Group of Governmental Experts of the High Contracting Parties to the 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

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Report of the 2017 Group of Governmental Experts on Lethal Autonomous Weapons Systems (LAWS)

I. Introduction

1. The Fifth Review Conference of the High Contracting Parties to the 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 (CCW) held in Geneva from 12 to 16 December 2016 decided, as contained in Decision 1 of its Final Document (CCW/CONF.V/10),

> "To establish an open-ended Group of Governmental Experts (GGE) related to emerging technologies in the area of lethal autonomous weapons systems (LAWS) in the context of the objectives and purposes of the Convention, which shall meet for a period of ten days in 2017, adhering to the agreed recommendations contained in document CCW/CONF.V/2, and to submit a report to the 2017 Meeting of the High Contracting Parties to the Convention consistent with those recommendations.
>
> The GGE will hold its first session from 24 to 28 April 2017 or from 21 to 25 August 2017 and its second session from 13 to 17 November 2017 in Geneva.
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> The GGE will be chaired by Ambassador Amandeep Singh Gill of India."

2. The Group of Governmental Experts met from 13 to 17 November 2017 in Geneva. The first session of the Group could not take place owing to a lack of adequate funding to hold all meetings.

II. Organization and work of the Group of Governmental Experts

3. The following High Contracting Parties to the Convention participated in the work of the Group: Albania, Algeria, Argentina, Australia, Austria, Belarus, Belgium, Brazil, Bulgaria, Cambodia, Cameroon, Canada, Chile, China, Colombia, Costa Rica, Croatia, Cyprus, Cuba, Czechia, Dominican Republic, El Salvador, Estonia, Finland, France, Gabon, Germany, Greece, Guatemala, Holy See, Honduras, Hungary, India, Iraq, Ireland,

Israel, Italy, Japan, Jordan, Kazakhstan, Kuwait, Lao People's Democratic Republic, Latvia, Lithuania, Luxembourg, Mexico, Montenegro, Morocco, Netherlands, New Zealand, Nicaragua, Norway, Pakistan, Panama, Peru, Philippines, Poland, Portugal, Qatar, Republic of Korea, Republic of Moldova, Romania, Russian Federation, Saudi Arabia, Serbia, Sierra Leone, Slovakia, Slovenia, South Africa, Spain, Sri Lanka, State of Palestine, Sweden, Switzerland, Togo, Tunisia, Turkey, Uganda, United Arab Emirates, United Kingdom of Great Britain and Northern Ireland, United States of America, Venezuela (Bolivarian Republic of) and Zambia.

4. The following Signatory State to the Convention participated in the work of the Group: Egypt.

5. The following States not party to the Convention participated as observers: Myanmar, Oman and Zimbabwe.

6. The representatives of the United Nations Office for Disarmament Affairs (UNODA), United Nations Institute for Disarmament Research (UNIDIR), European Union, Geneva International Centre for Humanitarian Demining (GICHD) and the International Committee of the Red Cross (ICRC) participated in the work of the Group in accordance with the rules of procedure.

7. The representatives of the following non-governmental organizations participated in the work of the Group in accordance with the rules of procedure: Campaign to Stop Killer Robots [Amnesty International, Article 36, Association for Aid and Relief, Japan, Facing Finance, Human Rights Watch, International Committee for Robot Arms Control (ICRAC), Mines Action Canada, Nobel Women's Initiative, Norwegian Peace Foundation, PAX, Pax Christi Ireland, Pax Christi Vlaanderen, Project Ploughshares (Canada), Pugwash Conferences on Science and World Affairs, Seguridad Humana en Latino América y el Caribe (SEHLAC), Women's International League for Peace and Freedom], Centre for a New American Security (CNAS), DiploFoundation, ICT for Peace Foundation, IR. Asia, Observer Research Foundation and the World Council of Churches.

8. The representatives of the following entities also participated in the work of the Group in accordance with the rules of procedure: Birmingham City University, Geneva Centre for Security Policy, Harvard Law School, Hiroshima Peace Institute of Hiroshima City University, Idiap Research Institute, International Panel on the Regulation of Autonomous Weapons (iPRAW), King's College London, Lancaster University Law School, London School of Economics and Political Science, National Defense University Washington DC, National University of Ireland Galway (NUIG), Stockholm International Peace Research Institute (SIPRI), University of Barcelona, University of Melbourne, University Paris II Panthéon-Assas, Paris Human Rights Center, University of Strasbourg and University of Tampere.

9. On Monday, 13 November 2017, the session was opened by the Chairperson, Ambassador Amandeep Singh Gill of India. Ms Anja Kaspersen, Head of the Geneva Branch of the UN Office of Disarmament Affairs, addressed the session on behalf of Ms. Izumi Nakamitsu, the High Representative for Disarmament Affairs.

10. At its first plenary meeting, the Group adopted is Agenda (CCW/GGE.1/2017/1/Rev.1), confirmed the Rules of Procedure as adopted by the Fifth Review Conference (CCW/CONF.V/4), and adopted its Programme of Work (CCW/GGE.1/2017/2). Ms. Hine-Wai Loose, CCW Implementation Support Unit, served as the Secretary of the Group, and was assisted by Mr. Bantan Nugroho, Head of the CCW Implementation Support Unit. Ms. Amy Dowler, Political Affairs Officer, Mr. Reint Vogelaar, Associate Political Affairs Officer, Ms. Melanie Gerber, Associate Political Affairs Officer, Ms. María José Orellana Alfaro, Documents Management Assistant,

Ms. Nadiya Dzyubynska, Staff Assistant and Ms. Isabelle Porcu-Cartier, Staff Assistant served in the Secretariat.

11. At the same plenary meeting, the following delegations participated in a general exchange of views: Algeria, Argentina, Australia, Austria, Belgium, Brazil, Bulgaria, Cambodia, Canada, Chile, China, Costa Rica, Croatia, Cuba, Egypt, Finland, France, Germany, Greece, Holy See, India, Iraq, Ireland, Israel, Italy, Japan, Kazakhstan, Mexico, Morocco, Netherlands, New Zealand, Nicaragua, Norway, Pakistan, Panama, Peru, Republic of Korea, Russian Federation, Sierra Leone, South Africa, Spain, Sri Lanka, Sweden, Switzerland, Turkey, United Kingdom of Great Britain and Northern Ireland, United States of America, Venezuela (Bolivarian Republic of), Zambia, Venezuela (Bolivarian Republic of) on behalf of the Non-Aligned Movement and other States Parties to the CCW, European Union, UNIDIR, ICRC, Campaign to Stop Killer Robots, Human Rights Watch, International Committee for Robot Arms Control, Mines Action Canada, Nobel Women's Initiative, PAX and CNAS.

12. In accordance with its programme of work (CCW/GGE.1/2017/2), the Group commenced with a general exchange and in examining the various dimensions of emerging technologies in the area of lethal autonomous weapons systems, in the context of the objectives and purposes of the Convention, held expert-led panel discussions on the following dimensions: technology, military effects, legal/ethical and cross-cutting issues. Interactive discussions among the High Contracting Parties were held on the Chairperson's Food-for-thought paper (CCW/GGE.1/2017/WP.1) and other issues and the Way Ahead. National working papers presented by High Contracting Parties enriched the discussions.

13. The Group heard presentations from the following experts:

(a) Panel 1 – Technology dimension: Professor Margaret Boden, University of Sussex; Professor Gary Marcus, New York University; Mr. Gautam Shroff, Tata Consultancy Services, India; Mr. Harmony Mothibe, BotsZA, South Africa; Professor Stuart Russell, University of California, Berkley; and Mr. Sean Legassick, Google DeepMind.

(b) Panel 2 – Military effects dimension: Brigadier (Armament corps) Patrick Bezombes, France; Professor Heigo Sato, Takushoku University, Tokyo; Lieutenant Colonel Alan Brown, Ministry of Defence, United Kingdom of Great Britain and Northern Ireland; Dr. David Shim, KAIST Institute for Robotics, Republic of Korea; Lieutenant Colonel Christopher Korpela, Military Academy - West Point, United States of America; and Dr. Lydia Kostopoulos, National Defense University, Washington D.C.

(c) Panel 3 – Legal/ethical dimensions: Ms. Kathleen Lawand, ICRC; Ms. Marie-Helen Parizeau, World Commission on the Ethics of Scientific Knowledge and Technology (COMEST), UNESCO; Professor Xavier Oberson, University of Geneva; Professor Bakhtiyar Tuzmukhamedov, Diplomatic Academy, Russian Federation; Mr. Lucas Bento, Attorney, Quinn Emanuel Urquhart & Sullivan, and President of the Brazilian American Lawyers Association; and Professor Dominique Lambert, l'Université de Namur.

(d) Panel 4 – Cross-cutting issues: Dr. Ing. Konstantinos Karachalios, Managing Director, IEEE Standards Association; Dr. Reinhard Scholl, International Telecommunications Union; Mr. Neil Sahota, IBM Watson and University of California; Ms. Kerstin Vignard, UNIDIR; Dr. Vincent Boulanin, SIPRI; and Dr. Marcel Dickow, Stiftung Wissenschaft und Politik.

14. The Group considered the documents listed in Annex I. The Group noted with appreciation the contributions of those High Contracting Parties submitting Working Papers, presenting their national policies and positions, and the input of civil society, including industry.

15. A summary of the discussions held during the Group prepared under the Chairperson's responsibility is attached to this report as Annex II.

III. Conclusions and recommendations of the Group of Governmental Experts

16. In pursuit of its mandate, the Group affirmed that:

(a) CCW offers an appropriate framework for dealing with the issue of emerging technologies in the area of lethal autonomous weapons systems. The Convention's modular and evolutionary character, the balance it seeks to strike between humanitarian considerations and military necessity as well as the opportunity it offers to engage multiple stakeholders make it an ideal platform for reaching a common understanding on this complex subject;

(b) International humanitarian law continues to apply fully to all weapons systems, including the potential development and use of lethal autonomous weapons systems;

(c) Responsibility for the deployment of any weapons system in armed conflict remains with States. States must ensure accountability for lethal action by any weapon system used by the State's forces in armed conflict in accordance with applicable international law, in particular international humanitarian law. The human element in the use of lethal force should be further considered;

(d) Acknowledging the dual nature of technologies in the area of intelligent autonomous systems that continue to develop rapidly, the Group's efforts in the context of its mandate should not hamper progress in or access to civilian research and development and use of these technologies;

(e) Given the pace of technology development and uncertainty regarding the pathways for the emergence of increased autonomy, there would be a need to keep potential military applications of related technologies under review in the context of the Group's work;

(f) Keeping in mind the discussion on the various dimensions of emerging technologies in the area of lethal autonomous weapon systems – technological, military, legal and ethical, there would be merit in focusing the next stage of the Group's discussions on the characterization of the systems under consideration in order to promote a common understanding on concepts and characteristics relevant to the objectives and purposes of the CCW;

(g) There is a need to further assess the aspects of human-machine interaction in the development, deployment and use of emerging technologies in the area of lethal autonomous weapons systems in the next stage of the Group's work;

(h) Further, there is need to continue the discussion in a focused and participative manner on possible options for addressing the humanitarian and international security challenges posed by emerging technologies in the area of lethal autonomous weapons systems in the context of the objectives and purposes of the Convention without prejudging policy outcomes and taking into account past, present and future proposals.

17. The Group therefore recommends that,

(a) The Group of Governmental Experts related to emerging technologies in the area of lethal autonomous weapon systems (LAWS) in the context of the objectives and purposes of the Convention on Prohibitions or Restrictions on the Use of Certain

Conventional Weapons shall meet for a duration of ten days in 2018 in Geneva in accordance with Decision 1 of the Fifth Review Conference of the High Contracting Parties to the Convention (CCW/CONF.V/10), consistent with CCW/CONF.V/2;[1]

(b) The Rules of Procedure of the Review Conference shall apply mutatis mutandis to the Group. The Group shall conduct its work and adopt its report by consensus which shall be submitted to the 2018 Meeting of the High Contracting Parties to the Convention. The widest possible participation of all High Contracting Parties is to be promoted in accordance with the goals of the CCW Sponsorship Programme.

18. At the final plenary meeting, the Group adopted its report as contained in the Draft report as orally amended, which is being issued as document CCW/GGE.1/2017/3.

[1] The schedule of meetings shall be decided in light of the financial situation.

Annex I

List of documents

Symbol	*Title*
CCW/GGE.1/2017/1/Rev.1	Provisional agenda. Submitted by the Chairperson
CCW/GGE.1/2017/2	Provisional programme of work. Submitted by the Chairperson
CCW/GGE.1/2017/3	Report of the 2017 Group of Governmental Experts on Lethal Autonomous Weapons Systems (LAWS)
CCW/GGE.1/2017/WP.1	Food-for-thought paper. Submitted by the Chairperson
CCW/GGE.1/2017/WP.2	Examination of various dimensions of emerging technologies in the area of lethal autonomous weapons systems, in the context of the objectives and purposes of the Convention. Submitted by the Netherlands
CCW/GGE.1/2017/WP.3	Towards a definition of lethal autonomous weapons systems. Submitted by Belgium
CCW/GGE.1/2017/WP.4	For consideration by the Group of Governmental Experts on Lethal Autonomous Weapons Systems (LAWS). Submitted by France and Germany
CCW/GGE.1/2017/WP.5	Weapons Review Mechanisms. Submitted by the Netherlands and Switzerland
CCW/GGE.1/2017/WP.6	Autonomy in Weapon Systems. Submitted by the United States of America
CCW/GGE.1/2017/WP.7	Characteristics of Lethal Autonomous Weapons Systems. Submitted by the United States of America
CCW/GGE.1/2017/WP.8	Examination of various dimensions of emerging technologies in the area of lethal autonomous weapons systems, in the context of the objectives and purposes of the Convention. Submitted by the Russian Federation
CCW/GGE.1/2017/WP.9	A “compliance-based” approach to Autonomous Weapon Systems. Submitted by Switzerland
CCW/GGE.1/2017/WP.10	General principles on Lethal Autonomous Weapons Systems. Submitted by the Bolivarian Republic of Venezuela on behalf of the Non-Aligned Movement (NAM) and Other States Parties to the Convention on Certain Conventional Weapons (CCW).

Annex II

Chair's summary of the discussions

Summary of the general debate, 13th and 15th November 2017

1. The appropriateness of the elevation of the discussion on LAWS to a formal exchange between High Contracting Parties in the form of a Group of Governmental Experts within the framework of the CCW was affirmed. The cancellation of the first scheduled session of the Group due to financial reasons was regretted. The discussions on lethal autonomous weapon systems (LAWS) at the three informal meetings of experts held under the auspices of the CCW in 2014, 2015 and 2016 were recognised. The substantive contributions of civil society, academia and private industry were welcomed. The need for gender perspectives to be integrated was affirmed.

2. The need to improve shared understanding of autonomous weapon systems was recognised. The elaboration of a working definition of LAWS, without prejudice to the definition of systems that may be subject to future regulation, was encouraged. Consideration was given to the scope of a possible definition, including questions of systems already deployed, defensive versus offensive weapons, and the distinction between fully and semi-autonomous systems. The view that it was premature or unhelpful to begin work on definitions was also put forward.

3. While some delegations expressed the view that fully autonomous weapon systems did not yet exist, others pointed to the existence of precursor technologies as well as the deployment by some States of increasingly autonomous technologies.

4. The importance of considering LAWS in relation to human involvement and the human-machine interface was underlined. The notions that human control over lethal targeting functions must be preserved, and that machines could not replace humans in making decisions and judgements, were promoted. Various related concepts, including, inter alia, meaningful and effective human control, appropriate human judgement, human involvement and human supervision, were discussed.

5. Delegations stressed the applicability of international law, and in particular international humanitarian law (IHL), in the context of LAWS. The need to ensure strict compliance with IHL and its fundamental principles of distinction, proportionality and precautions in attack, was underlined. Contending views were expressed regarding the ability of autonomous weapons to fully comply with, or potentially enhance compliance with, IHL. While some delegations stated that IHL is sufficient to regulate the use of any type of weapon, including LAWS, other delegations questioned whether this was the case.

6. Delegations raised concerns relating to responsibility, accountability and attribution in the context of LAWS. The general understanding reached at earlier informal meetings on LAWS that States bear legal responsibility for acts conducted by LAWS under their authority was recalled. Delegations affirmed that legal responsibility would always lie with a human in the chain of command. The utility of the Martens clause for addressing the potential gaps in understanding of the application of existing law was noted. However, the sufficiency of this clause was questioned.

7. The importance of conducting national legal weapons reviews as required by Article 36 of Additional Protocol I to the Geneva Conventions to ensure compliance with IHL was emphasized. The benefit of information sharing on legal weapons reviews as a transparency and confidence building measure was recognised. The view that national measures, including weapons reviews, were not in themselves sufficient to deal with LAWS was also put forward.

8. Delegations stressed the ethical and moral concerns raised by the prospect of the development and deployment of LAWS, particularly the delegation of decisions on the life and death of a human being to a machine.

9. Delegations discussed potential international security implications of LAWS, including an arms race in LAWS technologies, accentuating the technology gap between developed and developing States and the possible lowering of the threshold for the use of force. Concern was expressed about proliferation to and use by non-State actors. Concerns about the vulnerability of LAWS to hacking, including to interfere with the human control to which they may be subject, were also expressed.

10. Delegations expressed preferences for a range of policy options, including a legally-binding instrument, which could preventively prohibit LAWS. This prohibition could take the form of a CCW protocol. The need for an immediate moratorium on the deployment of LAWS pending agreement on a prohibition was mentioned in this regard. Other policy options proposed included a politically-binding declaration and a future Code of Conduct. Equally, the view that consideration of policy options was premature at this stage was emphasized.

11. The dual use character of autonomous technologies was raised, along with acknowledgement of the beneficial civil applications of autonomous technologies, including for the achievement of the Sustainable Development Goals. The leading role played by the private sector in developing autonomous technologies was acknowledged, and the importance of responsible innovation stressed. It was underscored that the Group's efforts should not hamper progress in or access to civilian research and development in related technologies.

12. The suitability of the CCW as a forum for the discussion of emerging technologies related to LAWS was underscored and there was support for discussions on LAWS continuing within the CCW in 2018.

Summary of the interactive discussion, 15th November 2017

13. During the interactive discussion, delegations exchanged views on various aspects of the food-for-thought paper submitted by the Chair, as well as on possible ways ahead. The discussion also took in the working papers submitted by High Contracting Parties.

14. On the technology dimension, the dual use nature and beneficial civil applications of autonomous technologies were again recalled, along with the need for the discussion to be balanced in this regard. Divergent views were expressed on whether autonomous weapon systems exist or could exist in the foreseeable future.

15. On the military dimension, there was some discussion of the potential military advantages that may result from semi-autonomous technologies and human-machine teaming. A view was put forward that autonomous weapon systems could be integrated into existing command and control structures.

16. There was also some consideration of the potential negative security implications of autonomous weapons systems, including the lowering of the threshold for the use of force and blurring of the line between war and peace.

17. The military undesirability of weapons beyond human control was emphasized. In this context, delegations reaffirmed the importance of maintaining human control over the use of force. Different views on the degree and characterisation of this control were presented.

18. On the legal dimension, delegations reaffirmed that IHL applied to LAWS. Divergent views were expressed on the ability of autonomous weapon systems to comply with IHL, with the notion that a system's ability to comply with IHL may rely upon the

degree of its autonomy also discussed. The ultimate legal responsibility of States and humans was underlined.

19. Delegations also discussed some options for the way forward. There was support for the continuation of the Group, either with an extension of its current mandate, or with a strengthened mandate.

20. In terms of next steps, a number of concrete proposals were raised, with various views expressed on each, including: focusing on agreeing a working definition, information sharing on legal weapons reviews, pursuing a political declaration, agreeing to negotiate a legally-binding instrument, and recommending a moratorium on the deployment of LAWS.

Summary of the discussion on the way ahead, 16th November 2017

21. Delegations supported the continuation of the Group in 2018 and continued to affirm the suitability of the CCW as a forum for these deliberations. Emphasis was placed on the need for discussions to be more focussed and for a shift to a format prioritising State interaction aimed at concrete outcomes. The desirability of a gradual, step by step approach was also underlined. The need to incorporate human rights and gender perspectives into future discussions was raised. While there was some discussion on altering the Group's current mandate, continuation of the current mandate was widely supported. The view that the Group should meet for two weeks, in two separate sessions, was supported. The importance of preserving the open, transparent and inclusive nature of the Group's deliberations was underscored.

22. There was a call for the future work of the Group to be focused on building shared understanding of characteristics and concepts related to lethal autonomous weapon systems. That a lack of agreement on definitional matters should not hinder progress on other issues was underlined. Delegations emphasized the importance of further work on exploring human-machine interactions, including inter alia through deliberations on the concepts of human control, supervision, involvement and judgement.

23. The need for the Group to identify practical measures for improving compliance with international law, particularly IHL, was stressed. This could include discussing best practices and exploring formal information sharing on legal weapons reviews required by Article 36 of Additional Protocol I to the Geneva Conventions. It could also take the form of conducting a review of international law applicable to lethal autonomous weapons systems.

24. A range of views were expressed on the value of the Group pursuing a politically-binding declaration on LAWS. Similarly, a range of views were expressed regarding proposals on the future pursuit of a code of conduct and technical group of experts on LAWS.

25. There was also a variety of views on the proposal for the Group to agree to pursue a legally-binding instrument on LAWS. The view that such an instrument would be premature was also articulated. Further, a call was made on States to declare a moratorium on the deployment of LAWS as an interim measure.

Summary of the panel on technical aspects, 13th November 2017

26. Artificial intelligence (AI) is different from typical information technologies as it demands a higher degree of interactivity and because solutions and improvements emerge through recursive learning, with pathways not always easy to predict and results not always guaranteed.

27. The achievement of 'strong' or general AI is not as close as many believe. Even headline catching developments such as Alpha Go Zero have to be seen in context. A lot is still being handcrafted, even in supposedly super-human algorithms. Not all AI technology

development is moving at exponential speed, some areas are developing at linear or less rates.

28. There are some hard engineering challenges in coupling AI and autonomous physical systems. These include figuring out how to do robust engineering with machine learning and addressing scientifically speaking how to build machines with common sense.

29. Due to the ever-changing nature of AI, it is hard to find a perfect definition of AI The focus should be on autonomy. Today's AI is tomorrow's software. Progress on various dimensions of autonomy such as energy autonomy and self-preservation, which could contribute to the realisation of fully autonomous systems, need to be looked at but still lie in the future.

30. AI has enormous potential for good and civilian uses are developing rapidly across the globe. The technologies are inherently multiple-use and it is hard to draw a line between 'good' and 'bad' AI.

31. There are more risks from 'dumb machines' and failures in human-machine interaction or 'natural stupidity' than from speculative 'smart machines' that can outthink and outperform humans. Due diligence is essential in technology development.

32. Industry is working to address risks, including through robust validation and verification as well as testing and evaluation methodologies. Some are integrating ethics into design and development and looking at best practices from around the world. Risk management is best pursued in a domain-specific manner.

33. Substantive human participation is essential as robots cannot be moral agents. Together with scrutability and explainability in AI systems, human participation is the key to addressing risks and avoiding surprises.

Summary of the panel on military effects, 14th November 2017

34. There could be a number of drivers for military applications of emerging technologies related to LAWS. These include enhancement of combat efficiency, reduction of the physical and cognitive load for soldiers and commanders as well as decision support systems, cost reduction, operation within defined moral bounds, providing realistic synthetic training and testing capabilities, enlarging the area and depth of combat operations and meeting demands for a raised tempo of operations. At the same time, the potential risks and the unpredictability associated with the deployment of such technologies could outweigh benefits accruing from their deployment.

35. There would be a degree of path dependency in the development of potential LAWS; certain demographic, technological, civil-military contexts might favour such development. The mutual interaction of the various drivers is difficult to predict. For States, whether such systems would be deployed depends upon: trust in the technologies; their fit within existing cultures, chiefly political-military and age-cohort cultures; and the availability of the technologies. Success in deployment in one domain might lead to greater trust in deployment in other domains; air and maritime domains are more likely environments for deployment than cluttered urban environments for example.

36. 'Weak' AI as available now can be employed for a variety of narrow military tasks today. Unlike many other military technology domains, most advances in the field of AI are happening in the civil sector, which holds most of the intellectual property, and data used in machine learning. Much of this technology is in the public domain. AI will get smarter as time goes on. The technology should neither be hyped nor underestimated. There is need for monitoring its development. As important as technology is, it is creativity in its employment which could bring decisive advantage.

37. However, there are inherent limits to the applications of AI to the military domain. Certain tasks, such as that of the infantry soldier, cannot be automated away. Context cannot be codified and full autonomy would not be desirable from a military operational and command and control perspective. Autonomy was described in this regard as an emergent property, which we can judge on the basis of context and tasking. Potential removal of functions, extrapolating from the existing employment of machines, is one way to seek to understand future deployments.

38. Possible military applications could be desirable from an IHL perspective: less collateral damage, allowing for the use of non-lethal force for force protection, better discriminating civilians from combatants, etc. A broad range of possible applications involving split-second decision-making, including through man-unmanned teams, was highlighted. Command and control issues in the context of an existing guidance on autonomous systems were described.

39. A four-fold taxonomy of automation and autonomy from a specific national context was described. Level 4 autonomy as per this taxonomy cannot be integrated into military command and control. 'Automatic' and 'autonomous' are subjective choices in this regard. Reaching too far back into legacy technologies or too far ahead into futuristic scenarios is problematic.

40. Poorly-designed AI-based applications might pose problems and new kinds of testing and evaluation parameters and procedures would be required. International standards setting could prove useful in this connection. Safety locks, provisions to avoid friendly fire and self-destruct functions were also raised in this regard.

41. Parallels can be drawn with the civil aviation sector. Standards, provisions for accountability and explainability (black box), the human-machine interface, pilot responsibility, safety considerations have also come up in this context.

42. In the context of the dual-use nature of these technologies, it is difficult to set boundaries and international oversight could be problematic. There should be no restrictions on technology development or its use for social and economic development. Nor is it possible to define subjective notions of 'good' and 'bad' LAWS.

43. There are risks of misuse by non-State actors, for example, a terrorist attack employing an autonomous vehicle. There is a possibility of future 'gray markets' in AI technologies.

44. With regard to broader international security implications, strategic effects, lowering the threshold for the use of force and the risk of an arms race were raised. With regard to strategic aspects, the effects of LAWS are not yet comparable to nuclear weapons and the more important question is whether LAWS can be deterred with LAWS. This is not yet clear. The fear of the potential development of LAWS by a peer competitor would be a factor in their development.

Summary of the panel on legal and ethical dimensions, 14th November 2017

45. Since IHL underpins the CCW and it is a living instrument, it is the relevant forum to take forward the issue.

46. The ICRC emphasized that its views on a working definition focused on autonomy in the critical functions of selection and targeting were without prejudice to an eventual regulation. The main reason for focusing on the critical functions was to distinguish such systems from human controlled systems. ICRC's approach to definitions is not technology based, but is related to the degree of human involvement.

47. Law is addressed to humans and accountability cannot be transferred to machines. Respecting the principles of IHL such as distinction, proportionality and precaution requires

a minimum level of human control and supervision, including an ability to intervene after activation, especially in a cluttered environment.

48. There may be a need to establish some sort of standards of predictability and reliability for weapons with autonomy in their critical functions given the fundamental concerns autonomous weapon systems raise about respect for IHL.

49. The question was posed whether in general, besides IHL, there is sufficient international law to deal with the subject. The main issue is compliance with existing IHL and this is where the novel characteristics of technology raise questions. These include the need for clarification of existing rules, how they could apply and how State responsibility under Additional Protocol I to the Geneva Conventions for weapons reviews is carried out.

50. With regard to weapons reviews, it was stated that these were conducted nationally by a small number of States. It was also stated that there could be certain conceptual and operational issues raised by emerging technologies related to LAWS. The ICRC will be updating its guide on Article 36 reviews, which should be available in 2018 and appealed to those States which conduct such reviews to share them.

51. Ethics is the ceiling to the legal floor and the Martens Clause denotes an ethical horizon. It is ethics that underscore the importance of intention. At the same time, legal clarity is important for universal application over time. Coding ethics into machines could potentially shift the issue from the legal and ethical domains into the technical domain.

52. The fundamental characteristics of humans in contrast to machines include responsibility, relationships, creativity and compassion. Defining LAWS might be difficult but there needs to be clarity on what is not desirable in ethical terms. Such ethical characteristics might include self-learning and auto-programming without human supervision.

53. In the discussion on national legal developments, including in the European Union, Estonia, Germany, Republic of Korea and the United States, parallels were drawn with concerns related to driverless cars. In the context of developments in commercial law, giving a legal personality to robots in the future was not ruled out and there could certainly be registries of such machines. The actualisation of legal liability in machines is controversial.

54. AI technologies are currently subject to sector-specific regulation in national contexts. There could be tension between the promotion of innovation and ensuring public safety. Public education, manufacturers' responsibility, cyber security, data recording, self-explanatory architecture and the ability of the machine to communicate with humans were inter alia relevant in this regard. There was discussion on whether lessons could be drawn from national regulatory experiences for the CCW discussion on LAWS.

Summary of the panel on cross-cutting dimensions, 17th November 2017

55. The internet of things, communications, sensor and computing technologies are converging, and the speeds involved necessitate the use of machine learning. The move from 4G to 5G is a qualitative shift.

56. True AI has three components: machine learning; the ability to understand natural language; and the ability to interact with human beings in a human-like manner. AI is already here, across every sector and every industry. The term AI can be misleading; he IEEE prefers intelligent autonomous systems.

57. Technology is not neutral; it enjoys a positive feedback loop with existing power structures. Developments in technology can impact power relations, and this is being observed with the accelerated development of information and communication technologies.

58. Practitioners are seeking to introduce self-regulation, including through IEEE standards, similar to the Hippocratic Oath in the medical field. This is centred on the concept of ethical design. Standards are needed to tackle the hard problems. The Partnership for AI, whose founding members are IBM, Deep Mind/Google, Amazon, Facebook and Microsoft, seek to advance public understanding of AI and formulate best practices on the challenges and opportunities within the field.

59. Autonomous weapon systems operating in increasingly communications-denied environments, and with long loiter times, pose questions of vulnerability and risk. There is a need to examine whether, in the event a vulnerability is discovered in an autonomous weapon, an operator would be able to patch it remotely, recall the weapon, or rely on some sort of fail-safe mechanism.

60. National and international policy discussion on LAWS to date has lacked precise terminology. There is an explainability deficit. There is a need for technological knowledge to be injected into the political debate. Political decision-makers often underestimate current technological achievements and overestimate future ones. Education in the wider sense of the term is important. Equally important is bringing people from different domains together.

61. States should try to avoid certain pitfalls when discussing autonomy, including viewing autonomy as a general attribute of a system rather than applying to various of its functions; attempting to draw a line between autonomous and automated systems; and focussing only on full autonomy. The latter does not reflect the reality of how militaries are envisaging the future. It is important to focus on the impact of increasing autonomy on human control, rather than just technological features.