Engineers[1] -Their Role in Society
A Mandate for a Globalization Committee for Engineers Canada

October 2016

Introduction

Engineers provide society with solutions to needs derived from the practical application of science, engineering principles and engineering knowledge. The profession, by virtue of its special education, training, and skills, assumes the responsibility for delivering these solutions safely and in an environmentally appropriate manner. By so doing, the engineer helps to develop the economy and delivers a better future for all Canadians. In exchange, the engineer receives a license to practice.

Society has a legitimate expectation from this arrangement – that it can hold the profession accountable for failure – and it leaves the details of professional regulation to the practitioners since they are the ones with the breadth of understanding necessary to develop appropriate rules and protocols. It follows that professional ethics arise naturally as the critical component to satisfy the primary objective of safety and public interest as well as the importance of engineering as an economic contributor to society and the importance of its implications for the environment in delivering these requirements in the real world.

There are implications for the two parties to this arrangement between society and the profession:

1. There must be a common understanding of the meaning of the term "safety" and "public interest"
2. Society, represented by its leaders, must be satisfied with the structure and application of the self-governance process
3. The profession must have a mechanism for reporting circumstances that prevent it from delivering an appropriately safe solution
4. Society must have a mechanism to measure the delivery of its expectations along with steps it can take if that delivery has been compromised.

[1] In this document an engineer is an individual who practices engineering and has been registered by the recognized authority in the jurisdiction of the practice. To be registered, the applicant must demonstrate appropriate education, skills, knowledge and experience, and is held accountable for their work. An engineer may be referred to as a professional engineer, licensed engineer, a chartered engineer, a registered engineer, or a certified engineer*.

Engineers Canada guides the regulatory process of engineering in Canada. Internationally, globalization of engineering services has the potential to impact quality. This document will serve as a framework to review current circumstances and recommend ways to understand and influence that impact.

Engineers undergo special education and training in order to apply science to practical matters and there is a requirement for experience prior to being licensed. Performance is monitored and governed by provincially mandated self-regulating organizations which issue a license to practice. It is essential that the engineer deliver safe solutions in the public interest.

Engineering solutions cost money to implement – design, construct and operate/maintain and available finances will influence the character of a project. There must be an agreed definition of the central objective under actual project constraints.

The Evolving Definition of Safety

The definition of safety is evolving. In addition to the traditional definition of physical safety, in many jurisdictions safety now includes mitigating danger to the environment and impact to society over the intended lifetime of the engineering project. The project time frame can vary (deliberately) from just a few years to much longer periods. Generally, a short term low capacity engineering solution will cost less than a long term high capacity solution. The time period of the safety warranty assumed by licensed engineers has always been an issue, with legislation in different jurisdictions setting out different limitation periods. Most limit it to a nominal period of a few years, recognizing the realities of damage beyond the control of the engineer, while accepting the fact that deficiencies might only appear later in the lifetime of the project. This needs to be factored into the modern context of safety.

There is also growing recognition that the engineer's design focus should include consideration of cost-benefit and sustainability aspects including the effects of predictable changes to the project environment i.e. climate change. This is not always possible. There are often circumstances that prevent the engineer from accurately predicting changes and there are always financial limitations that constrain design for the long term.

In certain engineering projects, consideration must be given to the possible consequences beyond the project lifetime and include planning for deconstruction and restoration, i.e. tailings pond or well closeout following the economic life of the primary project.

The Structure of the Self-Governance Process

The self-governance process in Canada is mandated by acts of provincial law that typically define the practice of engineering as it is viewed today and they change

over time as society's requirements change. They include the requirement to safeguard the economy, life, health, public welfare and the environment. The acts stipulate the need for a Regulator to regulate the practice including the requirement for:

- Standards of knowledge and skills,
- Standards of practice,
- Continuing competence,
- Enforcement to ensure that only those licensed practice engineering
- Standards of professional ethics, and
- Promotion of public awareness.

Circumstances May Prevent the Engineer from Delivering Safety

There are many ways in which the services of the engineer can fail to deliver an acceptably safe product. These circumstances may be divided into two categories – those that occur during the design process and those that occur post-design:

1. During the design period
   - Insufficient information on which to base the design
   - Misunderstanding of ultimate capacity requirements and changing considerations
   - Inadequate design
   - Inadequate resources (business terms) to complete a thorough design
   - Owner override of design features
2. After the design period
   - Failure by others to heed design engineering recommendations due to inadequate, unqualified or misappropriated resources to adequately monitor compliance during
     - Regulatory Approvals
     - Construction, manufacture, implementation or adaptation,
     - Operation, and/or
     - Maintenance
   - Unauthorized or Unapproved Changes
     - In design objectives after completion
     - In conditions forming part of the design brief
     - In project circumstances post design, and
     - Poor documentation of post design changes

Engineering Responsibility

Regardless of whether the client directive is to deliver a low capacity short term solution or a high capacity long term solution the tenets of 'safety' and "public interest" must be dealt with.

One of the engineer's primary responsibilities is to control and communicate any circumstances mentioned above, that may prevent the engineer from delivering safety safely. Responsibility lies with the engineer during the design process and

should also include the concept and planning stages where in most cases engineers are involved or should be involved to optimize the societal impact of the design.

During the design process, the engineer has several tools available to protect the integrity of the work product. They include:

- The quality assurance process as related to business practice as well as technical practice
- Operating and maintenance specifications intended to assure the effective and safe implementation of the design over its intended lifetime
- Increased factor of safety allowance for the unknowns
- The withdrawal of services in the event that irreconcilable differences prevent the engineer from completing services in an acceptable manner.

Post-design, the responsibility of the engineer can be extended by appointment to inspect and verify the work product during construction. Engineers (other than the designers) may also be involved during the construction, commissioning/implementation, manufacture, operation and maintenance and decommissioning phases. These engineers have a professional obligation to ensure that during these phases, the recommendations of the design engineer are known, understood, and implemented.

It is imperative that engineering designs have knowledgeable owners that understand how changes in objectives, conditions, and project circumstances can impact design integrity. These owners need to recognize the impact of changes, and are encouraged to seek additional feedback from engineers to determine whether the changes invalidate the original design.

Unforeseeable problems occurring after the completion of engineering tasks rely on repeated inspection by others (some of whom may themselves be engineers). Failure may not always show in the form of visible deterioration and catastrophic failure may occur without warning. Most engineering solutions are designed within fixed, agreed design criteria or using a limited state approach. Engineers are responsible for building redundancy into a design to enable a "graceful failure[2]" from which a system, product or infrastructure can recover and mitigate disaster thus protecting the safety of the public, the environment and the public interest.

Ultimately, responsibility for safe engineering in the public interest rests with society itself through legislated delegation of authority to the self-regulatory organization that licenses the engineer. Responsibility rests with individual engineers with regulators playing a regulatory role through setting of standards for qualifications, practice and quality management.

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[2] A "graceful failure" approach clearly acknowledges realistic protection levels and uncertainty, and includes contingencies that embed resilience in the engineering solution to enable functionality when portions of a system break down.

Measuring the Delivery of Engineering Expectations
Regulations, codes, and standards exist as one of the means of assuring society's acceptance of the engineering process. Codes and standards stipulate methodologies and design criteria that have delivered a satisfactory outcome in the past *but do not necessarily guarantee that under changed circumstances they will continue to do so in the future*. Regulations usually require submission of plans to agencies that impose some checking as confirmation of adequacy. Perhaps the most elaborate of these approaches is the environmental assessment in which the public plays a part by having the opportunity (*but without the responsibility*) for independent analysis.

There are also operating, maintenance and safety standards that also require updating to reflect best practices that evolved to become standard practices.

Monitoring is the principal tool used by society to measure its satisfaction with the delivery of engineering services in general. Absent a formal monitoring process, society relies on graceful failure of specific designs, and makes two crucial assumptions:

1. That deficiencies in design will visibly occur before the failure progresses to the point at which safety in its broadest sense is compromised, and that
2. That corrective action will be possible, in part through appropriate operation and maintenance and repair and replace as necessary.

The deliberate over-engineering of critical components with which there is a residual possibility of failure or greater uncertainty of performance is another approach that is sometimes adopted.

What the Regulator Needs to Deliver – Qualified and Accountable Engineers to Canadian Society
A point form interpretation of provincial statutes is that qualified engineers must:

- Meet the requirements of the legislation and guide changes in the legislation so it can be effective
- Limit their practice to areas for which they are qualified by education, training and experience
- Practice with honesty, integrity, accountability and professional judgment
- Gain knowledge and practice competency through acceptable education and training
    - Be appropriately educated and sufficiently experienced
    - Understand and comply with codes, standards and contribute to the development of codes and standards in the public interest and apply standard practices
    - Comply with quality assurance guidelines and standards in their practice,

- Understand and avoid corruption – high business integrity
- Practice ethically and in compliance with a Code of Ethics
- Allow for continuous improvement in knowledge and practice
- Remain current in knowledge and practice
- Have sufficient legal knowledge to inform their practice of engineering

In undertaking its obligation to deliver an engineer that can live up to the requirements of society, the Regulator understands it is not a matter of command and control but rather trust that the professional engineer takes his or her work seriously and performs to the best of their ability. The regulator accepts the mandate set out in provincial statutes that note the following:

- The requirements of an engineer's education are defined, checked and certified in conjunction with the academic institutions offering engineering programs. They also form the basis of examinations required by the academic institution or by the regulator to ensure that candidates hold the required knowledge base for engineering. Technical updating of that engineering knowledge base post-graduation is required through the Code of Ethics and often based on a requirement to report continuing professional development activities to the regulator
- Engineers working in conjunction with government as well as with non-government entities develop standards, guidelines and codes of practice intended to facilitate safe design and implementation procedures.
- Engineering groups and societies voluntarily adopt quality assurance procedures and overarching group protocols such as the ISO standards, to assure that members of the group know what is expected and deliver on that expectation.
- Ethical and legal knowledge are taught and practitioners are examined to ensure the expectation for proper behavior is known and followed.
- Finally, there is a requirement to demonstrate competencies at expected levels and in defined areas through a minimum period of postgraduate training in expected areas of experience to ensure that the otherwise qualified individual can be named and licensed as an engineer.

These elements exist in legislative acts to assure society that competent engineers are protecting the public interest through self-regulation. In addition, violations of the acceptable range of behavior in ethics and in practice are reviewed by the Regulator. Non-compliance to the expected behavior can result in censure, remedial activities and/or removal of the license.

Failures of engineering do occur although not many that result in loss of life, and are often accompanied by investigation through the Regulator, by judicial bodies put in place by government, and by the owners of the work product. These investigations can result in licensing penalties, actions in civil and criminal courts, and by financial

losses brought about by loss of confidence in the performance of the engineers in question.

In the case of corruption by individuals or engineering companies, conviction results in fines, jail, and/or exclusion from the ability to bid on government contracts for a period of time followed by the need to prove that new procedures prevent the return of the problem.

Limitations of the Existing System

There is room for improvement in the system- failures and negative impacts still occur. Perhaps the largest relates to the way some professionals deal with inconsistencies in the demand for engineering services. Governments acting as clients for engineering services sometimes, but not always require the surety of an engineer's signature and/or stamp on works submitted for the approval of regulatory agencies. As a result, individual engineers involved in such projects routinely apply for licensing, and owners whose projects are subject to regulatory review demand engineering input and assurance of design.

The manufacturing industry in Ontario has no such universal requirement and engineers involved in that industry may not bother to seek professional status. There are similar gaps in demand for certain aspects of environmental activities, and registration requirements for geoscience expertise are inconsistent across the country. Some software design does not require professional licensing. Where such gaps exist, society has no protection for failure other than civil litigation after the fact.

In the experience of Committee members, cases of engineering failure most cases of engineering failure in Canada are brought about by deficiencies in ethical/business practice, in acceptance of engineering constraints imposed in the interests of cost minimization (especially inadequate inspection during, and post construction), in poor communication, and in failure to follow the engineer's guidelines, maintenance, and operating specifications post-construction. Very occasionally, on new types of engineering with which there is inadequate experience, failures will occur as a result of technical deficiencies.

Implications of the Globalization of Engineering Practice

The globalization of engineering practice most directly affects the consulting engineering industry. This industry is the major employer of engineers in Canada.

The business model for consulting engineering has changed over time. In the past, it was common practice for a company offering engineering services in another country to move the required technical staff for the duration of the project. There was often no local partner to take engineering responsibility for the project or if such a partner existed, it was unusual for that partner to have the breadth of engineering experience to be as credible as the responsible entity in the project

country. It is understood that this approach is much less common today, and mostly still applies to projects in countries that have no legal system of engineering responsibility and as a result, recognition of license is not a factor. In a significant percentage of the developing world, engineers are not licensed as they are in Canada and have no formal obligation to sign their work product or to take responsibility for its impact on society outside of that imposed by successful civil litigation.

However, for the last 20 years there has been a steady increase of consolidation within the consulting industry. This increase was initially driven by a greater-than-organic growth of public ownership, and later by an increased client demand for companies that could deliver the full range of required in-house services. As a result, it is very common for Canadian firms to have parts of their operations located in other countries or for the Canadian operation to be a branch office of a much larger firm based in another country. These *multinational* firms typically operate as a collection of related entities rather than as an *international* firm with completely integrated operations. The business advantage enjoyed by these firms lies in the availability of wide-ranging experience from their activities and focus in different parts of the world, greater elasticity of operation to accommodate varied demand, and minimization/distribution of the cost of head office functions. Other important considerations relate to the ability to carry out project work in the least expensive location (salary and benefit costs). Over time business development and efficiency needs drive multinationals to behave in a more international (fully integrated) basis.

As a result of this trend, competition for projects in Canada is effectively international and the work may be carried out anywhere. Similarly, Canadian engineers may work on projects located anywhere in the world and may or may not travel to another country to do so. This practice is expected to continue and increase as trade agreements that include engineering services proliferate.

Under these circumstances, the licensing requirements/protocols, and indeed the engineers' role in society impacts the nature and scope of the products of service that are produced. Canadian engineers working on projects in other countries produce a product that is primarily determined by local needs and standards rather than by the Canadian perception of the engineers' role and responsibilities in society.
There is a strong case to be made for the full range of services to include local knowledge (project location), understanding of local issues and designs that are locally applicable even if the competing firm does not have a local presence. In either case this leads to the assembly of teams to work together to deliver and take responsibility for the project.

Deliverables and outcomes are strongly influenced by the local knowledge brought to the team as well as directions given to them by the organizations within which they work. They may or may not be asked to formally sign the work product.

From a regulator perspective, Canadian licensed engineers working in or for other countries are constrained by their Canadian codes of ethics and disciplinary processes. Similarly those working in other counties for Canadian projects and providing engineering services to Canadian entities are required to be licensed in Canada.

Engineers from other countries working on projects in this country should be similarly constrained by mutual recognition agreements. In practice, mutual recognition agreements at a professional level are very difficult to negotiate and nearly impossible to ratify among all the regulators. The term "mutual recognition" strongly implies that ratification should be withheld failing the achievement of reciprocity.

In practice, international project efforts are normally carried out in teams and it is common practice for a supervising engineer to take overall responsibility and sign the final documents on behalf of the entire project. It is also common practice for two stamps / signatures to be applied to the drawings and specifications prior to final issue – the supervising / coordinating engineer as well as the discipline engineer.

Further guidance on distributing the assumption of responsibility for the components of design is required.

Role of the Globalization Committee

A Globalization Committee will be formed to address these issues on behalf of the Canadian engineering profession. It will be an Operational Committee reporting to the Engineers Canada CEO. The scope of the committee's interests will be tied to the reality of increasing globalization in the profession. In keeping with the mandate of Engineers Canada to support the interests of the profession in this country, past versions of this committee working with staff were traditionally involved in four areas of interest. This should extend into a fifth area[3] as indicated below:

1. Information and registration support for engineers immigrating to Canada, as well as engineers living outside Canada that provide engineering services to projects located in Canada
2. Mutual Recognition Agreements and efforts to support Canadian engineers seeking to operate abroad, including international qualifications such as the International Professional Engineer or APEC Engineer.
3. Canadian participation in international engineering organizations
4. Trade in services agreement issues related to the Canadian government's bilateral and multilateral trade treaty efforts.

[3] It should be noted that the committee objectives and associated tasks are not intended to be constrained by the term of a particular committee but represent overall objectives that should be adjusted over time and serve as the raw context for committee activities.

5. Add a more generic effort to support the profession's role in society in an international context.

The committee's objectives and Terms of Reference in the form of annual Committee Charges should be defined in the context of these five areas of interest. There may be overlap with other activities undertaken by Engineers Canada, in which case the globalization committee will maintain a linkage to assist as appropriate. An analysis of the activities of Engineers Canada and the Regulators within the five areas of interest of the Globalization Committee will determine the scope and nature of work it will undertake or coordinate.

Area of Interest #1 – Licensing of immigrant engineers and foreign-based engineers performing engineering work in Canada

Only in case of an individual immigrating to another country (in either direction) is the mutual recognition agreement of key importance to the ability of the individual to continue to earn their livelihood in their chosen profession. Canada has a strong immigration policy and an ongoing need for engineering professionals. Engineers need access to information during their decision making process and the ability to complete the majority of the licensing process pre-arrival and supported by the activities of the Regulator upon arrival.

Because of the legal structure of engineering regulators and the Canadian Constitution, which places responsibility for professions at the provincial/territorial level, changes in licensing requirements are in place in each province and territory. This makes the whole process cumbersome, but perhaps ensuring a comprehensive ultimate perspective that serves the public interest.

The scope of Committee's work could include:

1. *Review the licensing of immigrant engineers in Canada and foreign-based engineers practicing in Canada with the objective of streamlining the process without losing quality, including a streamlined process for competent and ethical engineers. Conclude with a discussion paper on policy and procedural options that can be used to encourage coherent approaches within the provincial and territorial regulators that can be given to government at the federal and provincial level to support immigration efforts and indicate what the profession is doing to support immigration policy. It can form the basis of information pieces to the membership and to prospective immigrants engineers living outside of Canada that practice in Canada (especially those that continue living in the United States but have practice in Canada)..*
2. *Support a system of web resources showing prospective immigrants, foreign-based engineers practicing in Canada and Canadian engineers thinking about practicing on projects located abroad and indicating some of the realities of the globalized engineering profession.*

3. *Interact with ACEC on the information needs of consulting engineers in this regard.*
4. *Interact with ACEC on consulting policy especially in regard to the import of temporary workers, the execution of offshore engineering practice in Canada as well as work on "one-off" individual time-limited projects.*

Area of Interest #2 – Mutual recognition agreements

Attempts to develop mutual recognition agreements at the professional level between countries have been slow even in closely aligned countries. These efforts have been hampered by protectionism, by arrogance, by local thinking that often fails to recognize the increasingly global nature of the profession, and by the lack of a forceful driver given the ability of commercial organizations to work around any restrictions. The classic example for Canadians is the North American Free Trade Agreement (NAFTA), in which an international agreement completely failed to move the American states (with the exception of Texas) to recognize the P.Eng. as equivalent to the PE do anything in spite of decades of effort.

One variation of the mutual recognition agreement takes the form of organizations in which engineers can be registered and recognized by a number of countries as acceptable qualifications for work in those countries i.e. international registries. Few Canadian engineers are registered in these organizations suggesting that they are not really solving a pressing problem.

The scope of the Committee's work could include:

1. *Refine the Engineers Canada Mobility Register (enhanced International Professional Engineer and APEC Engineer registers)*
2. *Define the Key Considerations/Criteria for full mobility*
3. *Review existing efforts from a different perspective – that of the role of engineers in other countries and how it affects similarities and differences to the Canadian model – stand back from our current preoccupation with the details in order to look more at the context.*
4. *Produce succinct summaries of the status quo, put them on the web, and in this way provide them to the membership at large*
5. *Review status and effectiveness of existing MRAs with the Regulators and ACEC. Focus current efforts based on this review, but cut down on the time, effort and resources since they do not appear to be making much progress, nor do they appear to be driven particularly strongly by demand from the membership.*

Area of Interest #3 – Participation in International Organizations

Canada participates in a number of international engineering organizations. The organizations exist for a variety of reasons that may or may not be useful for our global objectives.

The scope of the Committee's work could include:

1. *Simplify our objectives in participating in these organization and develop a simple, coherent, measurable plan for each that can be evaluated on an bi-annual basis and presented to the provincial and territorial regulators*
2. *Use our memberships to push the Canadian model of engineering qualification and regulation and support the efforts of other countries to install this model*

Area of Interest #4 – Trade Agreements

The Canadian government strongly supports bilateral and multilateral trade agreements and since an increasingly important component of such agreements is trade in services, there needs to be a strongly maintained, government linkage to the profession to ensure that negotiators are aware of the absolute requirement for reciprocity or not, since the qualifications of engineers in some countries would fall far below what our regulators would be willing to accept even on a temporary basis in any terms that affect engineering.

The scope of the Committee's work could include:

1. *Develop a short coherent statement of engineering interests that would be of use to Canadian negotiators*
2. *Interact with the Department of Global Affairs by providing materials and representatives for Engineers Canada's activities in this respect*
3. *Provide comments to Canadian negotiators on elements of trade in services that positively or negatively impact engineering services in Canada and in the country or region as applicable*
4. *Review draft agreements to the extent possible and explain their implications to the membership*
5. *Liaise with ACEC to mutually support and coordinate efforts in this regard*
6. *Obtain an indication of work in progress activities*

Area of Interest #5 – The Role of the Engineer Internationally

In many respects this is a perspective that should be brought to all of our efforts in support of the other four areas, rather than being an area in its own right. The earlier parts of this paper attempt to define our current role in Canada without talking about what it should be so perhaps that is the first task.

The scope of the Committee's work could include:

1. *Write an aspirational paper defining what the role of engineers should be in Canadian society and internationally*
2. *Examine the impact of this overall objective in regards to the focus of the other areas of interest*
3. *Develop a plan to sell the concept both domestically and internationally*

Committee Charges for 2016-17

Five tasks have been suggested as the committee focus for the period October 1 2016 to June 30 2017. They are:

1. Undertake a study of the significance of offshore engineering activity as it relates to Canadian engineering projects, both domestically and abroad,
2. Promote International Mobility Registers such as APEC to facilitate recognized international mobility for registered engineers in the Authorized Member countries, and
3. Work with FIDIC and WFEO to inventory tools that support international standards of engineering behavior relevant to such an International Mobility Register (e.g. anti-corruption activities).
4. Develop a short coherent statement of Canadian engineering interests for Canadian government negotiators and provide input to draft trade agreement in service provisions as they may impact engineering on an as needed basis.
5. Develop a national position statement on globalization of engineering services.

These charges will be vetted through the committee membership and the final version tabled for acceptance by the Engineers Canada CEO.