International Coalition to Ban Uranium Weapons

Precaution in Practice:
challenging the acceptability of depleted uranium weapons

Preface

Depleted uranium (DU) weapons have proved a controversial addition to the conventional arsenals of militaries since their first development in the Cold War. Opposition to their use has varied in pitch over the years but has tended to correlate closely with their deployment in conflict. Yet throughout this period, it has been clear from the column inches printed, the parliamentary debates and, more recently the bills, motions and resolutions passed, that the use of DU munitions appears to be intrinsically unacceptable to most people.

The stigmatisation of inhumane and unacceptable weapons has been crucial to extending the impact of the international treaties banning anti-personnel landmines and cluster bombs. But while DU has shown itself, to a degree, to be self-stigmatising – evidence for which is clearly demonstrated by the energetic public relations strategies of its proponents, the difficulty of establishing a causal link between its use and humanitarian impact requires a different approach to judging its acceptability to those that have historically been applied to explosive weapons.

Common sense lies at the heart of people's innate response to assessing the acceptability of DU's use in conventional weapons, thus it seemed only right for ICBUW to launch a discourse rooted in precaution. The Precautionary Principle provides a useful model for both health and environmental protection, particularly where scientific complexity and uncertainty meet. Throughout the last three years, ICBUW has been applying a precautionary prism to different aspects of what remains a complex issue, from what is known about DU as a material and how it is regulated in peacetime, to how and where it is used in conflict, how it is managed after conflict and, crucially, to the cost/benefit calculations relating to its use.

The purpose of this report is to discuss the findings of ICBUW's research on precaution and, we hope, to provide policymakers with an accessible means of judging the acceptability of DU's use in conventional weapons.

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Special thanks to: Scott Peterson, Naomi Toyoda, Gretel Munroe, Dr Katsumi Furitsu, Prof. Manfred Mohr, Dr Mohamed Ghalaieny, Rachel Thompson, Andy Garrity, Pat Sanchez and to the ICBUW Steering Committee for their proof reading and forbearance.

Cover: BAGHDAD, IRAQ - MAY 3: A barefoot Iraqi boy ignores warning signs written by American troops to keep Iraqis away from a series of burnt U.S. ammunition trucks contaminated by U.S. Depleted Uranium (DU) bullets May 3, 2003 in Baghdad, Iraq. [The 'sabot' portions of DU tank rounds are clearly visible below the boy's feet.] Although some bulldozed topsoil points to a U.S. clean-up effort, piles of DU ash and even an exposed, three-foot-long DU penetrator still contaminate the site. DU bullets have been controversial since they were first used in the 1991 Gulf War, though until this war it had never before been used in heavily populated urban areas.

Research and publication funded by: The Government of Norway, Ministry of Foreign Affairs.

Published in September 2012 by ICBUW, Bridge 5 Mill, 22a Beswick Street, Ancoats, Manchester, M4 7HR, UK.
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PDF available to download via: http://www.bandepleteduranium.org/precaution-in-practice
Design by ICBUW
Print by: www.calverts.coop

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Acronyms

AFRRI	US Armed Forces Radiobiology Research Institute
CCM	Convention on Cluster Munitions
DU	Depleted Uranium
ERW	Explosive Remnants of War
KE	Kinetic Energy
IAEA	International Atomic Energy Agency
IARC	International Agency for Research on Cancer
ICBUW	International Coalition to Ban Uranium Weapons
ICRP	International Commission on Radiological Protection
IHL	International Humanitarian Law
MoD	UK Ministry of Defence
NRC	US Nuclear Regulatory Commission
SCHER	EC Scientific Committee on Health and Environmental Risks
UK	United Kingdom
UN	United Nations
UNEP	United Nations Environment Programme
US	United States (of America)
USAF	United States Air Force
WHO	World Health Organisation

Executive summary

Introduction

Depleted uranium (DU) weapons have proved a controversial addition to the conventional arsenals of militaries since their first development in the Cold War. Opposition to their use has varied in pitch over the years but has tended to correlate closely with their deployment in conflict. Yet throughout this period, it has been clear from the column inches printed, the parliamentary debates and, more recently the bills, motions and resolutions passed, that the use of DU munitions appears to be intrinsically unacceptable to most people.

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Throughout the last three years, ICBUW has been applying a precautionary prism to different aspects of what remains a complex issue, from what is known about DU as a material and how it is regulated in peacetime, to how and where it is used in conflict, how it is managed after conflict and, crucially, to the cost/benefit calculations relating to its use.

The purpose of this report is to discuss the findings of ICBUW's research on precaution and, we hope, to provide policymakers with an accessible means of judging the acceptability of DU's use in conventional weapons.

A role for precaution?

When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically. European Commission.

From the outset, ICBUW believed that any precautionary approach would require that a thorough assessment of DU's properties, the nature of its use in conflict and the constraints on the post-conflict management of contamination be made. We also felt that further guidance should come from a critical appraisal of DU's costs to civilians and affected governments and the benefits that militaries claim from its use.

Examples from environmental law, International Humanitarian Law and the Convention on Cluster Munitions demonstrate that, while no single interpretation of the Precautionary Principle has gained worldwide legal acceptance, precautionary thinking and approaches are widespread in relevant and related fields of law and regulation.

Precautionary approaches are now the peace time norm for reducing human exposures to hazardous substances. As the legacy of DU use lasts beyond the end of conflicts, it is reasonable to suggest that a similar approach is justified to protect human health. Doubtless lessons could also be drawn from how governments would manage widescale releases of DU under their own national regulatory frameworks.

ICBUW believes that sufficient evidence is now available to pass the *threshold of plausibility*, i.e. even though uncertainties may remain, enough is known about the nature of the potential risks to civilians and the costs of inaction, to support the adoption of a precautionary approach.

ICBUW is not alone in advocating for an approach based on precaution. The UK Royal Society suggested a range of precautionary measures in response to scientific uncertainties following its detailed review of the potential health effects of DU use. Similarly, the UN Environment Programme specifically called for a precautionary approach, with hazard awareness programmes and decontamination, following its fieldwork on DU strike sites in the Balkans, renewing this call in 2010 in a report to the UN Secretary General. The WHO has also issued a range of precautionary guidelines for reducing the risks to civilians in areas where DU has been used.

Is DU a hazard?

On the basis of reports by the Royal Society and others, the MoD does not consider DU is 'safe'. It is hazardous (making the accepted health and safety distinction between a hazard and a risk). Dr Liam Fox, UK Defence Minister, 2011.

DU's chemical toxicity and radioactivity, when combined with its propensity to combust and form particles of a respirable size, result in it being a recognised hazard. DU has been intensively studied and a wealth of new research, much of it carried out by the US military, indicates that DU may have an impact on health through a variety of different chemical and radiation-induced mechanisms. Much of this research post-dates the widely cited WHO Monograph on DU's risks and the UK Royal Society's study.

As Intermediate Level Radioactive Waste, its storage, use, disposal and transportation is tightly regulated in peacetime. Civil radiation protection norms seek to avoid unnecessary exposures wherever possible, and any exposure must be justified on the basis of its wider benefits.

Militaries have adopted a precautionary approach to DU, avoiding unnecessary exposures through hazard awareness training and providing health monitoring as required. When forced to operate within peacetime health and environmental regulations, DU users face considerable challenges.

It appears, therefore, that DU's intrinsically hazardous nature is well accepted and that its uncontrolled or accidental dispersal into the environment is broadly viewed as undesirable.

Uncontrolled and unpredictable: factors influencing the risks to civilians from DU.

Circumstances vary so enormously in war, and are so indefinable, that a vast array of factors has to be appreciated—mostly in the light of probabilities alone. Carl von Clausewitz.

Significant uncertainties develop when DU munitions are used. Some of these are avoidable although unlikely to be resolved – the timely release of targeting data for example, or avoiding the use of DU in civilian areas – but most relate to the nature of the weapons themselves and their mode of use. This results in a significant variability in the likely risks from different DU strike sites. This poses a challenge to the generalised statements often used to dismiss concerns over DU contamination and underscores the importance of detailed data collection and risk analysis for individual sites.

Recent use of DU demonstrates that it has been used in populated areas, leaving civilians facing contamination from weapons designed for very different military scenarios. That international mechanisms are not in place to fund and undertake DU clearance work ensures that civilians face a greater risk of exposure. Fear of radiation, particularly where information gaps or mistrust exists, increases the likelihood of the politicisation of DU, which in turn reduces the likelihood that effective hazard awareness work will be completed. Even on the rare occasions where DU contamination is adequately managed, DU's psychological legacy will live on in affected communities.

The uncontrolled release of DU in conflict not only breaches radiation protection norms but also presents a challenge to risk modellers. The risk of civilian exposure to DU residues is increased markedly by factors that are, to a certain extent, constants in post-conflict environments. Institutional capacity, technical expertise, access to analytical equipment, limited finances and a range of competing health and environmental problems will all pose challenges for efforts to safely remediate DU contamination – and to the acceptability of DU use.

Quantifying risk and responding to uncertainty

The absence of scientific proof of the existence of a cause-effect relationship, a quantifiable dose/response relationship or a quantitative evaluation of the probability of the emergence of adverse effects following exposure should not be used to justify inaction. European Commission.

The ongoing requirement to maintain the acceptability of DU munitions has resulted in the projection of an overly simplistic view of the health hazards that DU poses.

The data on uranium's chemical toxicity is a case in point, with many studies predating the development of modern analytical methods. The science of toxicology itself is currently in a state of renewal as it seeks to provide more sophisticated and detailed data on substances. Similarly, recent developments in our understanding of the means through which radiation interacts with cellular processes and repair mechanisms have highlighted that modelling the estimated dose and safe exposure limits to internal radiation is fraught with uncertainties. This is largely unsurprising as exposure limits have been on a downward trajectory ever since the discovery of radiation. While it has proved politically useful to communicate a clear safety message on DU, this is not supported by the science.

Uncertainties and gaps in the data needed to undertake detailed civilian risk assessments for DU appear to have rendered accurate risk characterisation impossible. As a result there are compelling reasons to suggest that a precautionary threshold has been passed.

Just as the uncertainty over accurate risk characterisation should not be used to justify inaction, the lack of detailed epidemiological data from Iraq and elsewhere should not be interpreted by the users as supporting the ongoing use of the weapons. The complexities of such studies are rarely mentioned by user states but are all too familiar to those physicians and researchers who have sought the truth about the potential civilian harm from DU munitions.

Costs and benefits

Examination of the pros and cons cannot be reduced to an economic cost-benefit analysis. It is wider in scope and includes non-economic considerations. ...the protection of public health should undoubtedly be given greater weight than economic considerations. European Commission.

An analysis of the costs and benefits of the use of DU sees the strategically overstated utility of the weapons pitched against the health, psychological and management burden they place on affected states, the lifecycle costs associated with manufacturing, development and testing and ultimately the public acceptability of using radioactive materials in conventional weapons.

State practice, and recent procurement decisions, appears to support the claim that their utility has been overstated, thus weakening the primary justification promoted by states to support DU's use. Contrary to DU users' hopes, the public's acceptability of DU has not increased with time, a trend that is unlikely to change as more work is undertaken to document its legacy in affected states and further research is undertaken on its interactions with the human body.

Although some lessons seem to have been learned by the US and UK militaries in the wake of concerns over DU's potential health impact on troops and civilians, it would be naive to expect these lessons to be adopted in future decision making without some external pressure requiring them to do so, be this through political pressure or a legal obligation.

Precaution in Practice?

> ***...if a proposal is made in the 1979 Weaponry Conference for a ban on the use of DU there might be scope for considering whether we should propose, as an alternative, restrictions on the uses to which such ammunition might be put... The difficulties of any such proposal in terms of verification are, of course, considerable.*** UK Foreign and Commonwealth Office.

The problems outlined throughout this report are intrinsic to the nature of DU and its mode of use in weapons, thus there are no quick technological fixes that might resolve them. Models for precautionary approaches that have been suggested in the past place too great a reliance on legal reviews and voluntary controls on behaviour, which past state practice suggests would do little to limit the worst problems associated with DU use. Stricter regulation might be one possible avenue to explore but this would require a level of transparency that has hitherto been lacking.

Therefore, it is reasonable to conclude that a voluntary moratorium, while potentially useful as part of a process of further stigmatising DU weapons, would not be the ultimate in precautionary measures – however a global ban on the use of uranium in all conventional weapons, would.

As they have most to lose from a ban on DU weapons, it is understandable that the military has historically sought the greatest influence in the debate over their acceptability. But this is a morally unsustainable situation as the users of DU are unlikely to voluntarily surrender a means of warfare that they perceive as valuable. Yet when those weapons overwhelmingly affect those not party to a conflict, and well beyond the cessation of hostilities, it raises questions of moral and political acceptability; questions that those with a vested interest in maintaining DU weapons are poorly placed to answer.

DU is a complex and emotive issue. Yet for all the scientific and technical arguments there is a simple principle at play: *is it politically acceptable to disperse large quantities of a chemically toxic and radioactive heavy metal, which is widely recognised as hazardous, in conventional warfare?*

Throughout our DU research, ICBUW has been conscious of the emergence of a broader thematic area relating to the humanitarian and environmental impact of the toxic legacy of military activities. This has included the means through which weapons components are assessed for toxicity and environmental behaviour prior to use; the role of precautionary approaches to civilian health because of the constraints on post-conflict monitoring and assistance; the need for analytical capacity and remediation expertise for managing toxic remnants of war and finally, a recognition of state responsibility for the environmental and health legacy of toxic substances released or abandoned during conflict. An acceptance by states of the need to resolve these issues could yet prove to be a positive outcome of the development and use of DU munitions.

Recommendations

1. Adopt a precautionary approach

On the basis of their potential civilian harm, the historical use of DU munitions in civilian areas and against civilian objects and the costs and technical difficulties inherent in their remediation, states should support calls for a precautionary approach to DU weapons and give serious consideration to a voluntary moratorium on their use.

2. Broader understanding of civilian harm

While they are far better documented, states must recognise that the risks to civilians resulting from munitions are not restricted to explosive hazards. Monitoring the health and environmental legacy of toxic and radioactive substances is challenging, therefore guidance should be sought in the precautionary health and environmental protection norms in place in domestic standards.

3. Provide technical and humanitarian assistance

DU users and affected states should recognise their obligations to protect civilians from the post-conflict legacy of DU. Far greater transparency over where the weapons have been used, and in what quantities, is urgently required as a first step towards implementing comprehensive risk reduction measures and decontamination. The international community should provide technical and financial assistance to affected states, both for health programmes and to assist in the assessment and effective management of contaminated materials.

4. Assessment of other materials and practices

As part of the developing normative framework for the protection of civilians during, and after, times of conflict, states should consider a broader range of military materials and practices that may result in environmental contamination and whose legacy lasts beyond the cessation of hostilities. Consideration should also be given to mechanisms to fund and undertake environmental impact assessments, health monitoring and post-conflict remediation of toxic remnants of war.

5. Accelerate removal of DU and consider mechanisms for a ban

If, as seems apparent, the use of DU munitions runs counter to both public acceptability and health and radiation protection norms, states should accelerate its removal from their arsenals and consider mechanisms through which to formally ban its use in conventional weapons.

1.0 Background

DU is a by-product of the process of uranium enrichment employed to manufacture nuclear fuel and weapons. Its high density brought it to the attention of weapons developers who, aware that the effective range and penetrative power of projectiles is primarily a function of their mass and velocity, wished to move beyond steel and lead in order to boost performance.

Although Nazi Germany was the first to develop uranium-based kinetic energy penetrators, ultimately it was the United States, Russia, the United Kingdom, France, China and Pakistan that chose to produce and, in certain cases, proliferate, modern DU-based kinetic energy penetrators. The motivation behind this varied, with the Cold War and regional arms races playing a significant role.

Currently around 20 states are thought to retain stockpiles of DU munitions of varying sizes. Of these 20, the US has the most diverse range of DU rounds in service, employing 25mm and 30mm medium calibre ammunition for use by armoured vehicles and aircraft and large calibre 105mm and 120mm tank rounds. The primary use for DU by most countries is in 105mm, 120mm and 125mm large calibre applications.

In addition to being dense, DU is also chemically toxic and radioactive. Even after the enrichment process, DU metal retains much of the radioactivity of natural uranium ore, albeit in a far more concentrated form. What makes DU particularly problematic from a health and environmental perspective is its property of pyrophoricity. Pyrophoric materials readily oxidise or burn when powdered; in DU's case the high temperatures generated during its impact with hard surfaces are sufficient to fragment and ignite a proportion of the penetrator. This leads to the generation of particles, many of which will be of respirable size and which can present a health hazard if inhaled. Larger fragments and intact penetrators deposited during use may lead to the contamination of soils and water supplies if not removed.

The first widespread use of DU in conflict was in the 1991 Gulf War, during which around 280,000kg of DU was expended, almost wholly by the US. DU was subsequently used in the Balkans in 1994/5 and 1999 and again in Iraq in 2003. On the basis of extrapolations from satellite data, UNEP estimated that DU use in 2003 may have exceeded 1000 tonnes. This is seven times more than the figure acknowledged by the US.

The US has consistently denied using DU in Operation Enduring Freedom in Afghanistan, in spite of repeated allegations to the contrary. Italian peacekeepers have been compensated on the basis of their exposure to DU during joint operations in Somalia in the early 90s and question marks remain over the possible Russian use of DU in Afghanistan, Georgia and Chechnya. The US and UK are the only two states to have publicly admitted DU use in active conflict.

Concern over the humanitarian impact of DU use arose in the mid 1990s as media reports of increased cancer rates and birth abnormalities among civilians began to emerge from Iraq. A second narrative developed over the role that DU may have played in Gulf War Illness amongst Coalition troops returning from the 1991 conflict. This developed further after 1999 as concern grew over peacekeepers serving in the Balkans. Fears over its civilian health impact were renewed after DU was used in Iraq for a second time in 2003, and grew as a clearer understanding developed of the constraints on the effective post-conflict management of DU contamination.

While subsequent government-sponsored health studies of veterans have found general exposures to be low, certain sections of the military do come into contact with DU or contaminated material and safety standards have been issued to reduce potential exposures. However, two decades after concerns were raised in Iraq, no detailed studies into DU's impact on the health of civilians living in contaminated areas have been undertaken. The reasons for this are varied and will be dealt with in a later section.

Opposition to the use of DU has strengthened and grown more coherent in recent years. DU munitions have now been the subject of four European Parliament resolutions, all of which advocated a moratorium on its use; in 2009 this was echoed by the Latin American Parliament. Since 2007, the United Nations General Assembly has passed three resolutions on DU, which have recognised its potential health risks, called for greater research in affected states and for greater transparency from users over where the weapons have been used, as a means of facilitating this. Two states, Belgium and Costa Rica, have passed domestic legislation banning DU weapons. A bill for a DU ban in Ireland attracted cross party support, becoming only the second Private Members Bill in nearly a century to pass through the Senate unopposed, before falling as the government collapsed in the economic crisis in November 2010. In 2012, New Zealand's minority centre-right government blocked similar legislation after a 60:60 vote.

International pressure on the issue appears to be slowly influencing the behaviour and procurement decisions of DU users, which in itself is a tacit acceptance of DU's intrinsic unacceptability and an acknowledgment that international pressure is mounting. Nevertheless, civil society actors and some states are keen for users to accelerate and complete the removal of DU from their arsenals and to provide assistance to post-conflict states in managing the legacy of the use of the weapons. But, as with other indiscriminate and inhumane weapons that were not subject to specific bans under arms control law, it is likely that a formal international framework will need to be developed to facilitate this.

2.0 A role for precaution?

From the outset, ICBUW believed that any precautionary approach would require that a thorough assessment of DU's properties, the nature of its use in conflict and the constraints on the post-conflict management of contamination be made. We also felt that further guidance should come from a critical appraisal of DU's costs to civilians and affected governments and the benefits that militaries claim from its use. This approach could be refined further by discussion of the Precautionary Principle and by analysis of the precautionary approaches and norms currently applicable to peacetime environmental and health protection, and related fields of law.

2.1 An introduction to the Precautionary Principle

While various strands of law and ethics have been cited as sources of the Precautionary Principle, perhaps the two most influential interpretations appeared during the 1990s, as part of the 1992 Rio Earth Summit Declaration[1] and later in the 1998 Wingspread Statement[2]. The former, which introduces a precautionary approach – having taken into account the cost of action versus the cost of inaction – is generally viewed as a softer interpretation than Wingspread.

Since the 1990s, different interpretations of the principle have proliferated. Nevertheless it is widely seen as a means of guiding regulation or behaviour, particularly where the impact of human activities on the environment, or in responding to uncertainty in complex systems, is concerned. Many have argued that precautionary approaches have now become normative, if not yet customary.

Attempts to apply precautionary values to new technologies and environmental problems have faced criticism for being overly simplistic, with detractors favouring reductive science-based risk assessment methodologies. This view often ignores uncertainties, ambiguities and ignorance – gaps in datasets that present considerable challenges for traditional risk assessment. However, when understood to be a process of appraisal, rather than a rigid decision making rule, precaution can provide a sophisticated framework for guiding decision-making[3].

1. "*In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.*"

2. "*When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically.*"

3. Stirling, A. (2008) *Science, Precaution, and the Politics of Technological Risk*. Ann. N.Y. Acad. Sci. 1128: 95–110 (2008). New York Academy of Sciences.

2.2 The structure of the Precautionary Principle

Given the variety of interpretations, it is perhaps more productive to analyse whether there is a consistent structure underlying most precautionary constructs. One simple interpretation is the 'precautionary tripod' with each leg corresponding to: (1) a threat of harm; (2) uncertainty; and (3) action[4]. The first leg represents the vulnerability of a population or the environment, and the second the scientific uncertainty relating to complex or unpredictable systems or the difficulties associated with gathering applicable data. The balance between the first two elements provides a means of calculating or justifying the third – action.

Therefore in order to determine the acceptability of DU weapons and decide on an appropriate response, this report will seek to explore the three dimensions of this precautionary equation.

2.3 Examples of precaution in practice

Before proceeding on to the detail, it is perhaps necessary to examine other applications of precautionary approaches as a means of determining whether it is an appropriate response to the problems associated with the use of DU munitions. The principle appears in legal instruments covering everything from climate change to biosafety and hazardous waste dumping, but the following three examples are particularly relevant to the DU debate.

European Union environmental law

A growing bloc of EU states including Germany, Italy, Finland, the Netherlands, Austria, Ireland, Belgium and Greece have supported recent UN General Assembly resolutions on DU. This echoes the longstanding concerns of the European Parliament[5] on the issue and, it could be argued, is in line with European environmental norms, which are informed by the Precautionary Principle.

France and the United Kingdom, which both possess DU munitions, have actively opposed UN resolutions on DU. Other EU Member States such as Spain, Portugal, Denmark and Sweden have historically abstained during voting. While the UK and France's positions are predictable, the reluctance of Denmark and Sweden is surprising given that both were early adopters of precautionary environmental protection, for example Sweden's 1969 Environmental Protection Act or *Miljöskydds-Lag*[6].

Although it had appeared in the text of the 1992 Maastricht Treaty, the European Union formally enshrined the

4. Trouwborst, A. (2007) *The Precautionary Principle in General International Law: Combating the Babylonian Confusion*. Review of European Community & International Environmental Law Volume 16, Issue 2, pages 185–195.

5. European Parliament resolutions on depleted uranium weapons are available via: http://www.bandepleteduranium.org/en/european-parliament

6. Miljöskyddslag (1969:387) http://www.notisum.se/rnp/sls/lag/19690387.htm

Precautionary Principle into its approach to environmental law and health protection in February 2000, confirming that:

> *...it is particularly relevant to the management of the risk. It covers cases where scientific evidence is insufficient, inconclusive or uncertain and preliminary scientific evaluation indicates that that there are reasonable grounds for concern that the potentially dangerous effects on the environment, human, animal or plant health may be inconsistent with the high level of protection chosen by the EU.*[7]

The Commission's communiqué on the principle was subsequently interpreted by different member states, for example by the UK government's Health and Safety Executive[8]:

> ...use should be made of the precautionary principle where the possibility of harmful effects on health or the environment has been identified and preliminary scientific evaluation proves inconclusive for assessing the level of risk.
>
> The scientific assessment of the risk must proceed logically in an effort to achieve hazard identification, hazard characterisation, appraisal of exposure and risk characterisation.
>
> Risk management measures must be taken by the public authorities responsible on the basis of a political appraisal of the desired level of protection.
>
> All stages must be conducted in a transparent manner, civil society must be involved and special attention must be paid to consulting all interested parties as early as possible.
>
> Measures must observe the principle of proportionality, taking account of short-term and long-term risks; must not be applied in a way resulting in arbitrary or unwarranted discrimination; and should be consistent with measures already adopted in similar circumstances or following similar approaches.
>
> Measures adopted presuppose examination of the benefits and costs of action and inaction, and the examination must take account of social and environmental costs and of the public acceptability of the different options possible.
>
> Decisions taken in accordance with the precautionary principle should be reviewed in the light of developments in scientific knowledge.

Elements of this approach will be present throughout this report, in particular risk identification and assessment, transparency, cost benefit calculations, public acceptability and civil society engagement. Crucially:

> *...decision-making should bring together all relevant social, political, economic, and ethical factors in selecting an appropriate risk management option*[9]*.*

A decade on from the Commission's communiqué, it is clear that the Precautionary Principle and precautionary thinking have become firmly enshrined within both European, and member state approaches, to health and environmental protection.

Precaution in International Humanitarian Law (IHL)

In statements from DU users on the legality or acceptability of the weapons, IHL is often rendered down to a crude equation. They argue that if the perceived or claimed effectiveness of the weapons is greater than the documented humanitarian or environmental harm stemming from their use, they are legal. This suits militaries, particularly as weapons or activities are presumed to be acceptable until proven otherwise, with the burden of proof historically being borne by civil society. In the case of DU, this has thrown up a huge number of data collection challenges relating to civilian harm. These will be discussed in a later section.

Nevertheless, precautionary thinking is well rooted in IHL and military manuals, most notably in imposing obligations of care in the planning of attacks, for example in ensuring distinction between military and civilian objects:

> *Rule 15. In the conduct of military operations, constant care must be taken to spare the civilian population, civilians and civilian objects. All feasible precautions must be taken to avoid, and in any event to minimise, incidental loss of civilian life, injury to civilians and damage to civilian objects*[10]*.*

Similarly, precaution is also required in the protection of civilians from the effects of attacks:

> *Rule 22. The parties to the conflict must take all feasible precautions to protect the civilian population and civilian objects under their control against the effects of attacks*[11]*.*

Clearly, establishing whether any action is legal or otherwise under IHL requires that an assessment of its likelihood of breaching IHL be undertaken. Thus these obligations may be interpreted as being precautionary in nature, in so far as military commanders are required to examine the impact and legality of their actions in advance. In places, this due diligence

7. Communication from the Commission on the Precautionary Principle /* COM/2000/0001 final */ http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:52000DC0001:EN:NOT

8. United Kingdom Interdepartmental Liaison Group on Risk Assessment (UK-ILGRA) The Precautionary Principle: Policy and Application http://www.hse.gov.uk/aboutus/meetings/committees/ilgra/pppa.htm#ref8

9. United Kingdom Interdepartmental Liaison Group on Risk Assessment (UK-ILGRA) The Precautionary Principle: Policy and Application. Available from http://www.hse.gov.uk/aboutus/meetings/committees/ilgra/pppa.htm#ref1

10. Henckaerts J and Doswald-Beck L. Customary International Humanitarian Law Volume I: Rules

11. *Ibid.*

or duty of care is clearer, most notably in:

Rule 44. Methods and means of warfare must be employed with due regard to the protection and preservation of the natural environment. In the conduct of military operations, all feasible precautions must be taken to avoid, and in any event to minimize, incidental damage to the environment. Lack of scientific certainty as to the effects on the environment of certain military operations does not absolve a party to the conflict from taking such precautions[12].

Rule 44 also introduces the question of scientific uncertainty, which is a persistent issue where there is a risk of environmental damage and stems from the complexity and unpredictability of natural systems.

Clearly IHL is based on the precautionary obligation on states to modify their behaviour in order to spare civilians and civilian objects from the worst effects of conflict. While none of the familiar interpretations of the Precautionary Principle currently feature in IHL, these few examples illustrate that there is much shared ground.

The Convention on Cluster Munitions

The Convention on Cluster Munitions[13] (CCM) was adopted in 2008 and entered into force in 2010. As a treaty ban on uranium weapons has been advanced as an appropriate solution for dealing with the problems stemming from their use, it is perhaps helpful to consider whether precautionary framing featured in the negotiations leading up to the passage of the CCM.

Although not immediately evident, several key strands of precautionary thinking could be found in the CCM debate, both during and after its adoption. At its most simplistic, the convention sought to avoid the humanitarian impact of the use of the millions of submunitions stockpiled worldwide. But subsequent analysis[14] demonstrated that precautionary components such as the burden of proof, uncertainties, ambiguities and ignorance were present throughout negotiations. Indeed they proved to be the focus of negotiations after research by Landmine Action[15] and others was employed to highlight the inadequacy of cluster munition users' datasets, and data collection, on the civilian harm stemming from the weapons' use. In doing so, campaigners effectively reversed the burden of proof, thus ensuring that munitions could only be excluded from the treaty's scope if they were proven not to cause unacceptable civilian harm.

The requirement for the party undertaking an activity or releasing a substance to prove that it will not cause harm is fundamental to many formulations of the Precautionary Principle. In the case of DU, this reversal of the burden of proof would require that militaries undertake studies not just into exposure and ill health in their own personnel, but also to gather data on civilian harm, something that has yet to take place.

Throughout the debate over the acceptability of cluster munitions, proponents of cluster munitions sought to utilise uncertainty to support their cause, while doing little to resolve it. This strategy has also been applied to the debate over civilian harm from DU munitions[16].

2.4 Should a precautionary approach be applied to DU?

The examples above demonstrate that, while no single interpretation of the Precautionary Principle has gained worldwide legal acceptance, precautionary thinking and approaches are widespread in relevant and related fields of law and regulation. Importantly, the sheer variety of precautionary frameworks currently in use suggest that precautionary thinking offers flexibility and, contrary to those who have sought to criticise it as anti-science, anti-progress or idealistic, a high degree of sophistication.

ICBUW believes that sufficient evidence is now available to pass the *threshold of plausibility*[17], i.e. even though uncertainties may remain, enough is known about the nature of the potential risks to civilians and the costs of inaction, to support the adoption of a precautionary approach.

ICBUW is not alone in advocating for an approach based on precaution. The UK Royal Society[18] suggested a range of precautionary measures in response to scientific uncertainties following its detailed review of the potential health effects of DU use. Similarly, the UN Environment Programme (UNEP) specifically called for a precautionary approach with hazard awareness programmes and decontamination following its fieldwork on DU strike sites in the Balkans[19], renewing this call in 2010 in a report to the UN Secretary General[20].

The World Health Organisation (WHO)[21] has also issued a range of precautionary guidelines for reducing the risks from DU use. At issue is whether these guidelines and suggestions

12. *Ibid.*

13. Convention on Cluster Munitions. Available: http://www.clusterconvention.org

14. Rappert, B and Moyes, R. (2010) *Enhancing the protection of civilians from armed conflict: precautionary lessons* Medicine, Conflict & Survival Vol. 26 No. 1, January-March: 24-47.

15. Rappert, B. (2005) *Out of Balance: The UK government's efforts to understand cluster munitions and international humanitarian law*. Landmine Action.

16. Kellay, A. (2012) *Managing Acceptability: UK policy on depleted uranium weapons*. CADU.

17. van den Belt, H. (2003) *Debating the Precautionary Principle: "Guilty until Proven Innocent" or "Innocent until Proven Guilty"?* Plant Physiol. 132 (3): 1122–6.

18. Royal Society statement on use of depleted uranium munitions in Iraq. http://royalsociety.org/News.aspx?id=1156&terms=depleted+uranium&fragment=&Searchtype=&terms=depleted%20uranium [Retrieved Sep 2012]

19. A summary of country and site specific UNEP recommendations for the Balkans is available in the appendix of *A Question of Responsibility: the legacy of depleted uranium use in the Balkans* (ICBUW). Available via: http://www.bandepleteduranium.org/en/docs/134.pdf

20. Report of the UN Secretary-General, Addendum A/65/129/Add.1. *Effects of the use of armaments and ammunitions containing depleted uranium*. September 2010.

21. World Health Organisation. (2001, updated 2003). *Depleted uranium, Sources, Exposure and Health Effects*.

have been applied following conflicts where DU has been used, and whether they are likely to be applied in future conflicts. If the answer is no, then from the outset this poses a major challenge to the acceptability of the weapons.

For the purpose of this report, the precautionary analysis will firstly consider the *threat*: the properties of DU as a material, how its hazards are perceived and the factors relating to its use and post conflict management that influence the risk that it poses to civilians. Secondly, the *uncertainties*: the limitations of existing risk assessments and knowledge gaps in DU's interactions with human health; and thirdly, *action*: its public acceptability, the costs and benefits involved and whether a precautionary approach is justified. In doing so it will be informed by the guidance offered to states in the European Commission's 2001 communiqué on the Precautionary Principle.

3.0 Is DU a hazard?

> *On the basis of reports by the Royal Society and others, the MoD does not consider DU is 'safe'. It is hazardous (making the accepted health and safety distinction between a hazard and a risk)*[1].

Historically, the supporters of DU use sought to argue that DU was safe, i.e. non hazardous and, in an effort to downplay its potential risks and deflect public concern over the use of radioactive materials in conventional munitions, even considered rebranding DU, suggesting that *Durametal, Staballoy or Penetroy* would prove less contentious names[2]. Similarly, UK parliamentary statements on DU's risks during the 1990s variously described them as: *not significant, infinitesimal, minimal, small, low, low-level, negligible and not immediate*[3]. Ongoing research into DU has made this position increasingly untenable and in recent years a new discourse based on risk management terminology has emerged.

That DU is a chemically toxic and radioactive heavy metal is not disputed. Uranium has been studied for more than a century and its chemical toxicity is often likened to that of lead. Acceptable exposure levels for lead compounds have been on a downward trend for many years in response to increased experimental evidence that exposure is linked to a range of health problems, with young children shown to be particularly at risk.

Many militaries view DU's heavy metal chemical toxicity as a more significant hazard than its radioactivity. Similarly the WHO and national regulatory authorities recognise the toxicity of uranium and guidance levels are in place to protect those exposed to high levels of naturally occurring uranium in drinking water. The body's uptake of uranium through the digestive system is comparatively low, so these standards are difficult to equate to the risks from inhaled uranium oxides.

Concern over the health effects of DU exposure has triggered a considerable quantity of research into the health implications of both its chemical toxicity and radioactivity. One of the leading researchers is Dr Alexandra Miller, whose findings from studies undertaken at the US Armed Forces Radiobiology Research Institute (AFRRI) over the last decade

1. D/S of S/LF MC00767/2011 correspondence between UK Secretary of State for Defence Rt Hon Liam Fox and Bill Wilson MSP. February 2011. Whereby hazard relates to the nature of a material or activity and risk the likelihood of that material or activity having a negative effect.

2. Kellay, A. (2012) *Managing Acceptability: UK policy on depleted uranium weapons*. CADU.

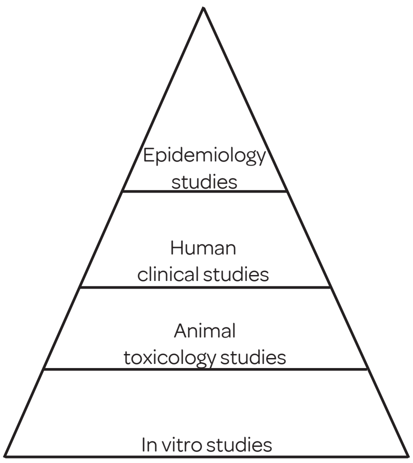
3. *Ibid.*

Internalised chronic DU exposure in vivo	Conclusions from in vitro studies
Causes uranium re-distribution to multiple organs.	DU induces neoplastic transformation, mutagenicity, and genotoxicity in vitro.
Is associated with mutagenicity	DU is involved in uranium-induced genomic instability.
Induces chromosomal damage.	Alpha particles similar in energy and distribution to those resulting from cellular uranium exposure to DU are sufficient to transform cells.
Preconceptional paternal exposure to DU induces genomic damage in unexposed offspring.	Radiation bystander effects are involved in uranium-induced neoplastic transformation and genomic instability.
Induces germ cell DNA damage	

Table summarised from *in vivo* and *in vitro* research outcomes by Miller, A.

are summarised above[4,5].

Research by Miller and others in the field is shedding light on the potential mechanisms through which DU may damage human health. The studies generally employ tissue cultures or animals and represent the bottom two tiers of a toxicological assessment pyramid (below) typically used to determine the quality of data and number of studies needed to confirm the health risks from chemicals, be they new medicines, cosmetics or environmental contaminants.



The next tier would be clinical studies on human subjects but this would clearly be unethical as DU is a potential carcinogen. An alternative source of human clinical studies is provided by troops exposed to DU during friendly fire incidents. The US Department of Veterans Affairs has an ongoing programme in place but their studies have been criticised by a Congressional committee[6] for their sample sizes being too small, and reporting too haphazard, to provide any statistically meaningful findings about the disease outcomes of interest – namely cancer. The sample sizes also make it impossible to extrapolate results to the other thousands of veterans who may have been exposed to DU weapons during their service. Members of the committee were also said to be 'puzzled' by the study director's non-disclosure of benign and malignant tumours in the participants.

The gold standard would be epidemiological studies on large cohorts of exposed civilian populations living, working and playing in contaminated areas but, as we shall see, designing and undertaking such studies in post-conflict environments is incredibly challenging (see 5.4). This supports the argument that a greater emphasis be placed on *in vitro* and *in vivo* (non-human) studies, and indeed they are widely recognised as playing a crucial role in identifying the mechanisms at play that may subsequently lead to pathologies.

As indicated above, DU has been shown to be genotoxic – it can damage DNA; mutagenic – it can trigger genetic mutations that may subsequently lead to negative health outcomes; can lead to neoplastic transformation - turn healthy tissue into cancerous tissue; mediate a range of damaging microscale radiation effects and produce genetic effects that can be passed on to the subsequent generation.

Is DU carcinogenic? The WHO's specialist agency for cancer research the International Agency for Research in Cancer (IARC), classifies substances as human carcinogens based on human epidemiology, animal experimentation data and mechanisms of carcinogenesis. These are divided into Group I (proven), Group IIa (probable) and Group IIb (possible) on the basis of the available research. In 2009, IARC classified all alpha and beta radiation emitting radionuclides, such as radon gas or DU particles, as Group I carcinogens when they get inside the body[7].

However on the basis of the available research – particularly the lack of human epidemiology into exposure to military-origin DU – as a material, DU would be likely to come under Group IIa - a probable human carcinogen - under IARC's classification system. This latter classification reflects gaps in research, rather

4. Miller, A. A Review of Depleted Uranium Biological Effects: In Vivo Studies: www.usuhs.mil/afrri/outreach/pdf/50thMiller_in-vivo.pdf [retrieved September 2012]

5. Miller, A. A Review of Depleted Uranium Biological Effects: In Vitro Studies: http://dodreports.com/pdf/ada539809.pdf [retrieved September 2012]

6. *'Reports on this cohort are often cited to indicate that there are no likely long-term effects of DU exposure, yet the limited types of information provided and the small number of veterans evaluated leave important questions unanswered. …the small size of the cohort and lack of an unexposed comparison group mean the project cannot determine whether DU exposure is associated with common or uncommon diagnosed conditions of concern such as cancer.'* The Research Advisory Committee on Gulf War Veterans' Illnesses, (2008). Gulf War Illness and the Health of Gulf War Veterans.

7. El Ghissassi et al, on behalf of the WHO International Agency for Research on Cancer Monograph Working Group. *A review of human carcinogens—Part D: radiation*. The Lancet Oncology - 1 August 2009 (Vol. 10, Issue 8, Pages 751-752)

than a clear statement about its carcinogenicity. Nevertheless, as an alpha-radiation emitter, when internalised DU would come under the Group I classification.

This section will introduce DU's properties and examine how its hazards are perceived by regulators and the military. The following chapter will discuss those ongoing uncertainties in assessing the health impact of uranium toxicity and in calculating its radiation risks.

3.1 Applications

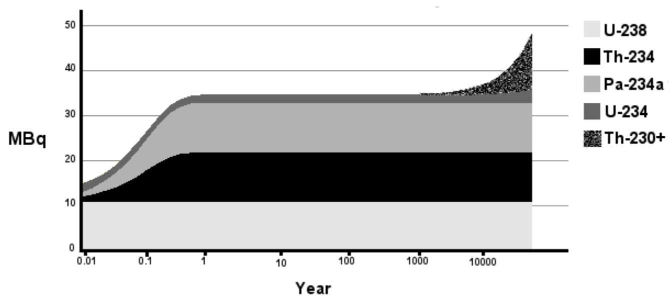
The primary military application for DU is for a range of armour-piercing rounds[8], with calibres ranging from 20-125mm, for use by aircraft, armoured fighting vehicles, naval defence systems and tanks[9]. The main motivation behind its development was DU's high density of 19g/cc (in comparison, iron is 7g/cc and lead 11g/cc). Other factors included its deformation characteristics, material costs and availability. DU munitions belong to a class of weapons called kinetic energy penetrators, which utilise speed and mass to pierce armour, rather than chemical explosives. Simply put, they are dense, solid darts fired at high velocity into their targets.

The situation is complicated by uranium's physical reactivity[10], which ensures that the high temperatures resulting from hard target impacts ignites the DU, leading to the generation of fine particles. The size distribution, shape and chemical composition of these particles is highly variable and, as we shall see later, accurate data on all of these qualities is crucial to quantifying the risk they pose if inhaled.

The uranium oxide particles formed during these combustion processes have been found to be highly stable[11], and thus represent a long-term contaminant, particularly where they may be re-suspended through human or natural activity. Larger fragments or intact penetrators deposited in or on soils may slowly break down, leading to soil and groundwater contamination. The rate at which this break down occurs is a function of soil type, moisture content and climate, with rates slower in soils with low oxygen levels or soils in arid areas[12].

3.2 Depleted uranium

Following uranium enrichment for nuclear weapons or nuclear fuel fabrication, the waste DU is typically comprised of the three naturally occurring uranium isotopes - U234, U235 and U238. Of these, U238 makes up around 98% of DU. At this stage the 'fresh' DU is around 60% as radioactive as naturally occurring uranium. However, within three months, the decay of the isotopes U238 and U235 into other radioactive elements – protactinium and thorium, increases the level of radioactivity back up to around 75% of that of natural uranium. Various authors have noted this discrepancy, suggesting that the term depleted is a misnomer and that the term 'slightly less radioactive uranium' might be more accurate[13]. In examining radiation hazards from DU, many agencies only consider the isotopes of uranium, and not these decay products[14]. Crucially, DU metal is a far more concentrated form of uranium than exists in nature, thus rendering direct hazard comparisons to the uranium that naturally occurs in soils and water difficult



Graph showing the rapid increase in DU's specific activity after enrichment due to ingrowth of decay products. (WISE)

Fresh DU is predominantly an alpha radiation emitter. Alpha particles are highly energetic and damaging but only travel over short distances. They can be stopped by the skin so are primarily of concern only when they get inside the human body – hence the IARC classification as human carcinogens above. The older DU present in munitions, which contains higher levels of decay products, emits increasing quantities of beta radiation, which after a short period may comprise as much as 40% of the absorbed dose to tissues around DU particles[15].

Lax controls on the processing of uranium in the US resulted in the mixing of reprocessed uranium from spent nuclear fuel with DU from uranium enrichment. This resulted in the contamination of DU with manmade radioactive isotopes such as plutonium and U236. A US assessment of DU tank armour found this to be at relatively low levels[16] but thus far these have

8. Speculation has surrounded the alleged use of DU in other types of weapons, largely due to the existence of patents describing potential applications. This has included bunker busting bombs and munitions utilising shaped charges and explosively formed penetrators. The majority of these claims have not yet been substantiated by hard evidence, although the Soviet Union developed an air to air missile that employed DU and also an anti-tank round with a shaped charge utilising a DU liner.

9. For a non-exhaustive list of platforms that can utilise DU munitions visit: ICBUW http://www.bandepleteduranium.org/en/weapons-and-platforms

10. Uranium is pyrophoric. A pyrophoric substance is a substance that will ignite spontaneously in air.

11. Parrish, R (2010) *Impacts of Depleted Uranium to the natural environment: A report commissioned by the Natural Environmental Research Council for the UK Ministry of Defence*.

12. *Ibid*.

13. Fairlie, I. (2008) *The health hazards of depleted uranium*. Disarmament Forum. UNIDIR.

14. See: IAEA (2003). *Radiological conditions in areas of Kuwait with residues of depleted uranium*. Report by an international group of experts and European Commission Scientific Committee on Health and Environmental Risks (2010): *the environmental and health risks posed by depleted uranium.*

15. Royal Society statement on use of depleted uranium munitions in Iraq. http://royalsociety.org/News.aspx?id=1156&terms=depleted+uranium&fragment=&Searchtype=&terms=depleted%20uranium [Retrieved Sep 2012]

16. The Royal Society (2001). *The Health Hazards of Depleted Uranium in Munitions: Part I*

not been comprehensive enough to discount higher levels of contaminants in munitions. The UK, which sourced its DU from the US, is yet to fully assess the extent of contamination in its DU ammunition, in spite of recommendations to do so dating back to the mid 1990s[17].

Clearly then, DU is not an inert substance. It is recognised as being chemically toxic and radioactive although in a solid form, and outside the body, presents a relatively low risk. Nevertheless, with a specific activity of 35MBq/kg[18] for DU older than three months, it is classified as Intermediate Level Waste[19] and subject to strict regulatory control in peacetime.

3.3 Regulating radioactive emissions and hazards

The [UK] Government considers that the unnecessary introduction of radioactivity into the environment is undesirable, even at levels where the doses to both human and non-human species are low and, on the basis of current knowledge, are unlikely to cause harm[20].

Frameworks establishing regulatory controls on the release and management of radioactive hazards exist on a range of levels. National standards are typically based on standardisation with specialist agencies or non-governmental bodies such as the International Atomic Energy Agency (IAEA) and the International Commission on Radiation Protection (ICRP). While the legitimacy of the specific safe exposure standards promoted by these agencies has been the focus of much debate, most regulatory frameworks governing radiation protection are based on shared principles and values which, in acknowledging the hazards that radiation poses, aim to promote its responsible use, for example:

The prime responsibility for safety must rest with the person or organization responsible for facilities and activities that give rise to radiation risks.

An effective legal and governmental framework for safety, including an independent regulatory body, must be established and sustained.

Facilities and activities that give rise to radiation risks must yield an overall benefit[21].

The system also employs allowances and exclusions which allow for a more flexible approach to exposure standards for key workers and the population at large in the event of a serious nuclear incident. As was the case with the recent Fukushima crisis, these are based more on pragmatism than science. Nevertheless, some DU users have sought to equate the use of DU with this more relaxed approach to statutory dose limits:

Although statutory radiation dose limits form a useful benchmark for comparison with hazard assessment results, it must be remembered that these dose limits have been designed to apply to peacetime situations.

What is not generally realised is that both national and international agencies with responsibility for setting radiation protection standards recognise that statutory dose limits are not a suitable reference quantity to apply in the aftermath of an exceptional event.

Although a major nuclear accident is usually cited as an example, it seems evident that armed conflicts involving the use of DU munitions also fall within this definition. In these cases, the procedure adopted is for each situation to be assessed on an individual basis and for the risks of radiation exposure to be weighed against the advantages and problems that might result from the introduction of any dose reduction measures.

The implication is that judgements on the peacetime use of DU munitions can be made by reference to statutory dose limits, but judgements on combat use should be made by reference to the criteria that would be applied after releases of radioactive material[22].

This seems hard to justify in circumstances where a deliberate policy has resulted in the creation of an *exceptional incident*, as opposed to merely reacting pragmatically to an unexpected or unplanned scenario.

As noted above, radiation risk assessments use dose limits from standards that were devised for civilian nuclear programmes[23] and medical applications of radiation. Exceptional events aside, it could reasonably be argued that even these standards are not applicable to civilian DU exposures during or after conflict because they depend upon institutions and safeguards that are unlikely to be available, or sufficiently robust, during and after conflict.

Furthermore, the standards are also conditional upon a society deciding that the risks from exposure to a radiation source are outweighed by the potential benefits, particularly as the prevailing consensus is that any exposure carries it with it some risk[24]. Civilians living with DU contamination might

17. WS Atkins Environment, 1995. *Environmental statement of the firing of depleted uranium projectiles at Eskmeals and Kirkcudbright ranges, Non-technical summary.* E5322/51/CO/WSA/043/1995/JAN

18. The becquerel is a unit of measurement of radioactivity. It equals one disintegration per second. A MBq is a million becquerels.

19. National classifications for radioactive waste vary, under the UK classification, DU is classed as Intermediate Level Waste.

20. UK strategy for radioactive waste discharges (2009). http://www.decc.gov.uk/Media/viewfile.ashx?FilePath=What%20we%20do\UK%20energy%20supply\Energy%20mix\Nuclear\radioactivity\1_20090722135916_e_@@_dischargesstrategy.pdf&filetype=4&minwidth=true [Retrieved September 2012]

21. Fundamental Safety Principles IAEA Safety Standards Series No. SF-1: http://www-pub.iaea.org/mtcd/publications/PubDetails.asp?pubId=7592 [Retrieved September 2012]

22. Brown, R, DERA Radiation Protection Services. Notes of a presentation to the UK Royal Society Depleted Uranium Working Group on 19 January 2000.

23. International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources. (BSS)

24. Radiological contamination entails excess risk at any level. This is the considered opinion of most experts in the field. Specialists believe that any radiation dose, however small, brings with it an increased risk of cancer. The risk of cancer increases

well struggle to recognise the benefits from its use.

Where, then, do the hazards stemming from the uncontrolled release of DU during conflict fit in with this approach to radiological protection? Radiological protection is broadly precautionary in nature, it clearly assigns responsibilities to polluters and it accepts that all exposures carry with them a degree of risk. In exchange, it demands that societal and individual benefits accrue from any radiation exposure.

So, by almost any measure, international radiation protection norms are at odds with the military use of DU munitions, especially where civilians face exposure and any resulting health impact.

3.4 Troop protection: DU hazard perception by the military

Following the 1991 Gulf War, US and UK military planners were strongly criticised for failing to warn troops about the potential risks from DU exposure. Two decades later, DU's hazards are widely recognised and precautionary safeguards have been developed both by the states that employ the weapons, and by those who face exposure during joint operations.

Dutch NGO IKV Pax Christi has recently reviewed both the characterisation of DU's hazards by different militaries and the risk reduction measures they advocate in order to protect personnel[25]. Overall, states that use the weapons tend to focus on the chemical hazards from DU, whereas non-users, whose own troops might be exposed, also highlight the radiological risk their use poses. The guidelines below were present in most of the recommendations issued by militaries:

Do not touch DU ammunition or contaminated vehicles. Cover exposed skin. Use a dust or NBC mask to protect the respiratory system when in a contaminated area.

Do not eat, drink or smoke during activities in contaminated areas. Stay upwind from burning vehicles that are hit with DU munitions.

Stay 50 metres away from contaminated vehicles (only if this does not jeopardise the mission). Wash hands thoroughly after the operation. Dust off shoes and uniform, and wash it after the operation.

Limit your stay in contaminated areas as much as possible.

In addition, the following procedures feature in most of the manuals:

Create a perimeter of 20 metres around the contaminated object. Alert NBC teams and report to the commander.

Measure radiation levels with RADIAC meters, Thermo Luminescent Dosimeters (TLDs) or other equipment.

If exposed, troops must take a range of bio samples such as nose fluid, blood and urine that should be tested for DU exposure.

In response to public concern over the use of the weapons, several states implemented urine testing programmes for personnel returning from operations. The precision of the methods used has varied considerably but overall, exposures in troops have been found to be low. However, it is important to note that hazard awareness is now high among personnel and the amount of time spent in contaminated areas is low as a result. This makes direct comparisons with the likelihood of civilian exposure – which some states have sought to make - difficult.

The problematic and hazardous nature of DU contamination is also reflected in the regulation of military firing ranges in peacetime. For example the UK does not use DU in training on its ranges – developmental and reliability testing involves sealed catch boxes and live firing into the sea at specific sites, while state and federal regulatory agencies in the US, including the Nuclear Regulatory Commission (NRC), have placed limitations on live firing on environmental and public health grounds.

Militaries clearly recognise that DU is a hazardous material that requires specific safety guidelines in order to avoid exposures.

3.5 Conclusion

DU's chemical toxicity and radioactivity, when combined with its propensity to combust and form particles of a respirable size, result in it being a recognised hazard. DU has been intensively studied and a wealth of new research, much of it carried out by the US military, indicates that DU have an impact on health through a variety of different chemical and radiation-induced mechanisms. Much of this research post-dates the oft cited WHO Monograph on DU's risks and the UK Royal Society's study.

As Intermediate Level Waste, its storage, use, disposal and transportation are tightly regulated in peacetime. Civil radiation protection norms seek to avoid unnecessary exposures wherever possible, and any exposure must be justified on the basis of its wider benefits.

Militaries have adopted a precautionary approach to DU, avoiding unnecessary exposures through hazard awareness training and providing health monitoring as required. When forced to operate within peacetime health and environmental regulations, DU users face considerable challenges.

It appears, therefore, that DU's intrinsically hazardous nature is well accepted and that its uncontrolled or accidental dispersal into the environment is broadly viewed as undesirable as a result.

proportionately with increasing dose. This relationship is known as the Linear No Threshold (LNT) model, meaning that the relationship between dose and risk is linear, and that there is no threshold below which this relationship does not hold.

25. Zwijnenburg, W. (2012) *Hazard Aware: Lessons learned from military field manuals on depleted uranium: how to move forward for civilian protection norms.* IKV Pax Christi.

4.0 Uncontrolled and unpredictable: factors influencing the risks to civilians from DU use.

Circumstances vary so enormously in war, and are so indefinable, that a vast array of factors has to be appreciated—mostly in the light of probabilities alone[1].

In developing a narrative on DU, advocates for its use have tended to focus on the risks to military personnel, to the exclusion of civilians. Military exposure scenarios have been proposed and modelled[2], but these may be far removed from the long-term chronic exposures faced by civilians living, working or playing in contaminated areas.

Field assessments undertaken by international agencies often take place many years after the conflict so may not accurately represent the level of exposure civilians face during or immediately after hostilities.

Representations on the use and purpose of DU munitions tend to be overly simplistic in arguing that they are only used against armoured vehicles, while the reality may be very different, particularly where fighting occurs in populated areas. What is often missing is the acceptance that warfare is inherently unpredictable, thus posing a considerable challenge to risk calculations.

4.1 Characteristics of use

This munition is designed for use against tanks, armoured personnel carriers or other hard [armoured] targets...should not be used in situations where risks are necessarily created that the fires caused by their use will spread to protected civilian objects or injure civilians… in combat situations involving the widespread use of DU munitions, the potential for inhalation, ingestion or implantation may be locally significant. These risks, of course, are potentially dangerous to friendly civilian populations as well as enemy populations. **United States Air Force memorandum on the legality of PGU-14B DU ammunition for the A10 gunship (1976)**.

Opposite page: an A10 strafing the Ministry of Planning, Baghdad, 2003.

As discussed previously, DU munitions are fired by aircraft, armoured fighting vehicles and tanks. Understandably the contamination footprint from each different platform is different and dependent on the circumstances of use; so in considering the specific risks that individual sites pose to civilians, a range of factors must be taken into account. Beyond the platform that fired the DU, these include, but are not limited to, the firing angle and dispersal of the rounds, the nature of the target, whether the impacting surface was hard or soft, the location and accessibility of the target and the quantity of DU fired.

The many possible configurations of contamination from DU's use in conflict pose challenges to general statements on the likelihood of whether it will prove problematic or not. This inherent variability of strikes strongly supports an approach that deals with the risks from sites on a case by case basis. Naturally some will be of lower risk, but those where large quantities of rounds have been fired, particularly into or around civilian infrastructure or in populated areas - as has repeatedly been the case - may leave civilians at risk.

DU rounds are often promoted as precision weapons capable of distinguishing between military and civilian objects, however:

…US Army information suggests that in a typical A-10 strafing run, 90% of the rounds will not hit their target. Instead they will be spread across an area of 500m^2 [3]

The A10 gunship is seen as particularly problematic due to the pilot's inability to select between different types of ammunition once airborne. In the Bradley Armoured Fighting Vehicle or Main Battle Tanks, the gunner is able to select whether DU or other types of ammunition are fired. The A10's standard combat mixture of DU rounds interspersed with high explosive incendiary ammunition is preloaded before takeoff, therefore DU will be used against all planned or opportunity targets where the cannon is used, whether they are armoured – and thus valid targets within the framework of its legal review - or not.

4.2 Transparency

The UK Ministry of Defence has reported that its troops fired approximately 1.9 metric tons of DU munitions during this conflict, and in June 2003 it provided UNEP with the coordinates of DU firing points of the UK Challenger 2 tanks. Information concerning the overall quantity of DU munitions used and the corresponding coordinates of the firing points from the United States has, as yet, not been made available[4].

In any precautionary calculation, information about risk of harm should never be monopolised, whether by public or private knowledge-holders, and should by definition be common

1. Carl von Clausewitz, *On War*, ed. and trans. Michael Howard and Peter Paret. Princeton: Princeton University Press, 1976.

2. Discussion has focused on exposure scenarios: Level I – troops in a vehicle struck, or entering it soon after; Level II – troops or contractors who enter vehicles to perform EoD work, repairs, etc once aerosol has settled; Level III – all others.

3. Cullen, D. (2010). *A Question of Responsibility: the legacy of depleted uranium use in the Balkans*. ICBUW.

4. Burger, M. (2008) *The risks of depleted uranium contamination post-conflict: UNEP assessments*. UNIDIR.

property[5]. Evidently this is a lesson that the US in particular seems reluctant to accept. States argue that releasing data on contamination from weapons implies responsibility for remedying the problems that they may cause. This has proved to be a recurrent issue with cluster munitions, land mines and also DU. The US and UK claim that no geographical records were kept of DU use in the 1991 Gulf War – only quantitative data. This may come as a surprise to those who think that this data would be crucial to reconstructing battles and skirmishes for training purposes.

After the use of DU in the Balkans, it took six years for Bosnian civilians to be informed that DU had been used[6]; whereas while the Serbian authorities were rapidly able to identify that DU had been used, it took two interventions from the then UN Secretary General for NATO to release firing coordinates. The UK MoD later noted that these coordinates were typically accurate only to plus or minus one nautical mile[7].

As UNEP discovered when they were asked by the Iraqi government to assist them with developing their capacity to identify and manage DU contamination after the 2003 war, the US government was unwilling to release targeting data to UNEP and relevant agencies. This posed considerable problems for their programme of work. In 2010, a UN General Assembly resolution[8], which called for DU users to release quantitative and geographic data on DU use to affected governments when requested to do so by them, was supported by 148 states. It was opposed by just the UK, France, US and Israel. In explanation, the UK, US and France stated:

> *We have serious doubts on the relevance of such a request, according to IHL. We consider that it is up to each state to provide data at such a time and in such a manner as it deems appropriate[9].*

International agencies that have published research on DU – research often cited by DU users as supporting their positions - have consistently called for precautionary action to reduce the risks to civilians. These vary in strength but a prerequisite for any of the measures suggested is knowing where the weapons have been used and in what quantity. Detailed information is particularly important as DU is often difficult to identify in the field[10]. Transparency is therefore a critical factor in reducing the risk to civilians from the use of DU munitions but it has historically been in short supply.

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5. Peter H. Sand (2000): *The Precautionary Principle: A European Perspective*, Human and Ecological Risk Assessment: An International Journal, 6:3, 445-458

6. Cullen, D. (2010). *A Question of Responsibility: the legacy of depleted uranium use in the Balkans*. ICBUW.

7. *Ibid*.

8. United Nations General Assembly A/RES/65/55 *Effects of the use of armaments and ammunitions containing depleted uranium.*

9. 65th session of the United Nations General Assembly First Committee. Explanation of vote by on behalf of France, the United Kingdom and the United States L19 "*Effects of the use of armaments and ammunitions containing depleted uranium*". 27 October 2010.

10. Cullen, D. (2010). *A Question of Responsibility: the legacy of depleted uranium use in the Balkans*. ICBUW.

Bad practice: Warning signs written by American troops to keep Iraqis away from a series of burnt U.S. ammunition trucks contaminated by U.S. DU bullets May 3, 2003 in Baghdad, Iraq. Although some bulldozed topsoil points to a U.S. clean-up effort, piles of DU ash and even an exposed, three-foot-long DU penetrator still contaminate the site. Scott Peterson.

4.3 Capacity to manage contamination

The UN Mine Action Service (UNMAS) lists 45[11] NGOs, in addition to the militaries and private contractors, who deal with the legacy of explosive remnants of war (ERW), the vast majority of whom do not, as a rule, deal with DU. The specialist nature of DU decontamination and lack of funding mechanisms has ensured that affected states have often been left to deal with managing legacy remediation themselves. The removal of large DU fragments or intact penetrators may be done during standard ERW clearance work but dealing with contaminated wreckage, soils or infrastructure presents considerable challenges that requires specialised capacity.

A complicating factor, even for the removal of fragments, is that awareness of DU among the demining community tends to be low – largely by virtue of the fact that DU does not explode - and, while guidelines exist, these are dated, in places inaccurate and cover only the removal of identifiable fragments[12].

Clearance has therefore been either limited, or undertaken on an ad-hoc basis and it has often been almost entirely dependent on governmental capacity following conflict[13]. This has often proved problematic as states recovering from conflict may face a range of differing health and environmental priorities. Comprehensive clearance work is also costly[14] and may present secondary challenges, for example the indefinite storage of contaminated soils and scrap metal.

UNEP assisted the Iraqi government in examining the extent of contamination following the 2003 conflict and trained Iraqis to assess sites. Following completion of their capacity-building programme, UNEP recommended that the international community should continue to support the Iraqi Ministry of the Environment, that contaminated military equipment be identified and segregated from the population, that scrap yards should be assessed and that stricter health and safety regulations be introduced, that education and awareness raising programmes be scaled up and that DU scrap should be dealt with alongside wider efforts to decommission and store radioactive sources[15].

What is readily apparent is that DU requires specific post-conflict risk reduction measures but, historically, their implementation has been unsatisfactory from a civilian health

11. United Nations Mine Action Service http://www.mineaction.org/orgs.asp?org_type=4 [Retrieved September 2012]

12. GICHD. Technical Note 09.30 /02 Version 2.0 *Clearance of Depleted Uranium (DU) hazards.*

13. Cullen, D. (2010). *A Question of Responsibility: the legacy of depleted uranium use in the Balkans*. ICBUW.

14. *Ibid*.

15. UNEP (2007). *Capacity-building for the Assessment of Depleted Uranium in Iraq - Technical Report*.

Best practice: Slaviša Simić, formerly of Serbia's Ministry of Environment and Spatial Planning stands beside a site contaminated by US A10 gunships in 1999. Fearing that DU would used in the conflict, the Serbian military later moved quickly to identify sites and restrict access to them. This was done well before NATO were persuaded to hand over targeting coordinates. Naomi Toyoda.

perspective. A recurrent problem has been a lack of institutional capacity to identify, characterise and manage contamination effectively. There are exceptions, such as Kuwait – which had the financial resources and political will, and Serbia – which had institutions capable of managing the work. More subtle problems, like the lack of a long-term storage facility for contaminated materials (Bosnia, Iraq) or a lack of analytical equipment (Kosovo, Iraq) have again impacted on efforts to reduce the risk from contamination.

A lack of transparency has also often confounded efforts by national and international authorities to design and implement effective action plans. Meanwhile DU users have sought to shift responsibility for remediation onto affected states[16], in the knowledge that those states lack the expertise, technical capacity and finances to complete the work. This has serious implications for preventing avoidable civilian exposure.

4.4 Civilian hazard awareness

> *In zones where DU munitions have been used, UNEP recommends that a campaign is conducted to educate people, in particular children, about the importance of avoiding being in close contact with war-related equipment[17].*

Providing reliable information to civilians living, working and playing in contaminated areas is crucial to reducing the risk of exposure and international agencies have consistently highlighted a need for hazard awareness programmes.

Thus far, programmes have been undertaken on a largely ad-hoc basis. For example UNEP produced a leaflet aimed at deminers in the Balkans[18]. But without clear data on the locations and risks from specific sites, focused awareness work is difficult. In Iraq, the Ministry of the Environment promoted hazard awareness via TV adverts but discovered that the issue had become highly politicised[19]. The problem was compounded by the difficulties of communicating responsible risk information about radioactive substances:

> *As DU strikes are difficult to identify and dusts and radioactivity are, to all intents and purposes, invisible, uncertainty and doubt may lead to a prolonged state of fear among the population, even in cases where DU is removed. Furthermore, the limitations in risk modelling highlighted by recent risk assessments show that it is impossible for authorities to argue scientifically that there is no risk to health. The post-conflict management of sites therefore represents a difficult*

16. Kellay, A. (2012) *Managing Acceptability: UK policy on depleted uranium weapons*. CADU.

17. Burger, M. (2008) *The risks of depleted uranium contamination post-conflict: UNEP assessments*. UNIDIR.

18. UNEP (2003) Depleted Uranium Awareness Leaflet.

19. Author's communication with Iraq's former Environment Minister Mrs Nermin Othman.

balancing act, particularly when the issue of DU becomes politicised[20].

Thus DU poses considerable challenges to the promotion of responsible hazard awareness work; this reduces the likelihood of this important work being undertaken effectively, thereby increasing the risk of civilian exposure.

The problems encountered by the Serbian and Iraqi governments in responding to the fear that the use of DU munitions evokes suggests that the psychological impact of their use may be considerable and long-lasting. The IAEA and others have regularly highlighted the psychological burden borne by communities affected by nuclear accidents and anecdotal evidence from Bosnia[21], Serbia[22] and Iraq indicates that this may also be relevant to DU use.

Conclusion

Significant uncertainties develop when DU munitions are used. Some are avoidable, although unlikely to be resolved – the timely release of targeting data for example, or avoiding the use of DU in civilian areas – but most relate to the nature of the weapons themselves and their mode of use. This results in a significant variability in the likely risks from different DU strike sites. This runs counter to the generalisations often used to dismiss concerns over DU and underscores the importance of detailed data collection and risk analysis for individual sites.

Recent use of DU demonstrates that it has been used in populated areas, leaving civilians facing contamination from weapons designed for very different military scenarios. That international mechanisms are not in place to fund and undertake DU clearance work ensures that civilians face a greater risk of exposure. Fear of radiation, particularly where information gaps or mistrust exists, increases the likelihood of the politicisation of DU, which in turn reduces the likelihood that effective hazard awareness work will be completed. Even on the rare occasions where DU contamination is adequately managed, DU's psychological legacy will live on in affected communities.

The uncontrolled release of DU in conflict, not only breaches radiation protection norms but also presents a problem for risk modellers. The risk of civilian exposure to DU residues is increased markedly by factors that are, to a certain extent, constants in post-conflict environments. Institutional capacity, technical expertise, access to analytical equipment, limited finances and a range of competing health and environmental problems will all pose challenges for efforts to safely remediate DU contamination – and to the acceptability of DU use.

20. Zwijnenburg, W. (2012) *Hazard Aware: Lessons learned from military field manuals on depleted uranium: how to move forward for civilian protection norms*. IKV Pax Christi.

21. Cullen, D. (2010). *A Question of Responsibility: the legacy of depleted uranium use in the Balkans*. ICBUW.

22. Author's communication with Norwegian People's Aid.

5.0 Quantifying risk and responding to uncertainty

The simplistic discourse on DU's potential health effects as presented by the users of DU munitions is, for the most part, stripped of uncertainty. For example, in explaining why they had voted against 2010's UN resolution calling for greater transparency on targeting data, the US, UK and France argued that:

The environmental and long-term health effects of the use of depleted uranium munitions have been so far thoroughly investigated by the World Health Organization, the United Nations Environmental Program, the International Atomic Energy Agency, NATO, the Centres for Disease Control, the European Commission, and others.

None of these inquiries has documented long-term environmental or health effects attributable to use of these munitions. It is regrettable that the conclusions of these studies are thus ignored[1].

This is understandable but it promotes a skewed view of the state of scientific understanding. Setting aside for a moment the fact that none of the organisations cited above have undertaken long-term studies into DU's health effects, closer examination of the reports from international agencies reveals a more balanced view. A useful example are the WHO's caveats (below) concerning the state of research into the chemical toxicity of DU on the kidney. It is notable that the WHO's desk study has nevertheless been widely used by states to justify the continued use of DU.

The database on the toxicity of uranium is limited; most of the studies are old, meaning that not all present methods available to assess renal toxicity were available at the time of these studies. Information, especially on long-term effects of different uranium species, is based on studies from a limited number of researchers…

The different studies tend to give rather different results vis a vis the quantitative risk estimates. In many studies, dose-response and dose-effect relationships cannot be assessed because of limited dose levels studied.

In inhalation studies, the physical–chemical characteristics of the aerosols are often not well characterized, and are likely to be different for different uranium species. There appear to be differences in the sensitivity of different species to uranium toxicity, but no general picture seems to emerge[2].

1. 65th session of the United Nations General Assembly First Committee. Explanation of vote by on behalf of France, the United Kingdom and the United States L19 *"Effects of the use of armaments and ammunitions containing depleted uranium"*. 27 October 2010.

2. World Health Organisation. 2001, updated 2003. *Depleted uranium, Sources, Exposure and Health Effects.*

5.1 On toxicity and uncertainty

Assessments of the chemical toxicity of uranium have historically focused on its effect on the kidney (*renal toxicity*), after it was identified in early studies as a focus for uranium damage and in spite of the admission above from the WHO regarding the quality of the available data. Assessments by the WHO, UK Royal Society and more recently the European Commission's Scientific Committee on Health and Environmental Risks (SCHER) also focused on damage to the kidney as a main health outcome of uranium's toxicity-mediated effects. However a wealth of new research is documenting uranium's ability to interfere with a range of processes and functions at the cellular level, which may then lead to negative health outcomes[3]. Therefore, solely focusing on renal toxicity ignores a range of other possible health effects.

There is of course no reason to suppose that the levels deemed to be safe for the kidney do not have the potential to cause other adverse health outcomes. Other health effects that have been less well studied could potentially be triggered at lower levels or could result from chronic long-term exposure to DU at levels below those that would damage kidney function.

Some, including genotoxic effects, may have no threshold or 'safe' dose. Although there is insufficient evidence to determine whether this is in fact the case, developmental effects have been recorded at dose levels below those that can cause kidney damage, and one study reported changes to the reproductive system at doses of 0.00039 mg/kg/day – 0.65% of the lowest LOAEL[4] dose level cited in SCHER's Opinion[5,6].

Increasing pressure to assess the thousands of chemicals present in consumer goods by regulatory regimes such as REACH[7] has placed the science of toxicology under considerable strain. This has resulted in upheaval and a new focus on alternative means of assessment. Animal subjects have historically been used to assess the toxicity of substances, but extrapolating the findings of mouse studies to rats, rabbits, humans or between individuals, to reach an estimated safe dose threshold has often been rather crude. Aside from the animal welfare issues, as they focus only on identifiable health outcomes, such methods do little to increase our understanding of the biological mechanisms involved.

Conscious that the issues of species extrapolation, dose extrapolation and the evaluation of sensitive populations had become a liability for the science of toxicology, in 2007 the US National Research Council published a report[8] calling for a paradigm shift in toxicological analysis. The report envisioned that this would employ molecular biology, bioinformatics, and computational toxicology and a comprehensive array of *in vitro* tests based primarily on human biology with the goal being to make toxicology fit for purpose.

Where does this leave our understanding of DU's chemical toxicity? As noted by the WHO, much of the toxicological research on DU is dated and was undertaken at a time when analytical methodologies were unsophisticated. Things are slowly improving but the historical focus on renal toxicity, to the exclusion of dose-response assessments in other tissues, undermines the credibility of older risk assessments. The admission that current toxicological analysis must increase its precision supports the contention that much remains to be documented on the effects of DU's chemical toxicity on human health. This sits awkwardly with the simplistic scientific case promoted by DU users.

5.2 On radiation and uncertainty

The status of radiation risk modelling is similar in some respects. As previously discussed, radiation exposure limits are based in part on a cost benefit analysis and carry the presumption that any exposure carries with it some risk. Yet although the models used to examine the radiation doses to different organs[9] are arguably more robust than those used in toxicology, they are still imperfect and subject to uncertainties[10].

The health risks from exposure to internal radiation – for example inhaled DU particles that become lodged in the deep lung or mobilised around the lymphatic system – are a case in point. In 2004, an independent committee of experts was established by the UK government to assess whether the risk from internal radioactive emitters could be accurately modelled[11] they found that:

Uncertainties in current methods of estimating risks from internal radiation require policy makers and regulators to adopt a precautionary approach when dealing with exposures to internal radiation[12].

3. See previously cited work by Miller, tabulated on page 12.

4. Lowest Observed Adverse Effect Level – the dose level below which no harmful changes can be observed.

5. Agency for Toxic Substances and Disease Registry (ATSDR) 2011. *Draft Toxicological Profile For Uranium*.

6. Cullen, D. (2011) *Commentary on the Scientific Committee on Health and Environmental Risks (SCHER) Opinion on the environmental and health risks posed by depleted uranium (DU)*. ICBUW.

7. Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) is a European Union Regulation of 18 December 2006. REACH addresses the production and use of chemical substances, and their potential impacts on both human health and the environment. Its 849 pages took seven years to pass, and it has been described as the most complex legislation in the Union's history and the most important in 20 years. It is the strictest law to date regulating chemical substances and will affect industries throughout the world. REACH entered into force in 1 June 2007, with a phased implementation over the next decade.

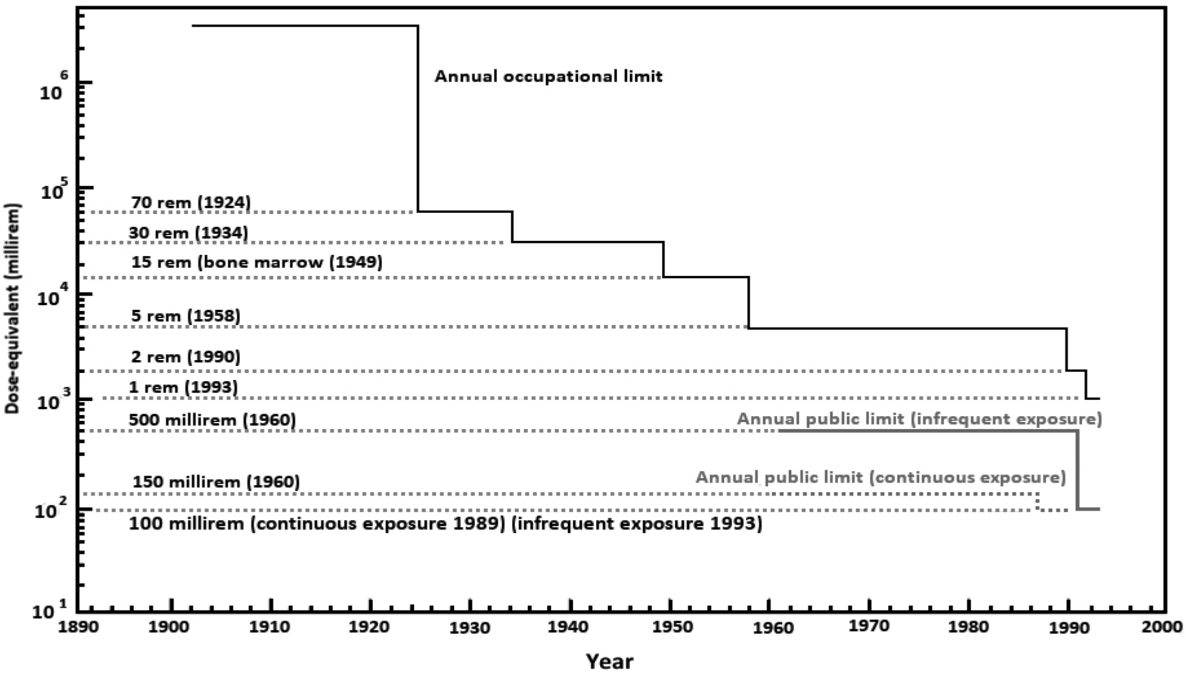
8. National Research Council. (2008) *Toxicity testing in the 21st century: a vision and a strategy*. Reprod Toxicol. Jan;25(1):136-8.

9. Cullen, D. (2011) *Commentary on the Scientific Committee on Health and Environmental Risks (SCHER) Opinion on the environmental and health risks posed by depleted uranium (DU)*. ICBUW.

10. UK Health Protection Agency. *Uncertainty analysis of the ICRP human respiratory tract model applied to interpretation of bioassay data for depleted uranium*.

11. CERRIE was an independent Committee established by the UK Government in 2001, following concerns about the risks of internal radiation. The Committee operated between October 2001 and October 2004. http://www.cerrie.org

12. Committee Examining Radiation Risks of Internal Emitters (CERRIE) Press Release, 20th October 2004 "*Report calls for precautionary approach to internal*



US radiation dose limits during the 20th Century (William C. Inkret, Charles B. Meinhold, and John C. Taschner, Radiation and Risk – A Hard Look at the Data. Los Alamos Science, Number 23 1995)

At issue was whether the models used to establish the dose from internal emitters were sufficiently accurate and that insufficient data were available on what appeared to be novel effects of internal radiation. These effects included genomic instability[13], bystander effects[14] and minisatellite mutations in the germline[15].

Eight years on and researchers believe that our growing understanding of radiation's interactions with the body hints at a far more complex picture than previously thought[16]. This may have significant implications for how safe exposure levels are calculated and for how the health effects of exposures are explored. We are far from a position where science can confidently state that W dose of internal radiation into X cells will lead to Y health outcome in Z person. Pretending otherwise – while convenient – is a poor reflection of the complexity of the issue.

Another emergent area of research is epigenetics[17], which may shed new light on the health impact of a wide range of environmental contaminants. Epigenetic responses have already been documented with DU[18] and have also been implicated in cancer development from exposure to other heavy metals such as nickel and chromium.

Since the discovery of radiation, safe exposure limits have trended downwards. The key driver has been the advancement of our understanding of radiation's interactions with the human body: its different tissues and its cellular mechanisms. Given that DU contamination may be long lasting in the environment, and that new approaches are providing new insights into assessing radiation risks, what will the impact of the next downward shift be and what does that mean for current risk assessments?

Because of the uncertainties generated by these findings, and the previous trends in dose limits, a precautionary approach seems both logical, and to offer the greatest protection. This is particularly important for individuals who may be genetically pre-disposed to suffering greater damage from radiation due to their cells being less able to repair themselves[19]. Such findings make the use of the standard Reference Man – long controversial due to its inability to accurately handle differential radiation risks relating to gender and age variability[20] - in health modelling increasingly untenable.

5.3 Limitations of recent risk assessments

Given that DU has been studied fairly intensively over the last two decades, it is perhaps surprising that recent risk

radiation" http://www.cerrie.org/pdfs/cerrie_press_release_final.doc

13. Whereby radiation can induce an ongoing long-term increase in mutation rate in cells and their progeny, which may contribute towards cancer.

14. Whereby un-hit cells in the vicinity of cells that have been hit by radiation may also be affected by the radiation.

15. Which leads to inherited DNA changes which may have health effects.

16. K. Baverstock and H. Nikjoo. *Can a system approach help radiobiology?* Radiat Prot Dosimetry (2011) 143(2-4): 536-541

17. Epigenetics is the study of heritable changes in gene expression or cellular phenotype caused by mechanisms other than changes in the underlying DNA sequence. Examples of such changes are DNA methylation and histone modification. These mechanisms can enable the effects of parents' experiences to be passed down to subsequent generations.

18. Miller A et al, *DNA methylation during depleted uranium-induced leukemia*, Biochimie, Volume 91, Issue 10, October 2009, Pages 1328-1330, ISSN 0300-9084, 10.1016/j.b

19. Denis A. Smirnov et al. (2009) *Genetic analysis of radiation-induced changes in human gene expression*. Nature 459, 587-591.

20. Makhijani, A. (2009) *The Use of Reference Man in Radiation Protection Standards and Guidance with Recommendations for Change*. IEER.

assessments have struggled to adequately quantify the risk that DU may pose to civilians.

The European Commission follows the standard four part methodology to risk assessment: *hazard identification, hazard characterisation, appraisal of exposure and risk characterisation*[21]. In 2010, its SCHER Committee published an *Opinion*[22] on DU after having been mandated to research the issue by the members of the European Parliament. The risk assessment has since been strongly criticised[23] for failing to adequately recognise the uncertainties resulting from gaps in the available data.

Three areas were identified where considerable uncertainty remains. Perhaps most crucially a near total lack of data on civilian exposure levels to military-origin DU was identified, although SCHER sought to present a single study of 25 Kosovar civilians – whose criteria for selection was unclear from the study's methodology – as a sufficiently robust dataset for estimating civilian exposure across all scenarios.

Beyond the lack of detailed civilian exposure data, uncertainties in ascertaining the dose to tissues other than the lung and kidney[24], the response from those tissues to those doses[25], and even the particle size distribution and particle composition from DU strikes[26] would have rendered accurate risk characterisation difficult.

In spite of these flaws, this represents the most detailed recent risk assessment on DU munitions by an international body. That it failed in its attempt to accurately quantify the risks that the use of the weapons poses to civilian populations, strongly suggests that recourse to the Precautionary Principle is now the only justifiable way forward. The European Commission states clearly that uncertainty over the risk from an activity should not be used to justify inaction:

> *Once the scientific evaluation has been performed as best as possible, it may provide a basis for triggering a decision to invoke the precautionary principle…*
>
> *The absence of scientific proof of the existence of a cause-effect relationship, a quantifiable dose/response relationship or a quantitative evaluation of the probability of the emergence of adverse effects following exposure should not be used to justify inaction*[27].

5.4 Lack of epidemiological data on civilian health outcomes

The campaigns against anti-personnel land mines and cluster munitions relied upon gathering detailed information on civilian harm[28]. The nature and visibility of the injuries caused by explosive weapons made this complex task achievable, even if the true picture of both the health and socio-economic impact of the weapons is unlikely ever to be known.

DU users have long argued that there is no proof of the civilian harm from the use of DU munitions. However, tracking and documenting the harm – for example a specific type of cancer - from environmental contaminants presents an even greater challenge than gathering data on the impact of explosive weapons:

> *Establishing the environmental links to human cancer occurrence is a difficult endeavor and fraught with ambiguity. The environmental exposures are complex, often very low, and variable. Cancer's intrinsic rarity, apparently random nature, and the long latency of onset serve to further obscure the cause-effect links.*
>
> *A common epidemiological approach for such rare diseases is to employ a case–control design to link the disease with historical exposure measurements or other assessments (e.g., records review, questionnaires, and data bases).*
>
> *In short, one identifies as large a group as possible of cancer victims, chooses a matched set of similar people without cancer, and then attempts to determine how the environmental exposures or history differ between the groups*[29].

Such work is recognised as difficult during peacetime, even where considerable resources and expertise may be available. Undertaking such work after conflict brings with it a range of additional problems. Healthcare systems might be only partly operational, under-resourced and tailored to treatment instead of research. Populations may be highly mobile both during and after conflict. Health records prior to the conflict may have been lost or destroyed and new systems may not support standardised data collection and retention.

Security issues may make it unsafe for researchers to get into the field and a distrust of the authorities can result in survey subjects being unwilling to provide information. Environmental degradation caused by conflict and the presence in the environment of a range of contaminants will serve to confound studies seeking a causal link between ill health and exposure to a single substance. Political pressure may constrain funding or accessibility to the field and a lack of

21. Communication from the Commission on the precautionary principle /* COM/2000/0001 final */ http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:52000DC0001:EN:NOT

22. Scientific Committee on Health and Environmental Risks (SCHER): *Opinion on the environmental and health risks posed by depleted uranium (DU)*

23. Baverstock, K. *Evaluation of the SCHER opinion on DU in 2010*, presented at the EP SEDE committee 6th October 2011. http://www.bandepleteduranium.org/en/docs/168.pdf

24. *Ibid.*

25. *Ibid.*

26. Cullen, D. (2011) *Commentary on the Scientific Committee on Health and Environmental Risks (SCHER) Opinion on the environmental and health risks posed by depleted uranium (DU)*. ICBUW.

27. Communication from the Commission on the precautionary principle /* COM/2000/0001 final */ http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:52000DC0001:EN:NOT

28. For example: *Circle of impact: The fatal footprint of cluster munitions on people and communities.* (2007). Handicap International.

29. Pleil et al, *Strategies for evaluating the environment–public health interaction of long-term latency disease: The quandary of the inconclusive case–control study*, Chemico-Biological Interactions, Volume 196, Issue 3, 5 April 2012, Pages 68-78, ISSN 0009-2797, 10.1016/j.cbi.2011.02.020.

data and accurate recording systems on the whereabouts of contamination may render any attempt to link environmental exposure to ill health impossible. Finally, a lack of expertise and analytical capacity may ensure that projects are difficult to instigate without external funding and technical assistance.

It therefore comes as little surprise that long-term, wide-scale and detailed epidemiological surveys in areas of Iraq which witnessed the intensive use of DU munitions, or were home to contaminated war wreckage, have yet to be undertaken. However, the lack of epidemiological data should not be seen as a justification for inaction when considering the acceptability of DU munitions:

> *…when international commentators call for more evidence on the effects of uranium weapons, they must understand the complexity of the work involved. Even in the most benign circumstances, conclusive results can be elusive, and the legacy of war is such that many potential studies simply lack the data that would be required[30].*

The difficulties inherent in conducting detailed epidemiological work in post-conflict environments present a clear challenge to those refusing to act on DU without the establishment of a direct causal link between the use of the weapons and civilian harm. On the contrary, the recognition and acceptance of these difficulties strongly bolster calls for a precautionary approach to the weapons.

5.5 Conclusion

The military's ongoing requirement to maintain the acceptability of DU munitions has resulted in the projection of an overly simplistic view of the health hazards that DU poses.

The data on uranium's chemical toxicity is a case in point, with many studies predating the development of modern analytical methods. The science of toxicology itself is currently in a state of renewal as it seeks to provide more sophisticated and detailed data on substances. Similarly, recent developments in our understanding of the means through which radiation interacts with cellular processes and repair mechanisms have highlighted that modelling the estimated dose and safe exposure limits to internal radiation is fraught with uncertainties.

This is largely unsurprising as exposure limits have been on a downward trajectory ever since the discovery of radiation. While it has proved politically useful to communicate a clear safety message on DU, this is not supported by the science.

Gaps and uncertainties in the data needed to undertake detailed civilian risk assessments for DU appear to have rendered accurate risk characterisation impossible. As a result there are compelling reasons to suggest that a precautionary threshold has been passed. We know enough of the potential risks to act, even where uncertainties have made it impossible to quantify them accurately. However in many interpretations of the Precautionary Principle, this may yet require a cost benefit test to be considered.

Just as the uncertainty over accurate risk characterisation should not be used to justify inaction, the lack of detailed epidemiological data from Iraq and elsewhere should not be interpreted by the users as supporting the ongoing use of the weapons. The complexities of such studies are rarely mentioned by user states but are all too familiar to those physicians and researchers who have sought the truth about the potential civilian harm from DU munitions.

30. Cullen, D. (2010). *A Question of Responsibility: the legacy of depleted uranium use in the Balkans.* ICBUW.

6.0 Costs and benefits

Examination of the pros and cons cannot be reduced to an economic cost-benefit analysis. It is wider in scope and includes non-economic considerations. The [European] Commission affirms, in accordance with the case law of the Court that requirements linked to the protection of public health should undoubtedly be given greater weight than economic considerations.

Besides, other analysis methods, such as those concerning the efficacy of possible options and their acceptability to the public may also have to be taken into account. A society may be willing to pay a higher cost to protect an interest, such as the environment or health, to which it attaches priority[1].

All but the purest and most idealised interpretations of the Precautionary Principle carry a requirement to assess the costs of action versus the costs of inaction. In the case of DU munitions, this might include: *the current effectiveness of the weapons, health and socio-economic costs, decontamination and management costs, lifecycle costs of the weapons versus alternatives and their public acceptability*.

6.1 Military utility versus political acceptability

Much has been written about the effectiveness of DU munitions, although most is long on hyperbole and short on actual data. This promotion is closely linked to the military's attempts to justify the use of controversial weapons in the face of actual or anticipated public opposition. As opposition to DU increased after the 1991 Gulf War, staff at Los Alamos Laboratory noted the importance of actively promoting its efficacy:

There has been and continues to be a concern regarding the impact of DU on the environment. Therefore, if no one makes a case for the effectiveness of DU on the battlefield, DU rounds may become politically unacceptable and thus, be deleted from the arsenal.

If DU penetrators proved their worth during our recent combat activities, then we should assure their future existence (until something better is developed) through Service/DoD [US Department of Defense] proponency.

If proponency is not garnered, it is possible that we stand to lose a valuable combat capability. I believe we should keep this sensitive issue at mind when after action reports are written[2].

Contrary to the spectacular claims made by the US Department of Defense concerning the effectiveness of DU following the 1991 Gulf War, research has highlighted that DU rounds fired by aircraft and tanks accounted for just 500 of the 3,700 Iraqi tanks destroyed by the US[3]. The real *silver bullet*[4] was the Maverick missile, which in use by A10 gunships, accounted for the destruction of 900 tanks.

A more recent analysis of the military effectiveness of large calibre DU rounds examined whether DU confers a unique military advantage that cannot be matched by alternative materials, such as tungsten alloys[5], or by modifications to the design of the weapons or platforms that fire them. It was found that, although historical studies indicated that on a like for like basis DU had outperformed tungsten alloys in trials:

Penetrator material is only one among many variables which determine the effectiveness of a kinetic energy round. Although DU appears to be the most effective material, it is quite possible to achieve similar improvements in performance by other means.

It appears that modifications to the round, gun or other factors, which are unconnected to the choice of penetrator material, will often give more significant improvements to performance than changing penetrator material[6].

Given the claims that are made for the efficacy of DU, it is perhaps surprising that its use in armour piercing ammunition has not become ubiquitous. While factors such as availability of DU and military capability have influenced procurement, one of the overriding constraints on DU's proliferation has been political acceptability. In the 1970s, West Germany was deeply involved with the US and UK trials of DU rounds[7], yet made the decision not to develop it further, largely on the basis of political acceptability[8]. Sweden, Switzerland and Norway have all made similar decisions.

There is ample evidence that the balance between DU's utility

1. Communication from the Commission on the precautionary principle /* COM/2000/0001 final */ http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:52000DC0001:EN:NOT

2. Lt col M.Y. Zeihmn to Maj. Larson, Studies & Analysis Branch (1991) *The effectiveness of Depleted Uranium Penetrators*, 1 Mar 1991, Los Alamos National Laboratory, New Mexico. [Available at: http://www.globalresearch.ca/index.php?context=va&aid=21545]

3. Fahey, D. (2003) SCIENCE OR SCIENCE FICTION? *Facts, Myths and Propaganda In the Debate Over Depleted Uranium Weapons*.

4. Famous from European folklore for its ability to kill werewolves, Silver Bullet was the nickname attached to the US Army's 120mm DU ammunition following the 1991 Gulf War.

5. Similar in density to uranium, tungsten is widely used by militaries around the world for armour-piercing and kinetic energy penetrator rounds. In early trials, DU is said to have outperformed tungsten due to its deformation characteristics. Attempts to find alternatives to DU have focused on tungsten alloys, or more recently bulk metallic glasses that replicate the deformation characteristics of DU. Nevertheless, a greater proportion of the world's militaries are satisfied with the performance of modern tungsten penetrators. In recent years questions have been raised over the toxicity of tungsten and the metals it is often alloyed with, such as nickel and cobalt. Cobalt is present as a contaminant in most recycled tungsten.

6. Cullen, D. (2012) *Overstating the case: an analysis of the utility of depleted uranium in kinetic energy penetrators*. ICBUW.

7. Kellay, A. (2012) *Managing Acceptability: UK policy on depleted uranium weapons.* CADU.

8. Mohr, M. (2001) *Uranwafeneinsatz: eine humanitar-volkerrechtliche Stanrtbestmmung in Humanitares Volkerrecht*.

and other considerations has shifted in recent years. The first DU round to begin to be phased out was that used by naval protection systems[9]. Its main application was shooting down incoming missiles, which are not armoured, thus tungsten was readily accepted as an alternative. That pyrophoric DU presents an onboard fire risk and inhalational hazard was doubtless also considered.

In seeking to replace its last operational DU round, the UK MoD baulked at the cost implications when it emerged that doing so would entail a major upgrade to the UK's Challenger tank fleet, thanks largely to short-sighted development decisions dating back to the 1960s[10]. The MoD argued that it shelved the plans after US research unexpectedly revealed that the tungsten alloy under consideration as an alternative was carcinogenic in rats[11] - even though the alloy outperformed DU[12]. In some respects this is a positive development and fits well with the conclusions of the UK MoD's Depleted Uranium Programme Independent Review Board, which argued that:

> *...lessons learnt in respect of the assessment of the health and broader environmental impacts of DU based munitions [should] be applied at an early stage in the development of alternative military technologies[13].*

Unfortunately this has left the UK facing something of an *impasse*. Until the situation is resolved they are left in the unfortunate position of having to doggedly defend their ageing DU munitions against all comers.

France, along with the US and UK has been part of the troika opposing DU resolutions at the UN, yet they also appear to be shifting their procurement policy:

> *The main area of work is to design battle tank kinetic ammunition able to penetrate future armours, which will appear beyond 2015, taking environmental constraints into account[14].*

These policy shifts appear to have been driven by a variety of factors, but international pressure over the weapons and the growing awareness of DU's hazards are likely to be focusing minds. Other considerations include lifecycle costs, decontamination of facilities, regulatory constraints on testing and the fear of liabilities for post-conflict decontamination.

Even before the spectre of tungsten's toxicity emerged, it was often argued that DU was cheaper. Yet 55% of the tungsten consumed in the US in 2011 came from recycled sources[15]. As most munitions that are produced are subsequently demilitarized without being fired, this would have proved a significant life cycle cost saving over DU if long term disposal costs had been factored in.

The US Army, which maintains the most diverse range of DU weapons has long been advised by its own think tank on environmental policy[16] to accelerate the search for alternatives. Signs suggest that a shift away from DU in medium calibre rounds is now underway[17] and development has also begun on a replacement round for the Abrams tank[18], a move which surprised observers, given the vociferous support for DU from the US military.

More recently, plans for a DU round for the international Joint Strike Fighter project were shelved after project partners requested than an alternative material be used[19]. Another sign of the opprobrium associated with DU munitions can be found in the wording of Australia's uranium export agreement with the US, which specifically forbids Australian uranium from being used for DU munitions[20].

Naturally, these developments place a question mark over the claims of military utility promoted by DU users. Applying circular logic, they argue that the effectiveness of the weapons overrides humanitarian concerns, which thus far have not been supported by long-term health studies (which have not been undertaken). However the apparent shift in procurement policy indicates that their calculations have also included an analysis of public acceptability and some of the practical considerations outlined above. Where then, does this leave arguments based on utility alone?

If nothing else it seems clear that the strategic costs to the military of a precautionary moratorium or ban are rapidly decreasing. Further evidence for this emerged during Operation Unified Protector in Libya in 2011. The US deployed A10 gunships during the early phase of the air war. Presumably their role was to attack Gaddafi's armoured vehicles on the

9. The Phalanx CIWS is a close-in weapon system for defending against anti-ship missiles. The basis of the system is the 20 mm M61 Vulcan Gatling gun autocannon.

10. Cullen, D. (2012) *Overstating the case: an analysis of the utility of depleted uranium in kinetic energy penetrators*. ICBUW.

11. Kalinich, F, et al. *Embedded Weapons-Grade Tungsten Alloy Shrapnel Rapidly Induces Metastatic High-Grade Rhabdomyosarcomas in F344 Rats*. Environ Health Perspect. 2005 June; 113(6): 729–734.

12. This was first reported by the well-connected defence journal *Jane's International Defence Review*, following trails in February 2006. Although the results of the trials were officially classified, Jane's was informed off the record that the test configuration outperformed a CHARM 3 round fired from the existing gun.

13. Smith, B. (2007) The MoD Depleted Uranium Programme Independent Review Board: *Closure Report*, CR/07/065N, Natural Environment Research Council (NERC)p. i. [Available at: http://core.kmi.open.ac.uk/display/60463]

14. Direction générale De l'armement. (2009) *Strategic Plan for Research & Technology in defence and security*.

15. *Tungsten Mineral Commodity Summary*, USGS Tungsten Statistics and Information, 2012.

16. WORLDWIDE EMERGING ENVIRONMENTAL ISSUES AFFECTING THE U.S. MILITARY U.S. Army Environmental Policy Institute Summarizing Environmental Security Monthly Scanning January 2008—June 2008

17. ICBUW. (2010) *US set to discontinue depleted uranium in medium calibre ammunition*. http://www.bandepleteduranium.org/en/us-set-to-discontinue-depleted-uranium-in-medium-c

18. International Defence Review. *NATO Tanks Aim at Wider Target Set with Smoothbore Ammunition*. (January 19, 2012)

19. U.S. Air Force Air Armament Center. *Dual Purpose Ammunition for the F-35 Aircraft Gun System (GAU-22A) - Final Requirements List*, April 24, 2008. Federal Business Opportunities Solicitation Number AAC685ARSS080424. https://www.fbo.gov/utils/view?id=f934399b74944eb51de1ec687f89bba8

20. Nuclear Regulatory Commission Documents and Publications. *Agreement between the Government of Australia and the Government of the United States of America Concerning Peaceful Uses of Nuclear Energy*. Effective November 8, 2011. http://www.law.cornell.edu/cfr/text/10/40.56 [Retrieved September 2012]

ground – a role that their 30mm DU ammunition, the cannon that fires it and indeed the aircraft were designed for. Yet the US later denied that any DU had been used[21]; given the claims of military necessity advanced for DU by the USAF this seems a surprising development.

6.2 DU's cost benefit imbalance

Put simply, militaries that use DU reap any actual or perceived benefits stemming from its use, while affected states and their civilian populations generally foot the bill for its post-conflict management and any associated health and social costs. This rather perverse imbalance lies at the heart of the debate over DU's acceptability.

DU clearance is time consuming and technically challenging. As a result it is also expensive, for example at one site in Montenegro it took 5,000 working person days to decontaminate 480 rounds at a cost of DM 400,000 (almost US$280,000). The rounds had taken one or more US A10 gunships a matter of seconds to fire[22]. Meanwhile Serbia spent £1.156m decontaminating four sites[23]. DU was fired at comparatively few sites in Serbia, certainly in comparison to Iraq, where at least 60 times more DU has been used than was fired in all the Balkan conflicts.

Figures for the cost of decontamination work undertaken thus far in Iraq are not currently available, partly because work has not been completed. However, other figures may be indicative, for example the cost to the Kuwaiti government for the collection and return to the US of 6700 tons of contaminated sand following a fire involving DU penetrators at a US base. This amounted to some US$34.8m[24]. That the US was amenable to hosting the long-term storage of the contaminated soils at a site in Idaho illustrates that geopolitical interests are often the primary driver of state responsibility for contamination. This is also true of funding for mine clearance, which is still dispersed on an ad-hoc basis and is often driven by political considerations rather than need.

Beyond the cost of remediation, it becomes difficult to quantify the precise economic burden of health care and medical surveillance. Long-term and intensive medical intervention for cancer patients is expensive, even where modern drug treatments and medical equipment are unavailable. For children born with disabilities resulting from exposure and who survive into childhood, the social and economic impact for their carers can be severe. Similarly, the psychological burden of living with contamination is not trivial and may ultimately impact on civilians' physical well being.

21. Edwards, R. *Mounting alarm over US use of depleted uranium arms in Libya* (3rd April 2011). http://www.heraldscotland.com/news/home-news/mounting-alarm-over-us-use-of-depleted-uranium-arms-in-libya.13148674 [Retrieved September 2012]

22. Cullen, D. (2010). *A Question of Responsibility: the legacy of depleted uranium use in the Balkans*. ICBUW.

23. *Ibid*.

24. State of Kuwait, Ministry of Defence, Contract No. 20051 of year 2005. *Concerning Disposal of Depleted Uranium Dust*.

More broadly, DU contamination may also have subtler, less predictable impacts on communities, be it through limiting access to land, property or infrastructure or impact on commerce and industry[25].

6.3 Conclusion

An analysis of the costs and benefits of the use of DU sees the strategically overstated utility of the weapons pitched against the health, psychological and management burden they place on affected states, the lifecycle costs associated with manufacturing, development and testing and ultimately the public acceptability of using chemically toxic and radioactive materials in conventional weapons.

State practice and recent procurement decisions appear to support the claim that their utility has been overstated, thus weakening the primary justification promoted by states to support DU's use. Contrary to DU users' hopes, the public's acceptability of DU has not increased with time, a trend that is unlikely to change as more work is undertaken to document its legacy in affected states and further research is undertaken on its interactions with the human body.

Although some lessons seem to have been learned by the US and UK militaries in the wake of concerns over DU's potential health impact on troops and civilians, it would be naive to expect these lessons to be adopted in future decision making without some external pressure requiring them to do so, be this through political pressure or a legal obligation. Therefore the opportunity to more closely scrutinise, and perhaps limit, by agreement, a range of hazardous materials that may lead to post-conflict environmental and public health problems could be one of the few positive legacies of DU's use. Such an approach could fit well with ongoing efforts to strengthen the international normative framework protecting civilians from the impact of conflict, be it controlling cluster munitions or restricting the use of explosive force in civilian areas.

25. Cullen, D. (2010). *A Question of Responsibility: the legacy of depleted uranium use in the Balkans*. ICBUW.

7.0 Precaution in practice?

This report has argued that a precautionary framework is applicable to DU weapons; it has shown that DU is recognised as a hazardous material; it has explored how conflict is an inherently unpredictable environment and the problems that poses for risk calculations; it has discussed the scientific uncertainties that continue to confound risk assessments and has discussed the cost benefit calculations that are relevant to the use of DU.

Interpreting these findings through a standard model of the Precautionary Principle demonstrates that:

Is DU a known hazard? – Yes.

Is there potential for civilian harm? - Yes.

Has a risk assessment been able to accurately quantify the health risks to civilians? - No.

Has a cost benefit analysis been undertaken? - Yes.

ICBUW is not the first to advocate a precautionary approach to DU munitions, international and expert agencies such as the WHO, UK Royal Society and UNEP have all called for precautions (although only UNEP has mooted a precautionary approach *per se*) primarily focused on post-conflict management and risk reduction.

Similarly, the militaries that use the weapons and their allies have also adopted precautionary harm reduction measures. The extent to which state users have followed the precautions suggested by international agencies is a matter of debate but by most measures they have performed poorly, in spite of being aware of the potential dangers that the use of the weapons entailed, prior to their deployment[1].

But what might a precautionary approach to DU look like? One framework advanced in 2008 suggested:

1. Legal reviews of DU weapons by states.

2. Precaution in targeting: restricting the deployment of DU weapons in civilian areas.

3. Precautions in the aftermath of DU use:

- Remedial and risk reduction measures;
- Testing of exposed individuals and populations and the conduct of further medical and scientific research by military and civilian bodies.

4. The voluntary adherence by user states to a moratorium on the use of DU weapons[2].

Based on past state practice, are these suggestions workable or realistic?

7.1 Legal reviews

The US has not undertaken a review of the legality of its DU tank ammunition since 1994. This was prior to significant advances in our understanding of the health risks from DU exposure. The UK meanwhile assured campaigners and parliamentarians for years that it had reviewed the legality of its CHARM3 DU round, only to be forced into making an embarrassing parliamentary apology when it emerged that no such review existed[3] but the weapons had been used in Iraq regardless. Having now produced one, the UK MoD has refused to make it public on national security grounds[4], thus blocking any scrutiny by parliament or civil society of its contents and findings.

Weapons reviews are supposed to be undertaken under Article 36 of Additional Protocol 1 to the Geneva Conventions[5] in order to assess whether new weapons are likely to breach existing IHL or future trends in it. However take-up is limited to a handful of states – including few DU users, they are not retrospective and they only apply to new weapons. While there is potential for improvement, at present they appear to be a poor vehicle for the ongoing assessment of controversial weapons such as DU.

7.2 Precaution in targeting

Is it possible to restrict the deployment of DU in civilian areas? This would be a major step forward in reducing civilian harm, although affected states would still face the burden of managing DU contaminated wreckage and sites outside these areas.

The nature of conflict has changed markedly since DU weapons were developed, with high intensity, mechanised warfare in mind. Fighting is increasingly focused on populated areas and it can prove difficult to make a clear distinction between inhabited and uninhabited areas. Platforms that are preloaded with DU and unable to select between different ammunition types, such as the A10 gunship, would face considerable operational constraints. Would states even be willing to forego the military effectiveness they claim DU offers in such cases?

The 2003 invasion of Iraq was a case in point, Coalition Forces were well aware that the bulk of the fighting would take place in civilian areas and yet this did not limit their use of DU. Would it even be practical for militaries to develop and deploy

1. Kellay, A. (2012) *Managing Acceptability: UK policy on depleted uranium weapons*. CADU.

2. McDonald, A. (2008) *Averting foreseeable and unexpected damage, in Depleted Uranium Weapons and International Law: a precautionary approach*. TMC Asser Press.

3. Edwards, R. *Armed forces minister sorry for misleading MPs over depleted uranium* (14th November 2011) http://www.guardian.co.uk/politics/2011/nov/14/minister-sorry-dangers-depleted-uranium?newsfeed=true [Retrieved September 2012]

4. Charm-3 (Legal Review), Ministerial Statement by Minister for the Armed Forces Nick Harvey. Hansard 12 July 2012 : Column 40WS

5. See: International Committee of the Red Cross, Geneva,(2006). A Guide to the Legal Review of New Weapons, Means and Methods of Warfare: Measures to Implement Article 36 of Additional Protocol I of 1977.

a parallel set of 'civilian friendly' munitions, or is removing DU from all munitions the only way to guarantee compliance?

Voluntary controls on DU targeting were discussed by the UK's Foreign and Commonwealth Office (FCO) as early as 1979, after the US and UK grew concerned that DU might be included in the scope of the Inhumane Weapons Convention[6]:

> *...if a proposal is made in the 1979 Weaponry Conference for a ban on the use of DU there might be scope for considering whether we should propose, as an alternative, restrictions on the uses to which such ammunition might be put... The difficulties of any such proposal in terms of verification are, of course, considerable[7].*

To which a Mr Judd of the FCO responded:

> *I am highly dubious as to whether any undertaking only to use ammunition of this kind against tanks would be worth the paper it is written on[8].*

7.3 Precautions in the aftermath of DU use

As we have seen, the ability of states to undertake post-conflict remediation measures varies enormously and at present it is limited by a lack of user transparency, technical expertise, financial assistance and domestic capacity. What would it take to remedy this situation? At present states are, for the most part, correct in asserting that they are under no legal obligation to provide post-conflict assistance for managing DU contamination. Nevertheless the UK MoD did recognise that it had a moral obligation to the people of Iraq over its use of DU in 2003[9].

Conscious of the liabilities they might face for decontamination and any health problems stemming from the use of the weapons, it is perhaps unlikely that the situation will change soon. This also applies to funding or facilitating the monitoring of at risk civilian populations, which again would suggest liability for any health problems identified.

That the US still has not reached a satisfactory agreement with the government of Viet Nam over its use of the defoliant Agent Orange, and the incidence of birth malformations and health problems induced through exposure to dioxins, only reinforces this. While welcome, a recent agreement to fund the remediation of a dioxin contaminated airfield near Da Nang in Viet Nam indicates that, as with transparency over DU targeting[10], post-conflict assistance will be provided at a time and through a vehicle of the US's own choosing.

CCW Protocol V on Explosive Remnants of War, which introduced modest obligations for dealing with land mines, cluster munitions and abandoned or unexploded ordnance after conflict, could provide a model for dealing with the toxic legacy of warfare. This has been raised by the ICRC[11], but some states were understandably reluctant to pursue it.

Finally, it is increasingly apparent that state responses to the toxic legacy of conflict illustrate a clear disconnect between domestic regulation[12] and practice, be it through the adoption of the Precautionary Principle or in the pursuit of polluters to remedy the environmental damage that they cause. The fact remains that when it comes to environmental contamination, it is often far cheaper to avoid the pollution incident than to manage its legacy.

7.4 A voluntary moratorium

The European Parliament has now made four calls for an EU or NATO-wide moratorium on the use of DU weapons[13]. A similar sentiment has been expressed by the Latin American Parliament[14]. The author of the proposed precautionary framework on page 28 suggested that a voluntary moratorium would be the ultimate in precaution, adding that it could be put in place until the safety or legality of DU weapons was proven one way or another.

How might a moratorium be promoted and, crucially, how might it be enforced? UN General Assembly moratoria have been advanced to restrict nuclear testing, the manufacturing of fissile nuclear material for weapons and to restrict the export of anti-personnel land mines[15]. They have typically met with mixed success, primarily because General Assembly resolutions are non-binding and the lack of any clear enforcement mechanisms limits state adherence. However, in the case of land mines at least, the export moratorium did play a role in sustaining the diplomatic environment which ultimately led to the Ottawa Convention.

6. The United Nations Convention on Certain Conventional Weapons (CCW or CCWC), concluded at Geneva on October 10, 1980 and entered into force in December 1983, seeks to prohibit or restrict the use of certain conventional weapons which are considered excessively injurious or whose effects are indiscriminate.

7. Wilberforce W.J.A. to Mr Moberly, (1978) PS/Mr Judd Depleted Uranium Ammunition, 16 Nov 1978, in Storage of depleted uranium ammunition for United States A-10 aircraft in the UK, FCO 46/1832, The UK National Archives (TNA).

8. Frank Judd to Secretary of State (1978) Depleted Uranium Ammunition, 17 Nov 1978, in Storage of depleted uranium ammunition for United States A-10 aircraft in the UK, FCO 46/1832, The UK National Archives (TNA).

9. Kirby, A. *UK to aid Iraq DU removal*. (23rd April 2003) http://news.bbc.co.uk/1/hi/sci/tech/2970503.stm [Retrieved September 2012]

10. 65th session of the United Nations General Assembly First Committee. Explanation of vote by on behalf of France, the United Kingdom and the United States L19 *"Effects of the use of armaments and ammunitions containing depleted uranium"*. 27 October 2010.

11. International Committee of the Red Cross. (2011) *Report: Strengthening legal protection for victims of armed conflicts*. http://www.icrc.org/eng/assets/files/red-cross-crescent-movement/31st-international-conference/31-int-conference-5-1-1-report-strength-ihl-en.pdf [Retrieved September 2012]

12. For example the closure of the National Lead factory in Colonie, New York State, United States. The facility was closed after it was found to be routinely breaching monthly airborne emission limits of 150 µCi – roughly equivalent to the radiation from a single 30mm A10 gunship round.

13. European Parliament resolutions on depleted uranium weapons are available via: http://www.bandepleteduranium.org/en/european-parliament

14. ICBUW. Parlatino calls for a moratorium on uranium weapons http://www.bandepleteduranium.org/en/parlatino-calls-for-a-moratorium-on-uranium-weapon

15. United Nations General Assembly resolutions: A/RES/48/75K (1993), A/RES/49/75D (1994), A/RES/50/70O (1995)

A DU moratorium was proposed among NATO members in 2001, at the height of public concern over the use of DU in the Balkans, however:

Britain and the United States on Tuesday opposed a moratorium on the use of depleted uranium (DU) weapons, heightening political tensions within the 19-member Nato military alliance. The two Nato allies shot down a request from Italy during a meeting of alliance officials in Brussels for a halt on DU arms until they had been deemed safe[16].

Is it even possible to prove that DU is safe? And safe for whom? It clearly is not perceived as safe by the military – hence their regulations for reducing exposure amongst personnel. It therefore follows that, under certain circumstances, it is not safe for civilians, particularly as they do not currently benefit from the extensive hazard awareness and risk reduction measures available to the military.

Will it be proved to be legal? The legality of DU under IHL is already contested and, setting aside the incendiary effect from DU ammunition, as we have seen there is a case to be made over whether it breaches the principle of precaution in avoiding foreseeable harm to civilians. A case may also be made on whether it is capable of distinguishing between civilians and combatants, particularly in populated areas – given that DU aerosol may spread up to 400m from impact sites. Finally the question of whether it is capable of causing unnecessary suffering and superfluous injury (injury beyond that required to remove them from the fight) to combatants who survive attacks, but are exposed, still remains unanswered due to the limitations of ongoing studies[17].

Would a temporary moratorium, if it were recognised and could be enforced, be in accordance with the precautionary approach discussed in this report? Certainly additional data could be of use in quantifying the risk to civilians – particularly civilian exposure data, further work on particle characterisation and dose response assessments - but other factors relating to the way in which DU is used in conflict and how it is managed afterwards are unlikely to be easily resolved. Similarly the gold standard of civilian epidemiological studies may for now remain out of reach and it is unclear how the intrinsic public acceptability of DU could increase. As such, what would a moratorium accomplish that a formal ban would not?

7.5 Conclusion

The problems outlined throughout this report are intrinsic to the nature of uranium and its mode of use in weapons, thus there are no quick technological fixes that might resolve them. Models for precautionary approaches that have been suggested in the past place too great a reliance on legal reviews and voluntary controls on behaviour, which past state practice suggests would do little to limit the worst problems associated with DU use. Stricter regulation might be one possible avenue to explore but this would require a level of transparency that has hitherto been lacking.

Therefore, it is reasonable to conclude that a voluntary moratorium, while potentially useful as part of a process of further stigmatising DU weapons, would not be the ultimate in precautionary measures – however, a global ban on the use of uranium in all conventional weapons would.

As they have most to lose from a ban on DU weapons, it is understandable that the military has historically sought the greatest influence in the debate over their acceptability. But this is a morally unsustainable situation as the users of DU are unlikely to voluntarily surrender a means of warfare that they perceive as valuable. Yet when those weapons overwhelmingly affect those not party to a conflict, and well beyond the cessation of hostilities, it raises questions of moral and political acceptability; questions that those with a vested interest in maintaining DU weapons are poorly placed to answer.

If we truly wish to judge the acceptability of DU, it is time for the voices of the victims, the public, the growing body of scientists who question the wisdom of DU's uncontrolled release in conflict and crucially, the politicians, to be heard. Only by thoroughly considering the nature of DU weapons, in a way that transcends mere questions of military utility, can we reach a clear understanding of their acceptability.

DU is a complex and emotive issue. Yet for all the scientific and technical arguments there is a simple principle at play: *is it politically acceptable to disperse large quantities of a chemically toxic and radioactive heavy metal, which is widely recognised as hazardous, in conventional warfare?*

Throughout our DU research, ICBUW has been conscious of the emergence of a broader thematic area relating to the humanitarian and environmental impact of the toxic legacy of military activities. This has included the means through which weapons components are assessed for toxicity and environmental behaviour prior to use; the role of precautionary approaches to civilian health because of the constraints on post-conflict monitoring and assistance; the need for analytical capacity and remediation expertise for managing toxic remnants of war[18] and finally, a recognition of state responsibility for the environmental and health legacy of toxic substances released or abandoned during conflict. An acceptance by states of the need to resolve these issues could yet prove to be a positive legacy of the development and use of DU munitions.

16. Geoghegan, I. *NATO ducks uranium ban amid clamour for research*. Brussels, Jan 9 2001, http://www.royalsociety.org.nz/2001/01/10/nato-uranium (Reuters).

17. The Research Advisory Committee on Gulf War Veterans' Illnesses, (2008). *Gulf War Illness and the Health of Gulf War Veterans*.

18. See the Toxic Remnants of War Project. http://www.toxicremnantsofwar.info

About ICBUW

The International Coalition to Ban Uranium Weapons (ICBUW) was launched in 2003 to take an evidence-based approach to examining the acceptability of the use of depleted uranium weapons. We are based in Manchester, UK and represent more than 150 civil society organisations worldwide.

ICBUW now campaigns for a ban on the use of uranium in all conventional weapons and weapon systems and for monitoring, health care, compensation and environmental remediation for communities affected by their use.

The main focus of ICBUW's work has been to inform and advise policy makers and governments on the threat to human health and the environment from uranium weapons. In the past this has taken the form of international conferences and seminars, and workshops for politicians and diplomatic staff at the United Nations, European Parliament and national parliaments. ICBUW also researches, produces and disseminates information, offers advice to its member groups and encourages domestic and regional coalition building and skills sharing.

ICBUW is grateful to the Polden-Puckham Charitable Foundation for supporting its educational outreach work and to the Norwegian Ministry of Foreign Affairs for its support for our core and project costs.

In 2012, and together with IKV Pax Christi, we launched the Toxic Remnants of War Project, which aims to take a broader view of the humanitarian and environmental impact of the toxic legacy of military activities. To learn more about the project, please visit: www.toxicremnantsofwar.info or follow @detoxconflict

For more information on ICBUW's work, please visit www.bandepleteduranium.org or follow us @ICBUW

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