Engineering, Morality and the Next One Hundred Years

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I thank you for the honor and privilege of addressing you today. When my long-time friend Charles Cushing asked me to speak, I hesitated. I was unsure of how to address a group with such varied backgrounds and experiences. Charles assured me that I was no different, and on reflection I supposed that has some truth. The common core of the physical sciences and mathematics and polymathy ranges through many of you in this Section as it does in me. On that urging and understanding I agreed to speak.

I will talk today about my thinking on several things which arise from an essay which I will publish the first part of next year. I come from academic training in logic, epistemology, mathematics, practical training in naval architecture and marine engineering, law, business and experiences in research and professing and practicing. Thus, I, as many of you, have computed, designed, operated, contrived financing and managed as well as argued and written and published and spoken. My efforts have been directly related or indirectly relatable to the international maritime and shipping industries for the past 48 years. I currently practice law and naval architecture and marine engineering in the United States and the United Kingdom and have credentials from each as well as credentials from the European Union. I started this unusual path when I was 17 years of age, influenced by family interests and ties and having substantial exposure as a child to farm life which is the essence of physicality, pragmatism, financial manipulation and morality. I spent many years at sea and have commanded a number of commercial vessels in the foreign trades which experiences have taught me humility and gratitude more than anything else a command at sea may offer.

My words here are necessarily imprecise because of the ambiguities inherent in our common spoken language. With language, I will start with an archaicisis which I think is apt.

Kings and Princes. Marine insurance invented the modern risk surety system in England in the 17th and 18th centuries. It did so when the first of the laws of probability were discovered and applied to gambling. As an insider I can tell you that insurance is nothing more than highly regulated corporate gambling with some limits against fraud. Risk is probabilistic and the mathematics worked and continues to do so pretty well. Insurance is for a maritime venture – a voyage for a ship – paid against monetary loss for many causes. Among causes of losses to the assured were and are mutiny, barratry, piracy and the restraint of kings and princes. I have

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borrowed the archaic term kings and princes to mean those deciding the most important matters in governments. I will talk about advisers to kings and princes of which this body and section are historical exponents.

Two Principles. I would like for you to keep in mind two principles today. The first is

The "Law" of Unintended Consequences. The axiom of unintended consequences says that the more complex a system the greater the probability of unintended consequences. The law is not absolute. Complexity may be relative but it may also be beneficial in that the collapse of complex systems of knowledge often leads to creative breakthroughs never imagined.

Collapse of Geocentrism. For example, the collapse of Ptolemaic geocentrism brought about the necessary understandings for Newton and Tycho Brahe and Johannes Kepler to refine heliocentrism.

Occam's or Ockham's Razor. Related to The Law of Unintended Consequences is a second law called Occam's or Ockham's Razor from the 14th century William of Ockham or the law of parsimony (*lex parsimoniae*). The law says that the simplest explanation is the best explanation. In this case, too I think you will see that simplicity is relative and may require a shift in referents to make it work.

The Rise of Heliocentrism. The Ptolemaic system of epicycles and the like was extraordinarily precise but also extraordinarily complex in calculation for the future or past position of a heavenly body. The Copernican system was vastly simpler and laid the way for the precision of Kepler's elliptical orbits. More subtly, and this is where unintended consequences comes into play, there is no way one can close the orbit of a planet under the Ptolemaic system. That is one of the elegances of the Copernican system such that orbits were closed into ellipses which were not perfect circles. Perfect circles were heavenly and implied that they were divine because they were perfect. Making closed orbits ellipses unseated the divine and made the orbits merely of planetary bodies working their ways around the sun. However, later, Einstein overturned even that and had the insight that falling in parabolas was another case of ellipses and that the bodies were indeed falling toward the sun in space-time in a gravitational field counterbalanced by the forces of centripety on the planetary masses. This was an equally profound revolution toward simplicity and explanation but an unintended and good consequence of the Keplerian ellipses.

Intent and Consequences. Looking carefully at The Law of Unintended Consequences, however, we see that an element of it is intent. The current engineering ethic assumes that engineering is for the good. However, a measure of intent for the good in what we produce is necessary as well as a measure of the unintended evil it will produce, as I will talk about a little later.

Definitions. Now reasonable people can disagree and some of you will disagree with what I will say and reject it out of hand. Others will consider it and believe it has some merit and leave it. Others will see the argument very clearly and the call I am making. So, as one our presidents once said, come, let us reason together and see where this goes. I think that definitions at the beginning make efficient any arguments. Therefore, I will define how I will use some epistemological

terms. These are not philosophical definitions but definitions to ease our way into the arguments I will make.

Subjectivity and Objectivity. Subjectivity is the form of inquiry wherein the observer and his or her methods are emphasized over the object observed. Objectivity then is the converse case wherein the object observed is emphasize over the observer. An example of a subjective philosophical branch is the criticism of literature. It is almost wholly descriptive with conventional words which fit its practitioners but is also almost wholly subjective and if inferential it is from Cartesian assumptions and logic and self-evidential statements. Some say that it is only in philosophy because Plato started it. I will not comment on that.

Secularity and Supernaturalism. Secularity is the nature of inquiry dealing with the states of the profane, as the Medievalists called it, or earthly things. We call these things natural and observable and explainable things within our rational-empirical methods of explanation. Supernaturalism is inquiry dealing with ephemeral things. It is not, however religion and should not be confused with the concept of a set of rules which are designed to bring its followers to various states of religious grace. Subjective Supernaturalism is, as its name implies, a resort to that which is beyond the objective consideration of nature and that which creates its own metaphysical explanations. I will not call it superstition which relates to imposing at a much lower level supernatural explanations on singular natural phenomena.

Governance and Anarchy. Governance is a state of social organization providing for orderly development, application and administration rules for the governed. Anarchy is a state of no governance.

Tendencies, Propositions and Arguments. Interwoven in what I will talk about are propositions and arguments about three large epistemic and social and biological tendencies and their implications to engineering over the next one hundred years. These tendencies, I believe, will strongly influence the course of human events. They are:

Technology. The first is technology of which engineering is an inseparable part.

Governance. The second is governance wherein kings and princes are the active and governing arm.

Population. The third is population of the world which also encompasses climate changes.

Implications. Each of the tendencies accumulates from the previously ranked tendency. Thus technology influences concepts of governance and government and each will influence governed populations.

Old Arguments. Within these tendencies I will touch on some old philosophical arguments. They are:

Objectivity and subjectivity. The first is the argument of objectivity *versus* subjectivity.

Good and evil. The second argument is that of good *versus* evil as it is currently expressed and as it was earlier expressed.

Social Order and Anarchy. The third is social order *versus* anarchy.

Advisors to Kings and Princes. But to put all of this in context, I must review some history as to how advisers to kings and princes evolved. The role of advisers to kings and princes and their governments is as ancient at least as recorded civilization. In the Indo-European cultures the secular or physical and the supernatural or metaphysical were always intertwined so that rulers rarely made a major decision without the consultation of the practitioners of the ghostly arts as Churchill once called the Anglican Church. Governance and advice each were subjective, frequently time-bound, usually ad hoc and personal and designed to address arising situations. Proactive behavior by kings and princes resulting in a physical beneficence for the ruled is remembered in history as good and moral. Reactive behavior by kings and princes gets mixed reviews and is sometimes distinctly bad or immoral. These events have occurred whether or not secular advice was sought or heeded.

Examples. The barbarian Celtic kings consulted their druids. Both Homer and much later Herodotus describe such consultations in detail. The Greek, Roman, Egyptian and Persian kings and princes of state consulted oracles and diviners and augers. In Rome the rulers consulted the pontiffs or state priests who were also diviners and augurs. As the Celtic and Roman religions were absorbed into Christianity in the West, the leaders of that religion gained extraordinary importance as advisers.

By the 17th century, however, with the treaties of Munster and Osnabruck in 1648, a clear break can be identified between subjective religion and objective state. Hobbes in Leviathan framed the propositions of societal order and strong governance and social disorder and conflict. This break has widened for several centuries although even recently in this country some leaders and some close to the inner circle consulted oracles. Others have called upon populist priests of religion for counsel. Be that as it may, the break in the 17th century in religious subjectivity and state objectivity occurred alongside the tremendous strides in objective thought. Modern science and engineering can -- in some minds -- trace its roots to Imenhotep of the 26th century BC, Aristotle and Plato in its earliest days, thence to Newton, Leibniz and Descartes but – passing by Lucretius and Bacon and others not in the empirical-rational predictive game fairly swiftly. Hindsight often discards precious foresight.

What does this mean? There has always in our history been demand for engineering advice and it continues and will continue. The opening of the door to physical objectivity has continued and widens in the current day. Resort to the supernatural, however, never dies and likely will not in the near future or in the next century. Indeed, it can be argued that there is a resurgence of supernatural thought playing out on the world stage today but expressed as religion and justified by a religiously viewed morality.

In the 17th century the concepts of objective governance asserted by Montesquieu and later Locke and Hume drew upon the objectivism of the emerging empirical sciences of Newton, Descartes and those who derived their thinking from

them. Indeed, in the 17th century objective, mathematicians and physicists in their various stripes began to hold a good deal of influence over government as advisers. Their subsidiary arts in astronomy and chemistry – not far removed from alchemy – developed and later have flourished.

With the unlamented death of logical positivism which flourished in the 1930's it is difficult to tell how objective things are done except that there are a set of generally understood rules that we hypothesize, observe, compare and calculate whether we should reject the hypothesis or not. We then store the observation and its hypothesis in the facts bank, knowing that a later hypothesis can come along with its observations and nullify a stored one, or modify it wherein it is put back into the fact bank with the newly unrejected facts.

The competition between governance of law and the profession of law and jurisprudence began about the same time. Law attempted to be objective as to social matters. As a lucky break in history, the genius of the common law started in the 13th century in England under Henry II who took social matters and applied fairly objective standards or laws fairly but at the same time accreted decisions used as legal precedents which could be corrected by future observations when warranted under the same system.

Therefore three parallel systems of law developed. The legislative acts of parliament became statutes. The accretion of court decisions were based on custom and experience. If either overrode sensibilities, the subject of these laws could appeal to equity which was an ecclesiastical court. Thus the common law attempted to use the objective system of decisions which is in many ways strikingly analogous to the objective physical systems with which we are all familiar. There was also a corrective process for justice greatly preceding Karl Popper rather than a wholly subjective one. The system also allowed the use of both secular and sacred advisers to reach its decisions.

The 17th and 18th centuries also saw a distinct break socially from subjective governance. It can be argued fairly effectively that the American Revolution was begun by the 17th century English Civil War following the subjective Personal Rule of Charles II. The parallels of the French Revolution to the earlier English even are striking. Here, the American Revolution extended to the War of 1812 and thence moved to the American Civil War before matters were settled to some extent.

In the East, laws tended to be civilest rather than common. Hence, there was no corrective mechanism. Hence there was more supernatural influence than secular influence. Hence the delays of the Russian Revolution to the 20th century and a marker point for discussions of that century occurred and a similar temporal delay to the French Revolution. Thus, the advisers to kings and prices in the west tended to be more and more secular from the 17th century, while in the east, the advisers were more nearly supernatural in their perspectives.

So, at the beginning of the 20th century the advisers to kings and princes tended toward social secularity through priests of the law with some objective secularity with the arising priests of the sciences. During and after World War II, the rise of the objective sciences began to supplant the advice of lawyers in an uneasy way which still has not played out. The role of spiritual advisers has declined to matters of personal choice for leaders in the west but has been resurgent in the east

in the form of virulent Islamism and in the west in the form of Christian fundamentalism. The need I see now is for the rejection of the secular priesthood of lawyers providing advice to a secular priesthood of knowledgeable engineer-lawyers providing advice and leadership to their governments. The bottom line, as is said in finance, is – using current slang – lawyers do not get it. Engineers can and will.

Why All This History and What Is Its Meaning? What does all this mean to engineers advising kings and princes? I think that engineers, being of the objective camp, cannot ignore the oppositions to objectivity in the subjective camp. Indeed, I suggest that the naïve belief that the objective truth will inevitably prevail may not be sufficient in the next century as things are tending to evolve. Hence, engineering advisers to kings and princes ought not be isolated within the objective but must consider the subjective within their objective deliberations.

Hence, the topoi of objective secularity, subjective supernaturalism, orderly governance and disorderly anarchy may be directly fitted within the three structures of modern engineering, modern governance and modern populations. When that is done the results are interesting. I emphasize that my thinking suggests that neither advice to kings and princes nor engineering nor the instruments of governance nor the governed populations is isolated from the other two or from the world at large.

Teleological approach. Now, let me tell you where I will end up. Engineering is a teleological enterprise so I am comfortable doing so. Keeping the end in mind will, I think, allow one to follow the dialectic in an easier fashion than if I present the trends and arguments with no background.

The Principal Proposition. My principal proposition is simple. In the next ten decades we will see life and society change in ways which are difficult to imagine within our current way of thinking. Our thinking will, perforce, change to meet the challenges which will face us. We in engineering can start to change now or be forced to change later. Thus, I see the next ten decades as integrating our worldwide accumulated knowledge into an almost seamless whole. I see in that process a synergy making the knowledge base much larger than the mere arithmetic sum of its parts. I further see a shift in who controls the knowledge base and who influences it most for the common good and the common evil. The influence of those new controllers will be critical to governments and their constituents and our mutual future. These new influencers will tend to be more objective than subjective, will tend to be more moral than amoral and will tend to defend social order and moral governance rather than social anarchy and immoral governance and will be moreover both technologically and legally accomplished.

Decline of lawyers qua *lawyers as advisers*. I see the secular priesthood of lawyers as advisers giving way to another secular priesthood of techno-lawyers as advisers and leaders. This will occur for many reasons, but the principal one is technology.

The integration of technology. I think that the integration of technology will be one of the most complex and challenging things ever done by civilized society and only those who can understand its elements in all their interactions will understand its implications for the common good and for the common evil.

Technology and concepts of governance. I think that the application of technology will change concepts of governance and will challenge good governance. Techno-lawyers and engineers will be the advisers to kings and princes who help restrain the abuse of technology to create evil governance and hence government evil practices.

Population growth and technology. In addition, I think that population growth will create extraordinary challenges to techno-lawyers and engineers ever envisioned in the past and will tax technology to the utmost to deal with itself, its use, its abuse and the consequences of each -- both good and evil.

Development of engineering morality. Hence, the new secular priests will have to develop a morality in their decisions and advices which is beyond the mere practice of ethicality and right and wrong actions.

Rejection of engineering amorality. The new engineering morality clearly will not be and cannot be the current amoral operating culture wherein engineering decisions are made.

Do not be repelled. Even Emmanuel Kant, the rejecter of Cartesian pure reason and the godfather of the scientific empirical-rational method of inquiry as applied in engineering thinking accepted the concept of a metaphysical realm of knowledge – things above physics.

Answerable questions within a closed system of method and language and accumulated facts. This is because the scientific and technical semiotic allows us only to answer answerable questions within a closed system of orderly inquiry using the language of accumulated facts and demonstrably valid methods of natural inquiry and engineering manipulation.

Validity of metaphysics. Therefore, we should be able to place morality of decision within the things which are necessary to be done but not necessarily demonstrable by the methods of science or engineering.

The advisers. The new advisers, guardians of technical knowledge, will be techno-lawyers and engineers. These advisers will be the quintessential advisory technologists cum lawyers. The engineering side will have to be trained or reshaped in their thinking from being amoral providers of the practica of Newtonian physics and its derivatives to moral providers and guides to governments as to how those applications are good and how they are evil. They will have to understand the power of technology and how it can be used for good as well as evil in maintaining or attaining good governance.

The challenge. Hence the extraordinary challenge for engineers and lawyers now and in the foreseeable future is looking at the science and the epistemology of the lawyer-engineer business as well as the epistemology of morality to do their jobs well and certainly to advise governments well.

Change in the semiotic. This perforce will require change in the semiotic of physical inquiry and application. This means that a different perspective from engineers is necessary than is currently prevalent. It will also require the learning of a new semiotic which may or may not reside comfortably. These in and of themselves are a difficult shift, however, as I think you will see, it will be both

necessary and beneficial to our ways of doing things, our advice to kings and princes and to the populations managed by kings and princes.

But why engineers? Cannot others do this just as well? No. Engineers will have the bully pulpit of technology. Engineers will have the underpinning of knowledge of technology unknown to those not in engineering. Engineers can translate technical concepts to those whom they advise. Engineers can communicate with each other efficiently. Most importantly, engineers, of all the professions, tend toward ethicality of action because of the large consequences of engineering failures to society. Hence, it may be argued that an inclusion of morality of action is a logical consequence of this ingrained ethic.

The integration of engineering ethicality and engineering-law morality. Therefore, the integration of engineering thinking, ethical thinking and moral thinking is desirable for the engineers of today. It will be a necessity for engineers of tomorrow. It will be *sine qua non* for those advising governments and their populations.

The Rise of Value and the Decline of Evil. The modern way of talking about good and evil is an economic one which started with Ricardo in the early part of the 20th century. The term value has replaced the term good which came from Smithian economics and goods and services. However, it is not easy to think about social negative value as evil. Hence, I shall continue to use good and evil and not value and negative value in what I say.

Clear Process Needed. This all suggests that engineers should develop a clear process of moral evaluation for the intended good as well as one which evaluates the unintended evil of the products of our creativity. The reason is that technology, governance and population all work closely together and without that understanding, we will not get very far.

Relationships of Technology, Governance and Population. I believe, therefore, that the three tendencies of change in technology, governance and population are closely relatable and that these tendencies will shape our future after this century as surely as similar tendencies. There are historical models. The 17th century in Northern and Western Europe and Asia made profound changes and created our thinking today. That was preceded by the Italian Renaissance of the 15th century. I think that the 21st century will have a similar or greater effect on future times.

Of course these notional tendencies are interactive and are impossible to predict in the large scales of the perceptions of everyday life. However, at the smaller scales useful in reviewing societal experience, they seem to be playing out to some likely inevitable ends. Hence what I say is perforce teleological. Do not think of these things as some sort of Hegelian reprise which tends toward the supernatural. I see not grand theories of history -- which have never worked.

How do secularity and supernaturalism fit into engineering? Engineers and scientists tend to be secular in the sense that they tend to objective, empirical, inferential and require sound assumptive positions before being deductive. Those assumptive positions too must be empirically derived from public observation, replicable and reliably so and measured by some valid standard contextually, facially

and appropriately and of proper scale. In this business, great effort is taken to avoid finding causality from mere correlation.

Hence, in its trade practice and structure – as Thomas Kuhn would have said – the paradigms of engineering are inviolably rooted in the physical sciences. However, this does not mean that one should not consider the effects of what secular engineering brings about and make kings and princes aware of it. Therein is a spiritual and moral component essential to the advice and contained in engineers practising engineering.

I see some tendencies which seem to be developing which are clear and identifiable. These tendencies are germane to the deliberations of those in the business of advising kings and princes exercising governance. Therein it is helpful to touch on some history of that noble endeavour.

Technology. In technology, I will take engineering first. Engineering to my mind is a practical and technical business which, indeed is true to the roots of its name, *teknos* or building. Lest our heads swell, consider Imenhotep of Egypt who was taken over and revered by the Greeks as the first engineer-architect-physician-posthumous god. None of us has anything on that! As such, engineering applies societally- gained knowledge to meet the needs and mandates of the economic entities and governments demanding and regulating it in the very broadest senses of these economic demands and regulations. Thus, engineering is technology and applied technology for the use of those who demand it and for those entities which guide it. Therefore, the engineering profession is a societal technology custodian and a technology supplier and a technology driver.

Hence the burden of engineering is socio-cultural and permanent and cannot be conscionably shirked or ignored as either a technical or as a moral matter or in its practice as an ethical matter. Economic demand, in its primary sense, arises from people. Secondarily it arises from groups of people. And, in a tertiary sense, it arises from entities representing groups of people, whether private or public. However, demand is not wholly economic but is tempered by the experiences, knowledge, abilities, financial resources, the environment, geography and other factors wherein people find themselves and is often distorted by the very demanders who need it. Thus, demand by the Saudi royal government for petro engineering may differ in almost incomparable ways to demand from the US government for information manipulation technology. Hence, ultimately, engineering demand can come about in a primary way or in an attenuated or diluted way. Because of the practical utility of engineering, it is reasonable to believe that it will be demanded in most futures we may or may not be able to envision. The supply of the demands of people calls upon every possible way of knowing which makes engineering not only challenging now but making it even more so in the future.

Governance. Governance is a philosophical metasystem over governments. Good governance, albeit in ideal as old as either Plat or Aristotle, has not been settled on. We can recall that Plato looked for subjective governance by philosopher kings [engineers are not philosopher kings]. Aristotle looked to laws agreed upon by a population through its leaders as standing alone and above any person. The Ricardo school of economists emphasized the most good for the most people most

of the time. Aristotle's notion goes straight to the rule of law which has slowly infused western culture but not necessarily other cultures.

Rule *of* law differs from rule *by* law as Shen Liu has called it. Rule *by* law is the use of law as a legalistic perversion and weapon by a government to express its will in a psuedo-justicial fashion. It is the equating of the exact words of law with just outcome with no equity. Some states, such as the Russian Federation, are masters of the rule *by* law. Sad to say, some parts of the United States laws are also applied in this fashion for the expediencies of the moment.

The health of rule of law can be seen in the criminal systems of states. Rule by law is despotism with a legal cloak where the Magna Charta Rights of Englishmen are perverted by procedure, denial of habeas corpus, prolonged detention without trial, inability for the accused to present evidence fairly to a fair and open court and enforcement abuses reign. Rule of law has most closely been obtained by only a few states such as Norway, Denmark and Sweden. Norway ranks 94 on a scale of 100 on the World Bank's most recent governance survey. The United States and the United Kingdom rank 65 and 66 respectively. Therefore, governance can be subjective tending toward rule by law or objective tending toward rule of law.

Advisers and Kings and Princes should be aware of this distinction and understand its application, in my opinion, even when dealing with the objective sciences and professions. I think that there is an accelerated leaning toward rule by law worldwide and an erosion of rule of law. This is furthered by technology which is created by engineers. This is to my mind a danger of which engineers should be aware in their moral deliberations. These kinds of questions must be posed when looking at new technology: What are the immoral consequences of the technology under consideration? In other words, how can the technology be used for evil both intentionally by the evil-doer and unintentionally by the initial user? What is the risk of evil use? What are the criteria for stopping a technology if its evil is clearly going to be manifest to the detriment of both humanity and rule of law and governance?

People and Population. Demographics is a somewhat fusty statistical exercise akin to immunology in many respects. The phenomena underlying it are likely the most important drivers of the 21st century. We have a planet designed for two billion souls. We have now and will have far too many people at the end of the 21st century by an exponent of two billion. Planetary security is ultimately protection of ourselves from ourselves and ourselves from the planet. The latter is a modern concept arising from both technological advances and government advances but also from the demands of the people to whom these two things are ultimately answerable. Security is usually a function of a government or governments of a sovereign or sovereigns. Our planetary security system, concentrating on protecting people from people, was set up 350 years ago. However, that system is eroding and not merely because of the glibness of uttering the word globalization. It is more fundamental than that; which returns us to the notions of knowledge which we now use – knowledge which is the feedstock of engineering and which in its reification is demanded by people and which ultimately can hinder or enhance planetary security.

How can this be? I see several things arising which will have profound effects on technology and therefore on engineering and therefore on engineering advice to

kings and princes. These are hard scientific concepts which cannot be ignored. I will mention two.

Time. In everyday life we see time as did Plato. It is an artificial marker of events which is regular, orderly and not subject to change. It is purely a dependent variable. However, rising thought currently is taking the opposite position that time is an independent variable and can be manipulated and indeed can evolve in its expression as a variable independent of its inverse measurement functions. We often think of things independent of time. Laws, whether in physics or socially are seen in the Aristotelian way of being supertemporal. We talk of prehistory before the relative time of the current day. We speak of the beginning of time and the end of time in another way of thinking which is opposed to time being independent. However, and subtly, we have failed to see that our physical laws, by calling on time to rule them, resorts to a supernatural belief as surely as Ptolemy looked to the heavens and proposed retrograde motions to account for the heavenly concept of perfection and heavenly spheres derived from the perfect circle. Or Newton's thought that the complete laws of motion could predict the future as well as the past of all motile events. Or Feynman, and others, who asserted that if the atomic positions in Cartesian space – fixed and perfect and eternal – were known in the human body that all human behavior could be predicted in the past and the future.

Clearly none of these things is possible because it is impossible to predict forward and backwards all things to their minutest detail. This has caused a difficulty in physics which in the big picture finds it difficult to relate quantum physics to Newtonian physics to Einsteinian relativistic physics seamlessly in one theory. How can this be? Further, to predict exactly we must predict for all time and to do that we must predict for all the universe for all time because it influences and will influence the body for which we predict. That cannot be done no ore ever without computational ability as large as the universe and outside the universe. Hence, Feynman and others like him are fallacious as well as wrong.

Quantum. It turns out that current work suggests that the rules of quantum can be derived from Bayesian discrete mathematics wherein time is not a variable. It further turns out that when this is done, entirely new sets of probabilistic propositions can be found which predict quantum universes expressing themselves in a multitude of ways. In other words, it appears that when we take time out as a determinant, we can see the glimpses of relating quantum and Newtonian and Einsteinian physics so that, as Einstein said, time is a continuous flow forwards and backwards and the laws of physics should be able to account for all events in either way if those laws are universal. Paul Dirac was emphatic that time was unnecessary to account for the universe. In other words, multiple universes can be postulated with and without time. All this suggests to me that physics will have to be rethought because, as one person working in the field has suggested, there is something hiding within plain sight here which will revolutionize physics and therefore engineering and therefore technology.

Concepts of mathematics. A good deal of this can be traced to mathematics. It is often said that mathematics almost eerily presages physics. How can this be? Mathematics is not reality. It is a Platonic expression of the ideal which misses in its summarizations the true affects of nature as observed. Equations and symbols are merely models representing reality. Therefore, mathematics has a

supernatural content which we cannot afford in the future to ignore. It is as supernatural as looking heavenward and trying to find perfect circles. It reduces nature to ideal states never seen and which will never be seen. The fallacy lies in taking the method and making it the phenomena. As a summary proposition mathematical models of reality are quite useful but hardly seamless and not explanatory of what we see and certainly not wholly predictive of the future or representative of the past.

I see the next century as being one of both physical and mathematical integration. This means that the heretofore disparate branches of mathematics such as discrete mathematics and continuous mathematics of function and the various geometries of space-time will become more and more integrated into a much larger mathematics expressing both the ideal and what goes with it. This is the province of so-called *big data* now in its nascence. That in and of itself will propel physics into its own integration and vice versa. Thus, the tendency of rethinking will present to us new ways of seeing nature and hence new ways of manipulating nature and hence new technologies which are not easily imaginable today within the way we think. Thus, mathematics may indeed direct us in its own metaphysical way to new physical thinking and discoveries which in turn will create new technologies.

I will summarize to some extent.

Governance. All forms of governance have several things in common. They are expressed by some identifiable form of government. These governments have rules and direct the rules, ordering the societies governed. The rules of governance, called laws, are attempts at Platonic ideals. Governments tend to self-preserving and, when stressed internally or externally, tend to be conservative and view their own preservation as more important in the long run than the legal rights of the governed. Hence governments tend to be dichotomized with Platonic, supernatural and metaphysical goals on one hand which are proactive and expedient and self-preservative actions on the other hand which are reactive. The supernatural goals are seen as morally good or moral goals by the founders of governments. The reactive and self-preservative acts are seen as reactive and often as immoral by the governed in the short term. These are the conundrums of governance.

What does this mean to engineering? Engineering is technology. Technology has always been funded and used by governments since our earliest recorded history to both control the governed as well as to resists external stresses. Technology historically has also been abused by governments in immoral ways in the short term which abuses have continued for the long term. We recall that Milton Keynes said that in the long run we will all be dead. Those who believe in the Platonic and supernatural forms of government are often antagonistic to those who believe in the secular and amoral forms of technological advance. However, the amorality of the perfectionist is as unrealistic as the amorality of the technologist. Thus, neither fits human needs necessarily.

At the turn of the 20th century, the economic notions of value replaced the medieval arguments of good and evil. The argument was re-labelled to those of value. However, negative value is a much more slippery concept than evil and is an artifact of the metaphysics of mathematics that it was so expressed as economics it became a quantitative exercise. This in turn, along with logical positivism and the

exclusion of any metaphysics, resulted in a culture of physical engineering and technological anomalism. This is as dangerous as the immoral use of technology by governments.

We have seen engineering disasters arise from originally amoral pretexts and evolve to immoral systems. Consider the Aral Sea or the Yellow River Dam or in its extreme case – no matter the political arguments, and I take no sides here – the development of many of our chemical and nuclear weapons of mass destruction. The effects of these weapons are real and obvious and quite predictable. The effects of improper agricultural engineering and practice are real and obvious and predictable. The effects of a mis-designed or misused crude oil tanker are real and obvious and predictable. I believe that if engineers do not consider the effects of engineering and technology in their various advices to kings and princes and view things in a solely amoral manner, they indeed have acted immorally. Hence, engineers, as technologists cannot afford to buy into the notion that technology is neither good nor bad – it is the people using it who are good or bad. If it is obvious that the technology can cause great harm, it ceases to be an amoral and objectively viewable thing and must perforce be case into the realm of morality of effect for the objectively observed technology – and not the subjectively observed persons who may use it. I believe this is beyond a duty for engineers and will become an imperative in the emerging century.

Thus, advisers to kings and princes, naturalists by nature, must also cultivate a moralist by rejecting the artefacts of supernaturalism brought on my mathematical idealism. This is greater than merely stating what could go wrong and then standing back while the government takes the risk of it going wrong and kicking the can down the road as we say. Engineers must be more proactive than that in guiding governments and in engineering safeguards to reduce evil effects from the beginning.

Population. So now we are back at population. That comprises the governed and those affected by technology. I was asked last evening by a member of this academy how we were going to deal with population. If there is no change toward moral decision making, my thinking is that it will deal with itself with the Four Horsemen again riding. I sense that governments will tighten their grips against insurrection. There will be increasing social unrest accelerated by almost universal technology for the dissemination of information. Social unrest will create wars and deaths which governments may or may not wish to deal with. I do not see how we will feed this many people despite the rosy optimism of the agronomists. With a warming climate and weather disruption we will have famines which we cannot relieve and populations governments cannot feed. Large and dense populations spread diseases and plagues which may or may not be controllable. I see a reduction in population by disease which governments may or may not wish to cure. Death as the pale horse will be the result of all these. Perhaps, though, technology will be the salvation of the planet not by stopping these processes but by helping us understand them.

This does not mean that the rides of the four horsemen will occur inevitably no matter what. It does mean that engineers have within their powers the ability to influence matters to reduce inherent and intended evil by the morality of their advisory choices. So, as the owl of Minerva folds her wings at the twilight of the

current day one hundred years hence, I see some hope that the new dawn will be better if engineers and lawyer-engineers understand how their advice will be used and if the advice is tempered by moral decisions and choices recognizing the good and the evil in technology.

Conclusion. I will end with this. Techno-lawyers will be the influencers of kings and princes to a progressively greater degree as the next one hundred years progresses. Advisers to kings and princes will become more influential in this Academy because of their knowledge of technology. Technology will be the driving force of government and will strongly influence government. It is only in engineers wherein a technological morality can lie as the complications of the years ahead increase and our understanding of those complications becomes real and tempered by the realities of everyday life.

I thank you the kind invitation, your patience in listening and I wish you Godspeed in guiding the technologically moral conscience of our nation and the planet.

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Speech given at Washington, D.C. at the National Academies Building, 2101 Constitution Avenue from 3:45 PM to 4:30 PM.