ASPECTS OF CHILD SAFETY IN AUTOMOBILES

By Matthew Bondy, Xilin Chen, and William Altenhof, PhD, P.Eng.

TRAFFIC INCIDENTS RESULT in not only the loss of property but also the loss of life, which includes our most valuable members of society–children. When children are victims of traffic accidents, it can have a devastating impact on the children and their families, both emotionally and financially. Road traffic accident-related injuries also result in heavy economic burdens to society. The direct and indirect costs of road traffic accidents are paid for by the taxpayer every day.

Injuries, in general, cost Canadians $19.8 billion and 13,667 lives in 2004. That same year, traffic incidents were the third leading cause of overall injury costs, accounting for $3.7 billion or 19 per cent of total cost of injury and economic losses. They were also the leading cause of indirect costs (the value lost to society as a result of the illness in question) of injury, accounting for $2.1 billion (23 per cent of total indirect costs). In Ontario, motor vehicle incidents resulted in 400 deaths, 4805 hospitalizations, 1249 permanent partial disabilities, and 126 permanent total disabilities in 2004. These incidents brought a heavy economic burden to the Ontario population, with $599 million in total costs, including $280 million in direct costs (the value of resources used to treat the people incurring the illness), and $319 million in indirect costs.

The number of occupant fatalities (ages 0-14) from 2002 to 2006 in Canada and the US is shown in Figure 1 (see p. 54). The Canadian data was obtained from Statistics Canada's Canadian motor vehicle traffic collision statistics. The US data source is the Fatality Analysis Reporting System (FARS). When considering the trend over the last five years, it can be observed that in Canada there has been no significant decrease in the number of child fatalities (a 3 per cent drop from 2003 to 2007), while there was a 20 per cent decrease in the US over this five-year period. This is especially significant when it is considered that in 2004, the World Health Organization specifically focused on reducing injuries and fatalities due to road traffic accidents. This finding clearly indicates the need for better research, education, policies and policing of child restraint systems (CRSs) use in Canada.

INJURY MECHANISMS

CRSs provide specialized protection for small occupants whose body structures are still immature and growing. The primary goal of these systems is to protect the central nervous system, since broken bones will mend and soft tissue damage will heal. To optimize tolerance to impacts, forces must be distributed as widely as possible over the strongest parts of the body. For adults, this includes the shoulders, pelvis and chest. For children, especially infants, restraint over larger and sometimes different parts of the body is required–correct placement and proper-fitting belts and harnesses are critical for an effective restraint system. Serious restraint-induced injuries can occur when belts are misplaced over areas of the body having no protective bony structure. For example, improper positioning of a lap belt can occur during a crash, if the belt is loose or is not held in place by a positioning device. A lap belt that is placed or rides up above the hips can intrude into the abdomen and injure internal organs. Without a shoulder restraint,

a lap belt can also act as a fulcrum about which the lumbar spine (lower back) flexes. Separation or fracture of the lumbar spine may result.

Understanding the anatomical, physiological and developmental differences between children and adults is of paramount importance to determine injury mechanism and implement countermeasures to mitigate the risk of injury for children in motor vehicle crashes (MVCs). The dissimilarity in body segment proportions (i.e. greater weight percentage of the head) and biomechanical properties (i.e. much weaker neck muscles) demands special consideration when designing safety devices for children.

RESEARCH TOOLS IN CHILD SAFETY

Anthropomorphic testing devices (ATDs) are mechanical surrogates designed to mimic pertinent human physical characteristics, including size, shape, mass, stiffness and energy absorption/dissipation. They are classified according to size, age, gender and impact direction. Due to the ethical issues and testing challenges, the assessment of the biomechanical properties of human beings is often difficult to obtain. Currently, the properties of human tissues are obtained from animals, cadavers and research from real-world crashes. These properties are incorporated into the ATDs and/or finite element models of these crash-testing devices.

Virtual crash testing began as early as the 1960s with multi-body models. In the simplest multi-body models, rigid bodies are connected by various joint types through which a number of degrees of freedom can be constrained. Alternatively, the finite element method of structural dynamics numerically solves a set of equations of motion for deformable bodies coupled with material stress-strain properties. A significant advantage of the finite element method is the capability to describe local structural deformations and stresses in a realistic way.

CHILD SAFETY RESEARCH IN CANADA

AUTO21 is a national research initiative supported by the Canadian government through the Network of Centres of Excellence program. AUTO21 brings together nearly 200 Canadian researchers at 45 universities and partners them with approximately 150 industry and government partners. This national collaborative support organization has almost certainly enriched the lives of Canadians. However, this organization, the Canadian populace, and the global community could benefit from more international collaboration on issues, like motor vehicle crashes, which affect countries around the globe.

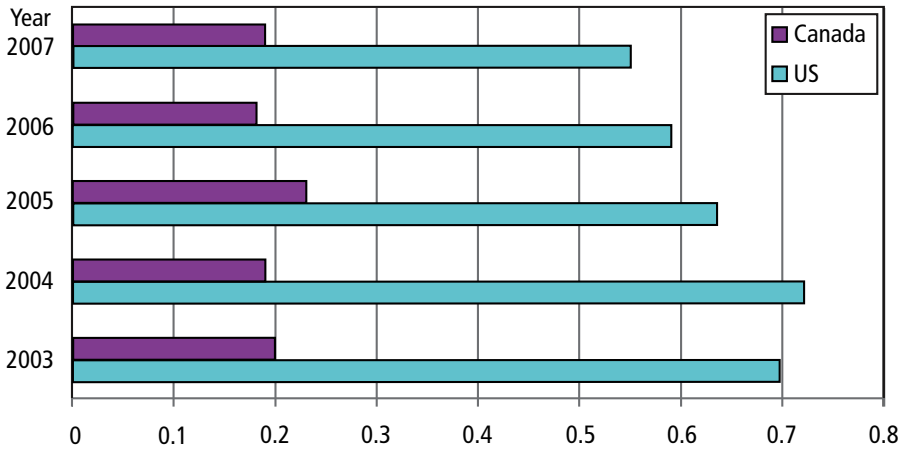

Figure 1: Occupant fatalities (ages 0-14) in Canada and the US per 100,000 population.

Researchers supported by the AUTO21 Network of Centres of Excellence have focused on understanding injury mechanisms and considering countermeasures to improve child safety in automobiles. Their researchers have used clinical data, experimental sled testing and numerical modeling to investigate child kinematics and loads that children may experience in a vehicle crash. Further consideration towards child restraint misuse, load-limiting tethers to secure the CRS, improvement of the neck behaviour of a finite element human model and ATD model both representative of a three-year-old child, and methods to mitigate injury in near-side impacts have been investigated.

AUTOMOTIVE CRS STANDARDS

Recent revisions to Canadian CRS standards and regulations are significant improvements with aspects that may inspire improvements in other standards around the world. These revisions were intended to realign Canadian and US policy with respect to automotive CRSs resulting from the US revision of their standard (2003). However, aligning Canadian standards with those of the US may not be the course of action that provides the best protection for Canadian children in automobiles. European and Australian standards include several tests and requirements that are not found in Canadian or US policies. This may stem from the absence of Canada and the US from the World Forum for Harmonization of Vehicle Regulations (WP 29), a working party of the United Nations Economic Commission for Europe (UNECE). If geography is a factor in remaining autonomous, it should be noted that members of this working party include Australia, Japan and South Africa. If Canada were to take part in

this working group, it might inspire representation from the US.

One of the many automotive subjects considered by this forum is automotive CRS testing standards. The European child restraint standard (ECE 44) requires testing under frontal and rear collision conditions, whereas Canadian and US standards require testing only in frontal collision conditions. Additionally, the permissible anthropometric testing device response from the European dynamic tests is more conservative despite harsher testing conditions.

In terms of the response, ECE 44 restricts the maximum acceleration of the chest to 55Gs, whereas the Canadian regulations allow chest accelerations of up to 60Gs. The European standard also specifies how many samples are required for each test based on the volume of production. Another example of the statistical requirements in ECE 44 is the head excursion limit. The sum of the mean head excursion and the standard deviation of the head excursion must not exceed 550mm for forward-facing restraints. This is another example of the more demanding requirements in the European standard. The comparable limit on head excursion in the Canadian and US regulations is 720mm.

Another impressive aspect of ECE 44 is the extensive appendix, which includes complete specifications for the trolley used in dynamic testing, anthropometry of different age groups, adjustment procedures for ATDs, a belt abrasion test and a corrosion test. There is an obvious effort to make the standard self-sufficient. This quality can also be attributed to the Australian and New Zealand CRS standards. Like the Canadian standards, the Australian standards were revised in 2010. The Australian standard is the first to incorporate dynamic tests for side impact conditions in addition to frontal and rear collision conditions. Overall, there is one major deficiency that all standards share: the bench seat used in the dynamic tests is not representative of the seats in common production automobiles. It is not just the shape of the bench, but also the properties of the foam and other internal components (e.g. lumbar supports). Additionally, many vehicles are equipped with captain's chairs in positions suitable, or even preferable, for mounting child restraints. However, we have seen literature forthcoming on this issue.

FUTURE WORK

Although there are guidelines for the safe use of car seats with children over five pounds, many infants are below the recommended five pounds for vehicle travel when they are discharged from the hospital. The majority of these infants are too small to be securely seated in rear-facing child seats. In addition, infants at this developmental stage have poor head/neck control and cannot protect their airway if their head should shift down and forward during vehicle transport.

An AUTO21 research project involving the University of Windsor and McMaster University seeks to reduce the risk of injury through the design of a contoured child seat insert for preterm and low birth-weight infants. The stages of this research will include a systematic review of literature on positioning high-risk infants in car seats, evaluating seating and positioning techniques at neonatal intensive care units (NICUs), generation of a seat insert CAD model, design of a low birth-weight infant computer model, and feedback from nurses and parents at NICUs.

Despite very recent updates, Canadian CRS standards lag behind those of Europe and Australia. Child restraint misuse also remains an issue with well understood, negative consequences. Engineers have the tools to design more protective restraints that are easier to use. However, greater collaboration between different disciplines could increase the efficiency and efficacy of the research and design process.

REFERENCES

1. Du Bois, P., C. Chou, B. Fileta, T. Khalil, A. King, H. Mahmood, H. Hertz, and J. Wismans. *Vehicle crashworthiness and occupant protection*, American Iron and Steel Institute, Southfield, Michigan, pp. 1-388, 2004.
2. Kapoor, T., W. Altenhof, A. Snowdon, A. Howard, J. Rasico, F. Zhu, and D. Baggio. "A numerical investigation into the effect of CRS misuse on the injury potential of children in frontal and side impact crashes." Manuscript submitted to *Accident Analysis and Prevention*.
3. Kapoor, T., W. Altenhof, A. Howard, J. Rasico, and F. Zhu. "Methods to mitigate injury to toddlers in near-side impact crashes." *Accident Analysis and Prevention*, 40:6, pp. 1880-1892. November 2008.
4. Kapoor, T., W. Altenhof, M. Tot, W. Zhang, A. Howard, J. Rasico, F. Zhu, and K. Mizuno. (2008). "Load limiting behaviour in CRS tether anchors as a method to mitigate head and neck injuries sustained by children in frontal crash." *Traffic Injury Prevention*, 9:3, pp. 243-255.
5. Motor Vehicle Restraint Systems and Booster Seats Safety Regulations, *Canada Gazette*, October 10, 2009.
6. NHTSA. (2010). Fatality Analysis Reporting System (FARS). www-fars.nhtsa.dot.gov/Main/index.aspx, accessed October 15, 2010.
7. SMARTRISK. (2009). *The Economic Burden of Injury in Canada*. SMARTRISK: Toronto, ON.
8. Statistics Canada. www.statcan.gc.ca/start-debut-eng.html, accessed April 27, 2010.
9. Weber, K. "Crash protection for child passengers: A review of best practice." *UMTRI Research Review*, 31:3 (2000), pp. 1-27.
10. Zhang, W., T. Kapoor, W. Altenhof, A. Howard, and K. Mizuno. *Implementation of child biomechanical neck behaviour into a child FE model*. Society of Automotive Engineers 2009-01-0472 (April 2009).

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EROSION OF PROFESSIONAL ENGINEERING BY THE FEDERAL GOVERNMENT

By John Roberts, P.Eng.

THE FEDERAL GOVERNMENT has for some time been transferring its accountability in the transportation sector under a policy known as Safety Management Systems (SMS). The *Railway Safety Act* and the *Canada Shipping Act* were updated in 2001 to include SMS.

Canada made SMS in the aerospace sector law with changes to the *Aeronautics Act* in 2005. In *Canada Gazette Part II*, June 15, 2005, SMS is defined as "a documented process for managing risks that integrates operations and technical systems with the management of financial and human resources to ensure aviation safety or the safety of the public."[1]

Aerospace is the last transportation sector targeted for SMS, because it is complex, it has high public visibility and the consequences of failure are high. The government has mandated SMS for air operators, airports and aircraft maintenance organizations.

RESPONSIBILITY FOR PUBLIC SAFETY IN AEROSPACE

As it currently works, the transport minister is responsible for public safety via management of various departments. The design and approval of aeronautical products are managed by Transport Canada Civil Aviation (TCCA) via airworthiness regulations. TCCA, the US Federal Aviation Administration (FAA) and the European Aviation and Space Agency (EASA) are the world's key airworthiness regulators, striving to balance sovereignty with acceptance of other governments' regulations. Airworthiness regulations are structured to be similar among TCCA, FAA and EASA, so that meeting the regulations of one implies that the regulations of the others are also met. However, each airworthiness regulator also determines for itself that its regulations have indeed been met before an aircraft (or aircraft product such as an engine) can operate in its jurisdiction. Hence, public safety is served by ensuring that products comply with regulations, while trade is enhanced by making it easier to accept foreign products.

However, TCCA, FAA and EASA, whose primary roles are to make regulations and then to ensure compliance to those regulations, each have extremely limited engineering resources.

The United States leveraged its government engineering resources through a process known as delegation, in which selected private sector aerospace engineers are granted privileges to make findings of compliance on behalf of the US government. This system of designees was institutionalized by 1946. At that time, it was envisioned that the US government function would be one of inspecting people who would, in turn, inspect products and personnel, with the aim of the government delegating authority to the greatest extent possible, while keeping tight control through spot checks.[2]

Canada introduced its system of engineering delegates in the 1960s. In the Canadian system, TCCA conducts full audits of a delegate's regulatory procedural conduct, detailed technical audits of high-risk subject areas and, when necessary, TCCA directly participates. In some specialties, such as structures, TCCA acknowledges that 99 per cent of all findings of compliance are made by delegates.[3]

This Canadian engineering delegates system, under which the transport minister manages public safety relating to design and approval of aerospace products by technical and regulatory management of aerospace engineering delegates, has proven effective and our aerospace industry cannot function without it.

Yet the transport minister has almost no role in the education, training, registration, ethics, competence or other aspects that define professional engineering, and although the minister expresses a preference that engineering delegates be professional engineers, it is not a firm requirement. In fact, it is Professional Engineers Ontario (PEO) and the other provincial licensing bodies that are responsible for defining professional engineering, making them effectively responsible for presenting to the minister the candidates for engineering delegates. Certainly, it is the minister (through TCCA) who determines which individuals will be granted the privileges of a

delegate, but it is not the minister who is involved with the professional conduct of the individual (outside of specific regulatory performance). Such conduct is within PEO's (and the others') domains.

AIRCRAFT CERTIFICATION–THE CORE OF AEROSPACE ENGINEERING

Aircraft certification is the core of aerospace engineering and the core of public safety for civil aerospace. No aeronautical product flies in Canada or almost any other country unless that product has been certified to meet applicable airworthiness requirements, with the exception of products for use by the military.

The engineering review to determine that an aeronautical product can be certified is conducted by TCCA staff (particularly staff engineers) and delegates, who are divided into two categories. The first comprises consultants available to support all of industry, called design approval representatives (DARs). The second comprises employees of businesses that employ several engineering delegates within their organization. These individuals, often called authorized persons (APs), are not available to all of industry. The most popular name for their employers is design approval organizations (DAOs).

It is essential to understand that the minister grants privileges–hence accountability for public safety–to individuals, who are accountable directly to the minister for matters of public safety, not to their clients or employers.

The aircraft certification process begins by defining airworthiness requirements for the design, which comprise a list drawn from regulations that apply to the product. This list constitutes the safety rules determining if a product is airworthy. This crucial first step is performed by TCCA staff and delegates. The next, and often crucial, step is to determine methods by which compliance to airworthiness requirements can be demonstrated.

Although today it is the norm to outsource work, including engineering, the aircraft certification process aspect of developing aeronautical products is jealously and most carefully guarded. If a new aircraft cannot be certified, it fails regardless of its merits. If a new design feature cannot be certified, a product loses a competitive advantage. Cheaper and faster means of demonstrating compliance to achieve design approval give manufacturers marketing and financial advantages. This is why aircraft certification is crucial to aerospace businesses.

Canadian aerospace is a $24-billion-a-year industry, and the number of TCCA staff and delegates supporting this industry is small–only about 60 DARs and roughly 480 APs within DAOs. This small pool means two things: that the number of aerospace engineers who understand the issues described in this paper is small and, since only the DARs are independent, the number of aerospace engineers who can and will publicly discuss these matters is extremely limited.

THE CHANGING ROLE OF GOVERNMENT

The reasons why the government wants to change its role are not complex: the aerospace industry is growing, requiring increased government oversight necessitating more engineering staff; TCCA will begin losing up to 46 per cent of its experienced staff to retirement starting in 2012;[4] and there are perennial demands to reduce the size and cost of government. It is also government policy (transcending TCCA itself) to reduce its liability.

SMS became the convenient opportunity for government to change its role, offloading accountability (liability) to the private sector while reducing size and cost (meaning staff). In aerospace, the new direction was articulated in Transport Canada's *Flight 2010–A Strategic Plan for Civil Aviation*.

As envisioned, SMS was never intended to replace government oversight, and TCCA is careful to repeat the mantra that SMS is "another" layer of safety. But a cursory examination shows this is not the case. The implementation of SMS–as opposed to SMS itself–is being used to eliminate the current system of engineering delegation. Engineering delegates are to be replaced with a new Aircraft Certification Accountability Framework (ACAF) that:

- eliminates individual engineering delegation;
- eliminates indemnification by the Crown;
- establishes new accredited design organizations (ADOs);[5] and
- replaces technical oversight by system audits to ensure ADOs are SMS-compliant.

The eliminated features in the first two bullets are linked. Under the current system, individuals acting on behalf of the minister are legally protected by the Crown (indemnification). This is an important safety feature, because it means an individual can act in the interest of public safety without fear of reprisal from clients or employers. Unfortunately, government policy-makers focus on indemnification as a vulnerability rather than an asset, making the Crown accountable for engineering delegates' mistakes. In SMS, someone who reports unsafe conditions or safety violations is supposedly protected from reprisals, but in reality no legislation exists to accomplish that.

In SMS, delegation is replaced by accreditation, with TCCA determining that a business organization demonstrates the technical knowledge and capability to be accredited as an ADO. But aircraft certification activities and the supporting design, analysis and testing are aerospace engineering, effectively making accreditation a licence the government issues to a business to engage in engineering.

Also, ADOs are typically part of a larger business organization, such as a manufacturer or operator, meaning they answer to corporate interests. With the government redirecting staff resources to conducting system audits and the small cadre of technically-oriented engineers TCCA retains being insufficient to engage in technical or regulatory oversight of ADOs, who will be keeping watch on the ADOs, which are effectively certifying aeronautical products?

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In fact, TCCA is replacing oversight with SMS, which in this implementation amounts to a system of self-regulation. In its Advisory Circular 505-003, *Safety Management Systems for Design Organizations*, outlining the requirements of SMS for business organizations, TCCA includes self-audits–engineers within ADOs checking each other's work–as a core feature of SMS.[6] In practice, however, aside from the very largest manufacturers, companies will not have more than one, say, aerodynamic flutter specialist on staff. So, who will check this person's work?

And who has a role in the education, training, ethics, competence or other aspects of the engineering behaviour of the organizations the government accredits to conduct engineering? SMS requires ADOs to undertake these responsibilities, including policing of their employees and the ADOs themselves–self regulation without restraint.[7] The government has shifted its role from technical oversight to "management" oversight, where it is not delegating individuals or ADOs themselves.

The stark reality is that aeospace is the domain of the federal government, which argues that federal authority supersedes the authority of PEO and the other engineering associations. The associations understand this and do not enforce their acts against the federal government. Instead, Engineers Canada engages the government on behalf of their constituent associations, but is not itself a regulator with an act to enforce.

DARs are highly motivated to be licensed by the provincial engineering associations, because as consultants they are visible to the public and to the associations. APs within DAOs are somewhat motivated, since the transport minister currently expresses a preference for registration. TCCA employees are fairly neutral on licensing, since the government does not make it mandatory. Engineering employees within the new ADOs will have no motivation to register, since they are not delegated individually. ADOs will have no motivation to encourage licensing of their employees, because they see it as increasing costs and not being required under ACAF, and the ADOs' authority to practise engineering is from the federal government.

Overall, TCCA is not an engineering organization. Indeed, engineering (meaning aircraft certification engineering) is one of the smallest groups within TCCA. By and large, government policies, procedures and guidance material (such as Advisory Circular 505-003) are not developed by aircraft certification. Instead, they are developed by government personnel outside of TCCA, as well as TCCA personnel in such departments as standards. So it is not surprising that engineering has little input into such policies and procedures as ACAF and ADOs. Nevertheless, aircraft certification engineering is utterly critical to the international recognition of Canada's aerospace industry, airspace sovereignty and public safety.

Interestingly, the FAA is implementing SMS across all facets of the US aviation community on a voluntary basis, although it will likely make SMS mandatory at some point. Meanwhile, the FAA is retaining its engineering delegates and incorporating them into the FAA SMS program. The FAA is also considering an ADO concept for the largest US aerospace companies, based primarily on industry requests for a more expedient aircraft certification process. The FAA estimates that only about four companies will qualify. Canada, on the other hand, will impose the ADO concept as if each aerospace organization is on the same scale as the largest US aerospace companies and either has all the engineering expertise in-house or has access to it through consultants.

THE POWER OF SEMANTICS

TCCA announced its implementation plan for SMS to industry in 2005. At that time, TCCA termed the plan the New Accountability Framework (NAF). NAF received instant criticism from the minister's delegates, which circulated throughout the aerospace industry. In response, the government simply changed the name of the implementation plan to the Aircraft Certification Accountability Framework (ACAF). Suddenly, the trade publication articles, websites, letters to MPs and more lost steam, because NAF didn't exist anymore. Although the critics tried to explain that ACAF was NAF, describing the policy change was complex enough–trying to account for name changes was a real blow to them.

The absence of professional engineers in ACAF was a point of criticism from many professional sources.[8] So, aircraft certification was deemed not to be engineering. The former director general of civil aviation, Merlin Preuss–himself a P.Eng.–once declared during a meeting: "The last thing we need is for the engineering associations to tell us how to design aircraft."[9] Preuss further elaborated on the government's perception of professional engineering with his statement: "A professional engineer has no standing in a federal system."[10] In a letter to Engineers Canada, Preuss pointed out that work conducted by delegates is not engineering.[11] He went further to imply that the responsibilities of design approval holders (those responsible for continuing airworthiness) is not engineering. The language was chosen very carefully.

By making this declaration, TCCA excluded any role for PEO and the other associations. TCCA would now control the entire environment of the ADO. Nor was the government alone in pursuing this line of thought; there was one large aerospace industry association that strongly supported the government's position on ACAF, perhaps seeing the potential of accelerating design approvals if professional engineers weren't needed. And as long as engineering associations choose not to enforce their acts, government and industry organizations know they are immune to adverse fallout. Today, there are DAOs that do not employ professional engineers.

The language for aircraft certification is precise, with words and phrases having meanings unique in

the international aircraft certification environment. One such word is delegation. In Canada, delegation means the individual engineering delegate acts on behalf of the transport minister. In the US, it means the individual engineering delegate acts on behalf of the FAA administrator. Because accreditation is not delegation, the minister is buffered from the ADO.

The primary role of the current engineering delegates and TCCA engineering staff is to "make findings of compliance." This precise phrase, used internationally, means an aeronautical product complies with its airworthiness requirements. An aeronautical product is certified, or granted a design approval, when the findings of compliance are complete and the product can enter service.

To limit its liability, the government has to avoid delegation and making findings of compliance. This is why ACAF does not delegate individuals or ADOs–hence the term accreditation. Additionally, ADOs will not make findings of compliance, but rather "show compliance" to the minister. Although what "show compliance" means has not been explained, it does indicate that ADOs will be taking on the full accountability for design compliance and, presumably, the full liability when things go wrong. In other words, the government is sidestepping its direct responsibility for public safety. This is a concern for engineering associations and public safety. It should also be a paramount concern for industry, especially small- to medium-sized enterprises, but they seem to have no understanding of their changing liability under ACAF.

In 2008, Auditor General Shelia Fraser confirmed what industry critics had been saying for the three years since SMS was introduced:

> As the first civil aviation authority to put in place regulations requiring aviation companies to introduce SMS, Transport Canada developed its own approach…However, in planning for the transition, the department did not document risks, such as the impact of the transition process on oversight of air transportation safety, and identify actions to mitigate these risks. Nor did it forecast the overall costs of managing the change.
>
> Resources have been shifted from traditional oversight activities to SMS activities. However, the department has not measured the impact of this on the frequency of traditional oversight activities.
>
> Transport Canada has not yet identified how many inspectors and engineers it needs, with what competencies, during and after the transition…Transport Canada could find itself unable to recruit the right mix of skills when it needs them.[12]

In November 2009, TCCA postponed the implementation of SMS for smaller commercial airlines. SMS was effectively postponed for other aviation groups, including aerospace engineering, as a result of rescheduling the government's SMS timetable. This postponement was largely in response to TCCA staff concerns about the lack of oversight, resources and planning within the government.

Yet Civil Aviation Regulation (CAR) 521, which is the introduction of ACAF to aerospace engineering, became law in September 2009, without following the normal regulatory process under which regulations are first published in *Canada Gazette Part I* (CG-I) to allow for public review and comment and then return to Parliament for final reading and publication in *Canada Gazette Part II*.

Bypassing CG-I is a topic requiring an investigation that is outside the scope of this paper, but one thing is certain: the opportunity to discuss the role of professional engineering was eliminated.

It was previously noted that airworthiness regulators use internationally recognized specialized language to preserve unambiguous understanding. One such word is "comply," which means that the design (not the physical product) of an aeronautical product complies with the regulatory requirements. Another word is "conform," which means that the physical product (not the design) conforms to the design criteria. These two words and their meanings were reversed in CAR 521, despite the opposition of TCCA engineering staff, who were overruled by government legal staff.

TCCA is now in the process of near-emergency amendments to CAR 521 to correct this and other problems, and has admitted that it will take years to correct the errors in the regulation. But there is one aspect of CAR 521 that offers an opportunity for professional engineering–the new requirement for a Declaration of Compliance, which will be discussed later.

IMPLICATIONS FOR PROFESSIONAL ENGINEERING

There are three main problems that prevent the integration of professional engineering into the aircraft certification process, whether it's under the current system of delegation or the proposed system of accreditation. First, professional engineering is not a nationally regulated profession. Second, the federal government has little understanding of professional licensing and fails to see its advantage in meeting its responsibility to public safety. Third, the provincial engineering licensing associations have little understanding of aircraft certification and fail to appreciate the government's sidestepping around their authority over professional engineering qualifications and practice and around its responsibility to public safety. Engineers Canada has had some success with the government as a national representative of its constituent associations, but little or none in affecting aerospace policies (although it hasn't been from lack of effort).

TCCA has insufficient resources to meet its responsibilities, let alone investigate the potential merits of the licensing of engineers. And there is also the problem of government lobbying being practically invisible.

As the core of civil aviation, if aircraft certification fails, the transport minister will fail in fulfilling the minister's responsibility for public safety. And if bad things happen because of it, the public will become angry,

possibly leading to wholesale changes engulfing organizations that were entrusted with public safety. If any association believes that it is immune to devastating backlashes, just think about the Canadian Red Cross.

Under ACAF, the erosion of professional engineering in aerospace will accelerate. If the ADO concept entirely replaces the current system of delegation, the government will have isolated itself from any professional engineering licensing requirements and from the provincial engineering associations. This is not simply a turf war, as some view it.

Remember, under the current delegation system, individuals are licensed by the associations and then granted delegation by the minister. Engineering delegates have a clear line of accountability to their profession and a clear line of accountability to the minister. It is difficult to envision a system that could be more beneficial to public safety while leveraging the government's limited resources.

THE NEED FOR ENGINEERING ASSOCIATION LEADERSHIP

There are three areas where engineering associations (through Engineers Canada) can introduce leadership in aerospace engineering.

The first relates to the Declaration of Compliance (DOC) introduced by CAR 521. (The DOC is still termed the "Declaration of Conformity" in CAR 521, but TCCA renamed it prior to correcting CAR 521.) The DOC cannot be signed by an engineering delegate acting on behalf of the transport minister, but must be signed by "someone" indicating to the minister that the aircraft design meets all the regulatory requirements. It is an engineering activity that in the interest of public safety should be undertaken by a professional engineer. Currently, CAR 521 does not restrict who signs the DOC. The regulation should be amended, so that the DOC must be signed by a professional engineer.

The second area is for engineering associations to review SMS and understand how it relates to professional engineering. ACAF–the vehicle for SMS in aerospace–is largely the product of non-engineering personnel and outside consultants who are using process-driven activities, such as flight operations and maintenance, and attempting to apply them to engineering. The fit is not good because design is more synthesis than process. TCCA engineering staff understand the difference but have little influence. Understanding realistic applications of SMS to engineering will allow the engineering associations to comment confidently on problems with the government policy and implementation.

The third area is to form strategic relationships with notable and knowledgeable critics and seek a review of aircraft safety. The rationale for a review would be to bring issues of professional engineering directly to the government's attention. This needs to be done at the highest levels, meaning the deputy minister, transport minister, cabinet, parliamentary committees and the like. Experiences over the last seven years have proven the futility of dealing with middle level bureaucrats. Σ

NOTES

1. Gazette Part II. 15 June 2005 Registration SOR/2005–173, *Regulations Amending the Canadian Aviation Regulations (Parts I, IV, V and VII)*, page 1445.
2. United States. Department of Transport. FAA. *Turbulence Aloft–the Civil Aeronautics Administration Amid Wars and Rumors of Wars 1938–1953*. 1979, p. 150.
3. Canada. Transport Canada. Aircraft Certification. *The Structures Certification Engineering Section (AARDD/S) in Ottawa*.
4. "Merlin Preuss on SMS," *WINGS Magazine*, March/April 2006, pp. 20-24.
5. Initially, TCCA termed the ADO the "approved design organization," but later renamed it the "accredited design organization."
6. See, for example, RDIMS#1233293V4, "Independent Checking Function."
7. Again, see RDIMS#1233293V4, "Independent Checking Function," and examine Transport Canada's wishful thinking of what will happen when a checker is overruled by management.
8. VANDARS. *Merlin Preuss Meeting Notes–9:30 to 10:30 am. 09 Feb 2006 Richmond Inn, Rm 170*. 09 Feb 2006; Roberts, John. "The End of General Aviation in Canada?" *Air Maintenance Update Magazine,* February/March 2006: 39-42; Roberts, John, et al. *Briefing Paper for APEGBC AND CCPE–Implications of the Transport Canada "New Accountability Framework" to Professional Engineering*. 23 Mar 2006; Canadian Council of Professional Engineers (CCPE). Correspondence from Marie Carter, P.Eng., director, professional and international affairs, to Merlin Preuss, director general, civil aviation, Transport Canada Civil Aviation. *Re: CARAC–New Accountability Framework*. 08 Nov 2006; Roberts, John. *Changes to Aircraft Certification (The End of General Aviation)*. Pacific Aircraft Maintenance Association Symposium 2007. Richmond, BC, 02 Feb 2007; Correspondence from Thiele, LLB, associate director, regulatory compliance, to John Nehera, P.Eng., regional manager, aircraft certification, Transport Canada Civil Aviation. *Re: The Practice of Professional Engineering by Aircraft Certification–Pacific*. APEGBC File No: S07-GC. 17 Sep 2007; Engineers Canada. Correspondence from Marie Carter, P.Eng., chief operating officer to Kathie Keeley, chief, regulatory affairs, AARBH, Transport Canada. *Re: CAR 521*. 17 Nov 2009; Memo from John Roberts, CJ Roberts and Associates Inc. to Jim Tinson, Wings Engineering Limited. *Subject: Response to Correspondence from A. Walasek, Special Assistant, Office of the Minister of Transport to L. Jones, CFIB dated 17 Mar 2008*. 25 Apr 2008; Roberts, John. *Your Engineering Future: The Need for Entrepreneurial Positioning in Your Career*. UBC Materials Engineering Industry Night.
9. The comment was made during a meeting with the lobby group VANDARS in Richmond, BC, 09 Feb 2006.
10. VANDARS. *Merlin Preuss Meeting Notes*–9:30 to 10:30 am. 09 Feb 2006 Richmond Inn, Rm 170. 09 Feb 2006.
11. Canada. Transport Canada. Correspondence from Merlin Preuss, director general, civil aviation, to Marie Carter, P.Eng., Canadian Council of Professional Engineers. CAIRS File No. FB-8758. 27 Nov 2006.
12. Report of the auditor general of Canada to the House of Commons, Chapter 3, Oversight of Air Transportation Safety. May 2008.

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