The Swiss draft Protocol on Small-Calibre Weapon Systems

Bringing the dumdum ban (1899) up to date

by Eric Prokosch

I

In August 1994, at the third session of the group of governmental experts to prepare the 1995 Review Conference of the 1980 United Nations Convention on Prohibitions or Restrictions on the Use of Certain Conventional Weapons which May be Deemed to be Excessively Injurious or to Have Indiscriminate Effects, Switzerland introduced a proposal for a new protocol to the Convention. The Swiss draft Protocol on Small-Calibre Weapon Systems would prohibit the use of small-calibre arms and ammunition which, at ranges of 25 metres or more, transfer more than 20 Joules of energy per centimetre to the human tissues during the first 15 centimetres of passage in the body.

This paper[1] examines the Swiss proposal against the background of the intergovernmental discussions in the 1970s which led to the adoption of the 1980 Convention. It argues that by taking advantage of the scientific work done since then, the Swiss draft overcomes the criticisms levelled against earlier proposals for a new ban. The Swiss initiative presents the States participating in the Review Conference with a new opportunity to ensure that the principle set forth in the 1899 Hague ban on dumdum bullets remains applicable to the conditions of modern warfare.

II

In 1899 the Hague Peace Conference adopted a Declaration prohibiting the use of "bullets which expand or flatten easily in the human body, such as bullets with a hard envelope which does not entirely cover the core or is pierced with incisions". The Hague Declaration Concerning the Prohibition of Dum-Dum Bullets was an early effort to reduce the suffering inflicted on combatants by prohibiting the use of a specific class of munitions. Since its adoption nearly 100 years ago, it has been largely respected, at least in the letter of the law: the bullets specifically described in the Declaration have not, for the most part, been used in war.

The Hague Declaration is a concrete expression and application of the prohibition of use of weapons and projectiles of a nature to cause superfluous injury or unnecessary suffering. This prohibition has most recently been enshrined in Article 35 of Protocol I additional to the Geneva Conventions of 1949 and is generally regarded as a rule of customary international law, binding on all parties to armed conflicts. Because of its wide acceptance, the Hague Declaration on dumdum bullets also can be regarded as a rule of customary international law. It can further be argued that with regard to small-calibre weapon systems, the Hague Declaration sets a minimum standard for what is meant by "superfluous injury" or "unnecessary suffering". Any other small-calibre projectile producing the same degree of injury should similarly be regarded as prohibited under customary international law.

When a missile such as a bullet or a bomb fragment hits the body and penetrates the tissues, some or all of its kinetic energy (energy of motion) is transferred to the tissues, thrusting them aside with explosive rapidity. The greater the amount of energy transferred, the greater the amount of tissue destruction.[2]

A bullet is aerodynamically designed to pass through the air with a minimum of air resistance, and the high rate of spin imparted to it in the gun barrel ensures its stability, so that the nose of the bullet faces forward. The materials of the human body are far denser than air, but a good design, a solid construction and a high rate of spin can still ensure that a bullet will maintain its nose-forward orientation and pass through the body without losing much of its energy or causing a massive wound (except at short ranges, because of the yawing of the bullet; see below, section VII). But the mushrooming of a dumdum bullet striking the body causes a large surface of bullet material to press violently against the tissues; the energy of the bullet is rapidly transferred to the body, and a massive wound results.

From the reasoning outlined above, it should follow that if a bullet does not deform like a dumdum but transfers its energy to the body rapidly by some other means, then it, too, should be regarded as prohibited for use under customary international law. That this reasoning is not sufficient in practice is shown by the appearance of new military rifles and ammunition tending to cause severe wounds, and by the efforts of weapons designers to produce such arms.[3] The dumdum ban needs to be brought up to date so that the protection against excessively damaging effects which it sought to achieve will be maintained under modern conditions.

III

The revival of international concern over the wounding effects of rifle bullets came with the appearance of the AR-15 (M16) 5.56 mm rifle in the US-Vietnam war. For many years, 7.62 mm had been the standard calibre for military rifles in both NATO and Warsaw Pact countries, and in 1957 the US Army announced the adoption of a new 7.62 mm rifle, the M14. Meanwhile, a US company, Armalite, scaled down its own 7.62 mm rifle by adapting it to shoot modified 5.56 mm (.22 calibre) hunting ammunition. The new rifle, which the company called the AR-15, had the advantage from a military point of view of weighing one-fourth less than the M14, and the ammunition also was lighter, reducing the recoil against the soldier's shoulder and enabling a soldier to carry more rounds. As interest in the problems of counter-insurgency grew under the Kennedy administration in the early 1960s, the US military quietly bought several thousand AR-15s and sent them to Vietnam for testing in combat conditions.

Soon reports began appearing of the lethality of the new rifle. "Unofficial reports say the AR-15's light bullet, travelling at 3,300 feet per second, does cartwheels as it penetrates living flesh, causing a highly lethal wound that looks like anything but a caliber .22 hole", the US magazine *Army* reported in August 1963. Two US Army doctors who evaluated AR-15 wounds at an Army hospital in South Vietnam in 1966 reported that while wounds inflicted at close range had small entrance and exit holes, those at larger ranges exhibited small entrance holes "whereas the exit wound is a gaping, devastated area of soft tissue and even bone, often with loss of large amounts of tissue", with disintegration of the bullet and minute splattering of lead.[4]

The AR-15 was redesignated by the US Army as the M16 rifle, and in 1967 the Army announced that it would be adopted as the standard infantry weapon for US Forces outside NATO. By 1978 the rifle had been exported to 21 countries and was being produced under licence in another three, with various other 5.56 mm rifles in production elsewhere.[5]

IV

In 1974, at the first session of the Diplomatic Conference on the Reaffirmation and Development of International Humanitarian Law Applicable in Armed Conflicts (CDDH), seven States presented a proposal for a new ban on the use of especially injurious bullets.[6] The proposal, later modified, was discussed at the two sessions of the Conference of Government Experts on the Use of Certain Conventional Weapons organized by the International Committee of the Red Cross (1974, 1976); by the *Ad Hoc* Committee on Conventional Weapons of the CDDH (1974-1977); and at the UN Conference on Prohibitions or Restrictions of Use of Certain Conventional Weapons which May be Deemed to be Excessively Injurious or to Have Indiscriminate Effects (1979-1980).

One of the problems faced by the proponents of the ban was the difficulty of obtaining scientific information on the wounding effects of military rifle bullets. The study of missile wounding, known as wound ballistics, had been placed on a sound scientific footing through extensive experiments conducted during World War II, but the missiles mostly used in the experiments were steel balls (approximating bomb fragments).[7] Missile wounding is an extremely rapid process, difficult to observe; most research is done in military laboratories, and the results are kept secret.

To compensate for the reduced size of the 5.56 mm bullet, the AR-15 (M16) designers had increased the velocity of the bullet so that it would have an adequate range and the flat trajectory needed for accurate aiming. The M16 bullet had a muzzle velocity (velocity on leaving the gun) of 980 metres per second as compared to 870 metres per second for the M14 rifle and 720 metres per second for the Soviet AK-47 7.62 mm rifle, while at a range of 100 metres the velocities of the three bullets were 830, 800, and 630 metres per second respectively, according to figures cited in the early 1970s.[8]

This feature led many commentators to attribute the wounding effect of the M16 bullet to its enhanced velocity. Thus, the two US Army doctors quoted above referred to the M16 as "a devastatingly effective combat weapon with tremendous wounding and killing power related to its high velocity and air-transit characteristics", although they noted that "many ordnance personnel" also thought the bullet tumbled, which could cause severe wounds.[9] The observation that bullets broke up in the body led to the supposition that this break-up might also be a cause of the extensive wounds.

The notion of high velocity as the principal reason for the M16 wounding effect was reflected in the report of the group of experts convened by the ICRC in 1973 to discuss the use of weapons which might cause unnecessary suffering or have indiscriminate effects:

> "Wounds from projectiles that strike the body at more than about 800 metres per second differ both in degree and in kind from wounds caused by lower-velocity projectiles. Because of the tendency of high-velocity projectiles to tumble and become deformed in the body, and to set up especially intense hydrodynamic shock-waves, the wounds which they cause may resemble those of dumdum bullets".[10]

The uncertainty over what caused the M16 wounds (and, thus, over what needed to be banned, or how the ban should be formulated) was reflected in the wording of the seven States' proposal at the CDDH in 1974. The proposal cited no fewer than seven possible factors — two possible causes (velocity plus other design features), two possible resultant sorts of bullet behaviour (deformation and tumbling) and three possible effects in the body (shock waves, damage outside the trajectory, and the production of secondary missiles). The text read:

> "Projectiles of small-calibre weapons may not be so designed or have such velocity that they are apt to deform or tumble on or following entry into a human body or to create shock-waves which damage tissue outside their trajectories or to produce secondary projectiles".

At the ICRC Conference of Government Experts on the Use of Certain Conventional Weapons held in Lucerne in 1974, the notion of velocity as a determinant of bullet wounding came in for attack. According to the conference report, the 1973 group's report "was strongly criticized by many experts for suggesting that, at impact velocities of around 800 metres per second, there was a discontinuity or jump in the relationship between bullet velocity and bullet wounding capacity".[11] Participants in the conference presented various, seemingly contradictory battlefield observations and experimental findings on bullet effects. A number of experts "estimated that there was insufficient evidence to warrant the conclusion that modern small-calibre projectiles caused unnecessary suffering. In their view, the evidence demonstrated merely that wounds caused by modern small-calibre projectiles, or by what had been termed high-velocity projectiles, might or might not be more severe than the wounds caused by larger-calibre or lower-velocity projectiles". These experts "were of the opinion that the formulation of a rule of restriction or prohibition on the weapons at issue did not appear warranted; nor, they felt, would such a rule be practicable without previous agreement on relevant parameters". One expert held that the adoption of the six States' proposal "would lead to the prohibition of every military rifle in use today".[12] The conference report records that "all experts taking part in the debate readily agreed that further study and research were required to arrive at more definite conclusions".[13]

The proposal was modified in an attempt to take account of the criticisms and resubmitted to the CDDH in 1975, now with 16 sponsors, all but one of which was a non-aligned country.[14] After the discussions at the second session of the ICRC Conference of Government Experts on the Use of Certain Conventional Weapons in Lugano in 1976, a further revision was submitted to the CDDH by Sweden.[15] Despite the changes, no consensus was reached, and the three Protocols attached to the 1980 Convention do not contain any ban relating to the use of small-calibre projectiles. Instead, the UN Conference adopted a resolution in 1979 inviting governments to carry out further research on the wounding effects of small-calibre weapon systems and appealing to all governments "to exercise the utmost care in the development of small-calibre weapon systems, so as to avoid an unnecessary escalation of the injurious effects of such systems".[16]

The research envisioned in the resolution had already begun. At the Lugano meeting in 1976, the Swedish and Swiss government experts presented soap blocks showing the results of tests carried out after the Lucerne conference of 1974. Various bullets had been shot through the blocks of soap, cast in the shape of a human thigh; the blocks were then cut open, revealing cavities which could be presumed to correspond to the permanent and temporary cavities that would be formed by similar shots in the human body and, thence, to the extent of tissue damage. The tests showed that certain bullets left a narrow, through-and-through track while others made a track that started small but blossomed where a mass of soap the size of a first had been violently thrust aside as the bullet passed through. It seemed evident that certain bullets produced much worse wounds than others, but the reasons were still not clear.[17]

In 1975 Sweden convened an international, interdisciplinary symposium on wound ballistics. Further symposia were held in 1977, 1978, 1981, 1985 and 1988. Many papers were presented by military and medical experts from different countries and many topics were discussed, including not only the physical process of wounding but complex physiological effects, the surgical treatment of injuries, and techniques of testing and observation. One of the benefits of the symposia was that a body of knowledge was being built up, freely available in the open literature and reflecting the approaches of different national research traditions.

V

In May-June 1994 the ICRC convened an expert meeting to help it prepare background documentation for the group of governmental experts preparing the Review Conference of the 1980 Convention. At the meeting, the ballistic scientist Beat P. Kneubuehl, Head of the Defence Technology Service of the Swiss government's Defence Technology and Procurement Agency, presented experimental findings on the wounding effects of different military rifle bullets. Drawing from a recently published textbook on wound ballistics which he had written with the German professor of forensic medicine Karl G. Sellier,[18] Kneubuehl was in a position to present a comprehensive and convincing account of the process of bullet wounding and the design parameters producing different levels of injury.

It has long been known that bullets can tumble inside the body and that tumbling is a cause of severe wounding, as, in moments when a bullet is moving through the body with a wide angle of incidence[19] rather than nose-on, the area of the bullet pushing against the tissues is relatively large, and the transfer of energy to the tissues is correspondingly great. The contribution of Sellier and Kneubuehl is to describe tumbling as a regular process and to explain it in terms of the forces acting on the bullet.

According to Sellier and Kneubuehl, a bullet which is fully enclosed in a metal jacket, as are virtually all military rifle bullets today, will start to turn around a lateral axis at some distance after entering the body. Once it starts to turn, the rate of turning increases rapidly; the angle of incidence reaches 90 degrees and the bullet continues turning until it is travelling nearly tail first. After that, it can partly turn several more times before entering the last phase, when it will again be travelling tail first. Depending on its construction, a full-metal-jacketed bullet can deform or break up because of the stresses placed on it during turning, but deformation or break-up of a full-metal-jacketed bullet is a by-product of turning and not an independent process, although, once it happens, the deformation or break-up adds to the wounding effect because of the increase in the surface area of bullet material pressing against the tissues.[20]

The turning, or "tumbling", of a bullet is thus the critical mechanism resulting in severe injury, and the likelihood of causing a severe wound will depend on how far a bullet penetrates the body before turning. An ammunition designer who is intent on inflicting the greatest possible damage will want to have the bullet turn as soon as possible, thus achieving the same effect (rapid transfer of most or all of the bullet's kinetic energy) as with the outlawed dumdum bullet. A designer wishing to avoid severe wounds will want the bullet to travel as far as possible before turning: a soldier hit in the arm or leg will be out of action temporarily but is unlikely to suffer permanent injury or to die.

The question which factors would produce rapid onset of tumbling in the body has long interested ammunition designers. As long ago as 1930, R. H. Kent, a physicist at the US Army laboratories at Aberdeen Proving Ground, Maryland, developed formulas to represent the tumbling of bullets in dense media.[21] He concluded that the tendency to tumble was dependent on the angle of incidence of the bullet on impact with the body and that a bullet with a light nose would have a strong tendency to tumble.[22] In 1967 another scientist at the Army Ballistic Research Laboratories at Aberdeen Proving Ground, Eugene T. Roecker, produced a more elaborate set of formulas and concluded from them that an M16 rifle bullet could be made to tumble more readily if the cylindrical section behind the bullet crimping were shortened.[23]

According to Sellier and Kneubuehl, the tendency of a bullet to tumble early on entering the body is dependent on the angle of incidence on impact, the shape of the bullet nose, and the gyroscopic stability of the bullet.[24] Gyroscopic stability, in turn, is dependent on such factors as the rate of spin, the moments of inertia, and the geometry of the bullet. In general, the greater the gyroscopic stability of a bullet (for example, because of a higher spin rate), the further it will go in the body before starting to tumble; and the shorter a bullet is in relation to its diameter, the less likely it is to tumble.

VI

In his 1967 paper, the US Army scientist Eugene T. Roecker lamented the fact that bullet designers seldom tried to maximize the wounding effect:

> "The design of a rifle bullet for combat purposes has generally been dictated by interior ballistics, exterior ballistics, and manufacturing conveniences. Lethality was rarely considered at the designing stages because of a lack of an adequate theory for lethality prediction".[25]

Roecker proceeded to construct what he described as "a means of designing a more lethal bullet". But if wound ballistics can be used to maximize injury, it can also be applied in reverse for humanitarian purposes.

In 1981, NATO announced its decision to adopt a second standard calibre for small arms, alongside the previous standard calibre of 7.62 mm. The second calibre selected was 5.56 mm, the same as that of the M16 rifle, but a Belgian round, the SS 109, was adopted rather than the M16 round as a basis for standardization of ammunition for NATO rifles.

In a presentation to the fourth International Symposium on Wound Ballistics in 1982, a representative of the Ballistics Laboratory of the Belgian *Fabrique Nationale*, manufacturer of the SS 109, said that the new bullet had a "high coefficient of essential stability" and a high rate of spin imparted by a rifling twist of one turn in 7 inches, as compared with the M16 twist of one turn in 12 inches.[26] He made it clear that the SS 109 design programme had been heavily influenced by the 1979 resolution of the UN Conference cited above, appealing to governments "to avoid an unnecessary escalation of the injurious effects" of small-calibre weapon systems.[27]

Test results presented by Beat P. Kneubuehl at the ICRC expert meeting in 1994 showed the superiority of the SS 109 over some other bullets in terms of compliance with humanitarian rules. The results were presented in the form of graphs showing the amount of energy transferred to the test medium during each centimetre of penetration. According to the test results, which are based on only a limited number of firings, the SS 109 bullet starts transferring energy rapidly (at a rate of 50 Joules or more per centimetre) only after penetrating 14 centimetres; by the time it penetrates 20 centimetres, it has deposited 600 Joules of energy in the tissues. In contrast, the Russian AK-74 5.45 mm rifle, which for some years had been reported to cause severe wounds, starts transferring energy rapidly after penetrating 9 centimetres and has deposited 600 Joules of energy by the time it penetrates 14 centimetres. The AK-74 bullet will cause a severe wound much closer to the surface of the body than the SS 109.

VII

The Swiss draft Protocol on Small-Calibre Weapon Systems reads:

"1. It is prohibited to use arms and ammunition with a calibre of less than 12.7 millimetres which from a shooting distance of at least

25 metres release more than 20 Joules of energy per centimetre during the first 15 centimetres of their trajectory within the human body.

2. The States Parties commit themselves to intensifying their cooperation in order to establish an internationally recognized experimental method by which the effect of small-calibre projectiles in the human body can be precisely assessed".

The Swiss draft Protocol has several advantages over previous texts.

— The term "small-calibre weapon systems" encompasses both ammunition and the weapons firing it, an acknowledgment that design features of a weapon, such as the rifling twist, may be responsible for wound effects. In contrast, the Hague Declaration refers only to "bullets". The use of this broader term closes an important gap wherein ammunition developers could design small-calibre projectiles such as flechettes in such a way as to break up on entering the body and claim that their use would not violate the Hague Declaration because they were not, strictly speaking, bullets.[28]

— Unlike the Hague Declaration and the texts proposed in the 1970s, the Swiss draft refers only to the effects of small-calibre weapon systems, not to the ways in which these effects are produced (mushrooming, tumbling, etc.). This approach avoids the arguments raised in the previous discussions over what mechanisms were actually responsible for the effects produced. It also ensures that the ban will cover any future weapon systems producing similar effects through the use of mechanisms not envisioned at the time of adoption of the protocol.[29]

— The effect of a small-calibre projectile is specified in terms of energy deposit, a physical process which can be measured by a simple procedure such as measuring the size of the cavity formed in a block of soap at different distances of penetration.[30] (The authors of the draft have not tried to specify a standard test procedure, perhaps out of a sense that such an attempt could excite controversy among the different national schools of wound ballistics, some of which use gelatin as a flesh simulant in ballistic tests while others use soap. The advantage of soap is that the passage of the missile through it leaves a permanent record of the temporary cavity, whose dimensions can then be easily measured. Soap is inexpensive and readily available to agencies wishing to conduct tests in different countries.)[31]

— The missile effects described in the Swiss draft correspond to the critical features of the wounding process as shown in experimental tests and explained in wound ballistics theory. The stipulation that the missile should deposit no more than a certain amount of energy per centimetre during a certain length of penetration into the body corresponds to what Sellier and Kneubuehl have called the "narrow channel" — the wound track created in the first phase of the passage of the projectile while it is still travelling nose-on and has not yet started to tumble.[32] The Swiss draft is based on the findings of wound ballistics; at the same time, wound ballistics can help ammunition designers and the responsible authorities to ensure that weapons for use in armed conflicts conform to the agreed rules.

The actual numbers in the Swiss draft are sure to be the subject of debate among States. Four figures are offered: a figure for the upper limit of what is covered as a "small-calibre" weapon system, and figures for the shooting distance,[33] the minimum length of the narrow channel, and the maximum amount of energy deposit in the narrow channel.[34] The length of the narrow channel, specified at 15 centimetres, is an especially critical figure, as it is this which will most affect the likelihood of causing severe injury or death. Ideally this figure should be as large as possible in the interest of minimizing the risk of severe injury.[35]

The Swiss initiative does not rest on scientific findings alone. The concern expressed by the UN Conference in its 1979 resolution, and the example of the NATO countries in trying to respond to that concern when standardizing their 5.56 mm rifle ammunition, should help to move the initiative forward. The States participating in the Review Conference of the 1980 Convention should seize the opportunity to set up a drafting process for the elaboration and ultimate adoption of the strongest possible ban on the modern dumdum bullets. Such a ban would serve the interests of States and the interests of humanity by protecting the soldiers of present and future generations against the unnecessary harm inflicted by especially injurious small-calibre weapon systems.

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NOTES

[1] This article was also published in the University of Essex *Papers in the Theory and Practice of Human Rights.*

[2] Rapid energy transfer results in the violent formation of a "temporary cavity" in elastic tissues such as muscle. The temporary cavity expands and contracts very quickly several times before collapsing around the "permanent cavity" or wound track left behind as a record of the passage of the missile. According to the findings of an extensive wound ballistics research project conducted at Princeton University during World War II, "study and measurement of a large number of temporary cavities show that the total volume of the cavity is proportional to the energy delivered by the missile". As the Princeton study revealed, the stretching and displacement of tissues during the formation and contracting of the temporary cavity can result in serious damage within a large region around the path of the missile. Tissues are torn and pulped, capillaries are ruptured, nerves may lose their ability to conduct impulses, soft organs may be damaged, gas-filled pockets in the intestines can rupture, and bones that have not suffered a direct hit may be broken. (E. Newton Harvey, Howard McMillen, Elmer G. Butler and William O. Puckett, "Mechanism of Wounding", pp. 144, 175, 197-198, 201-211, in James C. Beyer, ed., *Wound Ballistics*, US Department of the Army, Washington, 1962, pp. 143-235.) It follows that the larger the temporary cavity, the greater the extent of damage and the greater the risk of damaging a vital organ which is not directly in the path of the missile.

Energy transfer (also referred to as energy deposit) has long been recognized as a crucial element in missile wounding. It was, for example, the main factor used in a 1969 US Army Laboratory study of the wounding capacity of M16 rifle ammunition. The study noted without disagreement that "previous investigators have asserted the inherent logic in the assumption that the level of incapacitation which would be caused in a soldier by a missile is proportional to the amount of energy deposited in a target by the missile". The previous investigators referred to had studied the wounding capacity of fragments, rifle bullets, and flechettes. (Larry M. Sturdivan, William J. Bruchey, Jr. and David K. Wyman, "Terminal Behavior of the 5.56 mm M193 Ball Bullet in Soft Targets", US Army Ballistic Research Laboratories report No. 1447, August 1969, p. 24.)

[3] A US Army weapons engineer wrote in 1967: "Bullets can be designed to deform in a dense medium, such as flesh; Geneva Convention [sic] and other rules, however, prohibit their use. To conform to such rules and still maintain a typical bullet shape (ignoring dart-like configurations), the optimum wound ballistics design is often considered to be one that imparts maximum kinetic energy to the flesh by means of high drag". The logic of this statement is that a bullet producing exactly the same effect as a dumdum bullet — maximum energy transfer — will "conform" to the laws of war as long as the bullet itself does not mushroom. (Eugene T. Roecker, "The Lethality of a Bullet as a Function of its Geometry", US Army Ballistic Research Laboratories report No. 1378, October 1967, p. 13.)

[4] Francis C. Dimond, Jr. and Norman M. Rich, "M-16 Rifle Wounds in Vietnam", *Journal of Trauma*, Vol. 7, No. 3, 1967, pp. 620-624.

[5] Stockholm International Peace Research Institute, *Anti-personnel Weapons*, Taylor & Francis, London, 1978, pp. 98-104.

[6] Document CDDH/DT/2, submitted by Egypt, Mexico, Norway, Sweden, Switzerland and Yugoslavia, later joined by Sudan, as quoted in Hans Blix, "Current Efforts to Prohibit the Use of Certain Conventional Weapons", *Instant Research on Peace and Violence*, Tampere, Vol. 4, No. 1, 1974, pp. 21-30.

[7] A detailed account of the US World War II wound ballistics research programme may be found in Harvey *et al.*, *op. cit.*

[8] International Committee of the Red Cross (ICRC), *Weapons that May Cause Unnecessary Suffering or Have Indiscriminate Effects; Report of the Work of Experts*, ICRC, Geneva, 1973, Table III.1, p. 34.

[9] Dimond and Rich, *op. cit.*, p. 624.

[10] ICRC, 1973, *op. cit.*, paragraph 112, p. 38. The group of experts was convened by the ICRC at the request of 19 States represented at the second session of the ICRC Conference of Government Experts on the Reaffirmation and Development of International Humanitarian Law Applicable in Armed Conflicts. At both the first (1971) and second sessions of the Conference of Government Experts, Sweden and other countries had called for the elaboration of explicit draft prohibitions of specific categories of conventional weapons. (Blix, *op. cit.*)

[11] International Committee of the Red Cross, *Conference of Government Experts on the Use of Certain Conventional Weapons (Lucerne, 24.9-18.10.1974); Report*, ICRC, Geneva, 1975, paragraph 129, p. 40.

[12] *Ibid.*, paragraph 151, p. 46.

[13] *Ibid.*, paragraph 154, p. 47.

[14] Document CDDH/IV/201, part IV, reproduced in *Official Records of the Diplomatic Conference on the Reaffirmation and Development of International Humanitarian Law Applicable in Armed Conflicts; Geneva (1974-1977)*, Berne, Federal Political Department of Switzerland, 1978, Vol. 16, p. 602. Document CDDH/IV/201, a working paper, was submitted by Algeria, Austria, Egypt, Lebanon, Mali, Mauritania, Mexico, Norway, Sudan, Sweden, Switzerland, Venezuela and Yugoslavia, later joined by Afghanistan, Colombia and Kuwait.

[15] Document CDDH/IV/204, reproduced in *ibid.*, p. 607.

[16] The resolution is reproduced in Yves Sandoz, "Prohibitions or Restrictions on the Use of Certain Conventional Weapons", *International Review of the Red Cross*, No. 220, January-February 1981, p. 33.

[17] International Committee of the Red Cross, *Conference of Government Experts on the Use of Certain Conventional Weapons (Second Session — Lugano, 28.1-26.2.1976); Report*, ICRC, Geneva, 1976, pp. 61-69, 116-119.

[18] Karl G. Sellier and Beat P. Kneubuehl, *Wound Ballistics and the Scientific Background*, Elsevier, Amsterdam, 1994.

[19] The angle of incidence of a projectile (also known as yaw) is the angle between the axis of the projectile at any moment and the tangent of the trajectory traced by the centre of gravity of the projectile.

[20] A full-metal-jacketed bullet striking the body at less than about 600 metres per second remains intact despite tumbling, but at impact velocities above 600 metres per second it deforms as a result of stresses during tumbling. The bullet is squeezed, mainly at the base; bits of lead are squeezed out of the base, forming separate fragments, and the bullet is flattened. When the impact velocity is increased to a certain threshold, the bullet separates into two parts of approximately equal size, in addition to the fragments from the core. At still higher impact velocities, more fragments are produced. (Sellier and Kneubuehl, *op. cit.*, pp. 174-177.) The wounding effects of bullet deformation and fragmentation have been studied by, among others, Martin L. Fackler of the Wound Ballistics Laboratory at the US Army's Letterman Army Institute of Research; see Fackler, "Physics of Missile Injuries", in N. E. McSwain, Jr., and M. D. Kerstein, *Evaluation and Management of Trauma*, Appleton-Century-Crofts, Norwalk, Connecticut, 1987, pp. 25-41.

[21] Over the past century, students of wound ballistics have used firings into dense media such as clay, water, soap, or gelatin as approximations of what happens when a missile penetrates the body. Because these materials have uniform physical properties throughout and can be cheaply prepared in uniform lots, an experimenter can afford to

conduct a series of trial shots, varying such factors as the missile shape, size, or velocity. Materials such as gelatin and soap are good "flesh simulants" in ballistic tests because their density is close to that of the soft human tissues, which — like them — are made mostly of water.

[22] R. H. Kent, "The Theory of the Motion of a Bullet about its Center of Gravity in Dense Media, with Applications to Bullet Design", US Army Ballistic Research Laboratories report No. X-65, 14 January 1930.

[23] Roecker, *op. cit.*

[24] *Op. cit.*, p. 138.

[25] *Interior* ballistics (the motion of a projectile inside a gun), *exterior* ballistics (its motion through the air) and *terminal* ballistics (its motion on hitting a target) are the three branches of the science of ballistics. Wound ballistics is a subfield of terminal ballistics.

[26] The M16 twist had earlier been increased from one turn in 14 inches so that the bullet would be stable when fired in Arctic conditions (*Jane's Infantry Weapons 1975*, Jane's Yearbooks, London, 1974, p. 327).

[27] C. de Veth, "Development of the New Second NATO Calibre: The '5.56' with the SS 109 Projectile", in T. Seeman, ed., *Wound Ballistics; Fourth International Symposium, Acta Chirurgica Scandinavica*, Stockholm, Supplementum 508, 1982, pp. 129-134.

[28] A flechette is a small, nail-like object with several fins at the blunt end. In the early 1960s the US Army embarked on a programme to develop a flechette-firing rifle, the "Special Purpose Individual Weapon". In 1966, engineers working at AAI Corporation, one of the companies involved in the project, filed applications for patents on a "concave-compound finned projectile" and a "multiple hardness pointed finned projectile" (granted as US patent numbers 3,861,314 and 3,851,590 respectively). The purpose of both of these constructions was to make the nose deform on impact, causing the flechette to tumble. ("It will be readily apparent that increased effectiveness is obtained with this projectile in a soft, dense type target, such as an animal, due to the tumbling and enlarged effective projected peripheral area of the projectile in the tumbling curled configuration . . . as compared to the small piercing configuration of the projectile if it should pass into or through the target in a straight linear fashion", the inventor wrote in the second patent application cited above. The first application contained similar language.)

Another design, tested for wounding effects at the US Army Ballistic Research Laboratories, was for a bimetallic flechette; the two metals would have separated on impact, greatly increasing the area pushing against the flesh. The deformation of the first two flechettes is very close to the "expanding" or "flattening" of dumdum bullets, in the terminology of the Hague Declaration, and the break-up of the bimetallic flechette would be prohibited under the Hague Declaration if the Declaration were applied to flechettes. (As Louise Doswald-Beck and Gérald Cauderay have pointed out, "the French authentic text [of the Declaration] refers to 'balles qui *s'épanouissent*', which means bullets which open up, and therefore includes fragmentation"; Louise Doswald-Beck and Gérald Cauderay, "The Development of New Anti-personnel Weapons", *International Review of the Red Cross*, No. 279, November-December 1990, pp. 565-577, at p. 568.)

[29] Cf. Sellier and Kneubuehl, *op. cit.*, p. 313.

[30] The use of energy deposit as a criterion for wounding effect is an improvement over the Swedish working paper on "Possible Elements of a Protocol on Small-Calibre Projectiles", introduced at the CDDH in 1976 (document No. CDDH/IV/214, cited above). The Swedish paper proposed banning the use of small-calibre projectiles which, among other things, tumble rapidly in the human body; with reference to tumbling, it specified that the average yaw angle (angle of incidence) of the projectile must not exceed an agreed number of degrees during the first 14 centimetres of penetration. The Swedish paper and the Swiss draft Protocol describe the same phenomenon, but the measurement of average yaw angle as required under the Swedish text would have necessitated the use of expensive equipment for high-speed photography in gelatin or high-speed X-ray photography in other media, or for average yaw angles to be derived from other measurements by an agreed formula.

[31] For a discussion of the choice of flesh simulants, animals, and other materials used in ballistic tests, see Sellier and Kneubuehl, *op. cit.*, pp. 188-214.

[32] According to Kneubuehl (personal communication), the onset of the temporary cavity corresponds to an angle of incidence of about 20 degrees.

[33] The Swiss draft applies only to ranges of 25 metres or more. The reason for excluding shorter ranges is that bullets at these ranges are subject to a yawing motion. As Sellier and Kneubuehl have noted (*op. cit.*, p. 109), gas flows produced by the air column ejected from the gun barrel or by powder gases flowing around and in front of the projectile can be observed at the muzzle of the gun before the bullet has left the barrel. During the first few centimetres of its flight, these gases exert a lateral force on the bullet, setting up a yawing motion (a periodic deviation of the attitude of the projectile from a nose-on orientation). During the first 10 to 20 metres of its flight, the angle of incidence of the bullet varies between 0.5 degrees and 3 degrees, reaching the maximum every 1.5 to 3 metres. As the propensity of a bullet to tumble in the body is greatly affected by the angle of incidence at the moment of impact, it is quite possible that one bullet, striking a person at close range with an angle of incidence of, say, 3 degrees, will tumble soon after penetrating the body, causing a severe wound, while an identical bullet, fired under the same conditions, will strike with a minimal angle of incidence and start tumbling much later.

After 10 to 20 metres' flight, the effect of the spinning motion of the bullet (known as angular momentum) overcomes the yawing and the angle of incidence declines. It is at these longer ranges that the difference in wounding effect of different small-calibre weapon systems becomes evident.

[34] Another possibly significant factor in the wounding process, not covered in the Swiss text, is the effect of a small-calibre projectile hitting bone. At the ICRC expert meeting in 1994, Kneubuehl stated:

> "When a rifle bullet hits a bone shortly after the impact, it penetrates the bone with only a small loss of velocity and energy. Measurements showed that at an impact velocity of 800 metres per second the velocity decreases by only 30 metres per second (energy loss ca. 220 Joules) penetrating a femur. The resulting impulse is too low for deforming or breaking the projectile. On the other hand the penetration of the bone disturbs the stability and after [penetrating] the bone the bullet turns earlier to the sidewise position. So it is possible that a bullet which would not break in soft tissue can fragment after hitting a bone because of the earlier destabilisation. Bullets that hit bones with low velocities have not yet been examined".

The effects of missile shots into bone have been studied much less than effects in soft tissues. It is possible that future research may reveal differences among small-calibre weapon systems as to the severity of wounds produced as a result of projectile deformation or tumbling when hitting bone. If it turns out that these differences are significant and do not coincide with the differences in severity of injury in soft tissues already covered under the protocol, the protocol could be modified accordingly.

[35] As Karl G. Sellier stated at the third International Symposium on Wound Ballistics in 1978, "An essential demand must be to make the narrow channel as large as possible, that is to utilize bullets with the largest possible longitudinal moment of inertia. By means of an elongation of the narrow channel one can, in practice, attain that no vital organs lie in the range of the extremely large wound cavity, which is caused by the transverse position of the bullet". (Karl G. Sellier, "Effectiveness of Small Calibre Ammunition", in T. Seeman, ed., *Proceedings of the Symposium on Wound Ballistics, Acta Chirurgica Scandinavica*, Stockholm, supplementum 489, 1979, pp. 13-26, at p. 24). According to Kneubuehl's figures (which, like those quoted earlier, are based on only a limited number of test firings), the 7.62 mm NATO bullet travels 19 centimetres before starting to deposit energy rapidy, and by 22 centimetres it has deposited 600 Joules of energy. Thus the SS 109 bullet, while an improvement over the M16 bullet, is still more likely to cause a severe injury than the larger-calibre NATO round.