamed Accreditation Board for Engineering and Technology, i.e., ABET) in 1947 (see "Code of Ethics of Engineers," ECPD, Oct. 5, 1977).

2. The ECPD language (see note 1) is used, for example, in "Code of Ethics," ASCE, October 25, 1980; "Code of Ethics of Engineers," ASME, March 16, 1975 and adopted by the National Institute of Ceramic Engineers, October 25, 1980; "NCEE Model Rules of Professional Conduct," NCEE, August, 1979, and so forth.

3. The Fundamental Principle of the American Association of Engineering Societies states "The engineer as a professional is dedicated to improving competence, fairness and the exercise of well-founded judgment in the practice of engineering for the public, employers and clients with fundamental concern for the public health and safety in the pursuit of this practice." See "Model Guide for Professional Conduct," AAES, December 13, 1984.

4. See "IEEE Code of Ethics," IEEE, February 18, 1979.

5. See, for example, W.C. Terpey, *Optimum Utilization of Scientific and Engineering Manpower,* printed in U.S. by Whittet and Shepperson, Richmond, VA, 1970, p. 311; and *Unemployment Rates and Employment Characteristics for Scientists and Engineers,* 1971, NSF: 72-307, Washington, DC, 1971, p. 971, p. 102. Data show that only 4% of all engineers are self employed, 69% are employed in private industry or business; 16% are employed in government; 9% are employed in educational and non-profit institutions; and the remaining 2% are distributed among other types of employment and among the unemployed. Of the engineers employed in industry, 55% are employed in organizations which have 1,000 or more employees. Subsequent reports indicate these data to be virtually constant.

6. See *Engineering Manpower Bulletin,* EJC, No. 25, September, 1973. Data show that by the time engineers are between 40 and 45 years of age, 24% of them are supervisors of projects or sections; 25% are managers of major departments, divisions or programs; and 12% are in general management. Subsequent reports indicate these data to be virtually constant.

7. E.T. Layton, *The Revolt of the Engineers* (Cleveland: Case Western Reserve University Press, 1971).

8. This problem was first considered in T.H. Broome, "Should Engineers Hold the Welfare of the Public Paramount?," read at the AAAS Convention, June, 1984.

9. Similar observations have been made by P. Caws, "Praxis and Technē" in G. Bugliarello and D. Doner, eds., *The History and Philosophy of Technology,* (Urbana: University of Illinois Press, 1980); J. Ellul, *The Technological Society* (New York: Knopf, 1967); and M. Stanley, *The Technological Conscience* (New York: Free Press, 1978).

10. See B.V. Koen, "Towards a Definition of the Engineering Method," *Engineering Education,* 75, no. 3 (December, 1984), pp. 150-155.

11. The term "praxiology" apparently originated in T. Kortabinsky (trans. O. Wajtasiewicz), *Praxiology* (Oxford: Pergamon Press, 1965), p. 1. Kortabinsky defines praxiology as the theory of efficient action. A somewhat different definition of the term is presented in this paper.

12. G. Skirbekk, ed., *Praxiology: An Anthology* (New York: Columbia University Press, 1984).

13. T.H. Broome, "Engineering in the Philosophy of Science," *Metaphilosophy,* 16, no. 1 (January 1985), pp. 47-57.

14. *Ibid.*

15. *Ibid.*

16. Koen, "Towards a Definition," pp. 150-155.

17. M. Martin, and R. Schinzinger, *Ethics in Engineering* (New York: McGraw-Hill, 1983).

18. Certain sections of this paper rely heavily on "Engineering Responsibility for Hazardous Technologies," *Journal of Professional Issues in Engineering* (New York: ASCE, Jan., 1987). Whereas the paper is concerned with differentiating scientific from engineering responsibility, the present builds on the same basic praxiological analysis to address the public paramountcy issue.