DEPLETED URANIUM

A POST-WAR DISASTER
FOR
ENVIRONMENT AND HEALTH

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Laka Foundation
May 1999

(Note: The layout of this electronic version slightly differs from the printed version of the brochure)

Preface

In the course of the preparations for the Hague Appeal for Peace '99 conference, Laka decided to make a brochure about the use of depleted uranium in conventional weaponry and its consequences. The idea was born because of the short time reserved during the session for the presentation of all details about depleted uranium (DU). Although the word "depleted uranium" may suggest no harmful impact from radiation, this brochure will clarify the real radiotoxic (and chemotoxic) properties of DU.

Laka asked several "insiders" to take part in the completion of the brochure. Thanks to their efforts, we have been able to present well-documented articles for activists, scientists, scholars and students to share with them valuable information about the hazardous impact of DU contamination and its consequences on human health and the environment. Taking notice of the growing military use of DU, we must consider not only the increased threats of radioactive battlefields but also the whole dirty cycle in the uranium industry connected with the DU technology and its impact on health and the environment in the surroundings of test areas and in the uranium industry itself.

This brochure was completed thanks to Felicity Arbuthnot, Rosalie Bertell, Ray Bristow, Peter Diehl, Dan Fahey, Daniel Robicheau, Campaign against DU (CADU) and the Military Toxics Project. The contents of all the contributions are under the responsibility of the authors.

Laka Foundation
Amsterdam, The Netherlands
May 1999

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Depleted Uranium: a by-product of the Nuclear Chain

By Peter Diehl

Enrichment waste: Depleted uranium

For the use of uranium as fuel in light water reactors, the percentage of the fissile uranium isotope uranium-235 has to be raised from its value of 0.71% in natural uranium to a reactor grade of 3.2% (for Boiling Water Reactors - BWRs) or 3.6% (for Pressurized Water Reactors - PWRs). The enrichment technologies commercially available at present are the gaseous diffusion process and the centrifuge process. Both of them require the prior conversion of the uranium to the gaseous form of uranium hexafluoride (UF_6). The product stream of enriched UF_6 obtained is then converted to the form of UO_2 for further processing to nuclear fuel assemblies.

The enrichment process not only produces the enriched product, but also a waste stream of uranium hexafluoride depleted in uranium-235 ("depleted uranium"), typically to 0.3%. The degree of depletion of uranium-235 (the "tails assay") in this depleted uranium waste is a parameter that can be adjusted to economical needs, depending on the cost of fresh natural uranium and on the enrichment cost (expressed in $ per Separative Work Unit - SWU).

In the example shown, the depleted uranium waste stream is seven times larger than the enriched uranium product stream.

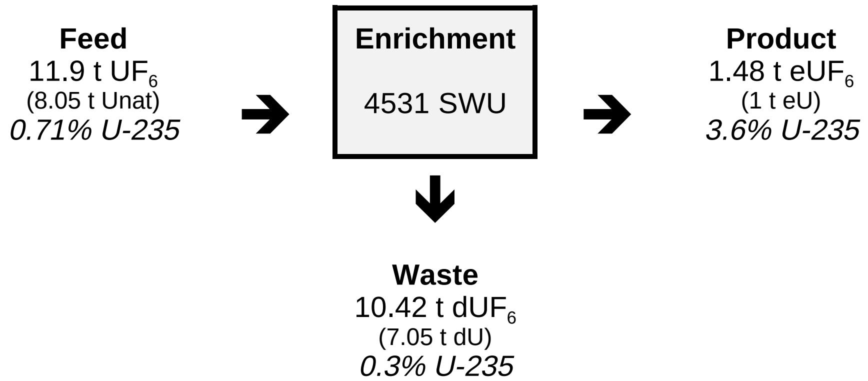
Cylinder storage of depleted uranium hexafluoride

Most of the depleted uranium produced to date is being stored as UF_6 in steel cylinders in the open air in so-called cylinder yards located adjacent to the enrichment plants. The cylinders contain up to 12.7 tonnes of UF_6. In the US alone, 560,000 metric tonnes of depleted UF_6 have accumulated until 1993; they are currently stored in 46,422 cylinders. Meanwhile, their number has grown by another 8,000 new cylinders.

At ambient temperature, UF_6 is a crystalline solid, but at a temperature of 56.4°C, it sublimates (becomes a gas). Chemically, UF_6 is very reactive: with water (atmospheric humidity!) it forms the extremely corrosive hydrofluoric acid and the highly toxic uranyl fluoride (UO_2F_2). The hydrofluoric acid causes skin burns, and, after inhalation, damages the lungs. Further health hazards result from the chemical toxicity of the uranium to the kidneys, and from the radiation of the uranium (an alpha emitter).

Mass balance of uranium enrichment
(per metric tonne of enriched uranium)

Assumptions:
- 3.6% product assay (for PWR), 0.3% tails assay



In the storage yards, the cylinders are subject to corrosion. The integrity of the cylinders must therefore be monitored and the painting must be refreshed from time to time. This maintenance work requires moving of the cylinders, causing further hazards from breaching of corroded cylinders, and from handling errors.

As a worst-case scenario, the crash of an airplane into a cylinder yard must be assumed. If cylinders are involved in long-lasting fires, large amounts of UF_6 can be released within a short time. If the whole contents of a cylinder is released during a fire, lethal air concentrations of toxic substances can occur within distances of 500 to 1,000 meters.

Civilian uses of depleted uranium

Historically, uranium has been used as a colouring matter in pottery. More recent civilian uses include the use of uranium as a steel-alloying constituent, and the use of several uranium compounds in chemical processes, for example as a catalyst. For its high density of 18.9 g/cm^3 (67% higher than that of lead and slightly lower than that of tungsten), uranium can be used in dense metal applications such as counterweights or flywheels. For example, the first 550 Boeing 747 aircrafts built utilized depleted uranium weights for mass balance of outboard elevator and upper rudder assemblies. But this use of depleted uranium in the form of uranium metal also included drawbacks: over 20% of these weights were corroded at each major aircraft overhaul and had to be reprocessed, although nickel and cadmium plated. In more recent aircraft designs, however, the use of counterweights has been minimized due to advanced design technology.

During the production process of uranium metal applications, the pyrophoric behaviour of small uranium metal particles constitutes a problem. These particles, such as finely divided metallic saw turnings and chips, sawdust, and abrasive saw sludge are capable of spontaneous ignition, and have caused many incidents. Inhalation of dust from fires involving uranium metal can cause high radiation doses.

Another possible use of depleted uranium based on its high density is the use in radiation shields: though an alpha-radioactive material itself, it is suitable for shielding penetrating gamma-radiation better than lead.

For all of the uses mentioned, it doesn't matter other than for use as nuclear fuel, that the uranium is depleted in uranium-235.

To date, none of the civilian uses of depleted uranium has brought an appreciable decrease of the existing stockpiles of this material. In the US, however, the Department of Energy (DOE), urged by the increasing maintenance problems of its cylinder yards, is now performing the first steps towards a large-scale civilian use of depleted uranium. The DOE's preferred alternative for the management of its 560,000-metric-tonne stockpile is to use the entire inventory of material in the form of metal or oxide, mainly for radiation shielding in casks for spent fuel and high-level waste, but also for other industrial uses to be developed. The depleted uranium, now contained at a few sites, would then be dispersed over a wide range of products. The DOE now plans to build two plants to convert the UF_6 to more stable forms that could be manufactured to marketable products or used for disposal, at costs of nearly $200 million each.

Long-term storage or disposal

The portion of the depleted uranium for which no use can be identified must be disposed of, or must be safely stored in the long term for possible future uses. According to the nuclear industry, changes in the market or new enrichment technologies might allow for an economical recovery of the residual uranium-235 still contained in the depleted uranium in the future.

For long-term storage or disposal, the depleted UF_6 must be converted to a less reactive chemical form: candidates are UF_4, U_3O_8, and UO_2. UF_4 has the advantage of being easily reconvertible to UF_6, while U_3O_8 is the most stable form, also existing as a natural mineral.

The depleted uranium long-term storage project at Bessines (France)

France's nuclear fuel company Cogéma is going to store 199,900 metric tonnes of depleted uranium at the site of the former uranium mill of Bessines-sur-Gartempe (Haute Vienne) near Limoges. The project was licensed on December 20, 1995.

This license was revoked by the Administrative Tribunal of Limoges on July 9, 1998, mainly for the reason that the depleted uranium had to be regarded as a waste under current conditions, though an extraction of the residual uranium-235 might be viable in the future.

On Nov. 5, 1998 however, a Bordeaux appeals court ruled that the material is no waste, but a "directly usable raw material that is effectively used for multiple uses". Following the court decision, Cogéma sent the first depleted uranium shipment to Bessines on Nov. 12, 1998.

Originally, Cogéma had applied for the storage of 265,000 tonnes, but during the hearings held on the project, it became obvious that Cogéma had "forgotten" to consider some radionuclides (artificial uranium-236, among others) in its calculation of the total activity inventory: the specific activity of the depleted uranium is 21,100 Bq/g instead of 15,902 Bq/g. The project would therefore have exceeded the 100,000 Curie ($3.7 \cdot 10^{15}$ Bq) limit, requiring a different type of license (Installation Nucléaire de Base) involving wider public participation. Cogéma was not able to provide a reasonable explanation for the presence of the uranium-236.

The depleted uranium is a residue of the Eurodif Tricastin gaseous diffusion enrichment plant in the Rhône valley. Its residual contents of uranium-235 is 0.2 to 0.3% and it has the chemical form of uranium hexafluoride (UF_6). Cogéma doesn't declare it a waste, but wants to store it for possible future use. Cogéma hopes that the stored depleted uranium can be useful, if future enrichment techniques would allow for economic extraction of the residual uranium-235, or if uranium prices would rise significantly.

For storage, the UF_6 is converted to the chemically more stable form of U_3O_8 at Cogéma's Pierrelatte facility. Then it is transported by rail to the Bessines site and stored as a powder in iron containers. The containers (8.5 or 11 tonnes each) are to be stored in 11 special storage buildings. Each building can store 2,500 containers. The maximum dose that an individual would be exposed to at the fence of the facility is calculated at 0.7 mSv (70 mrem) per year, far below the (extremely high) French limit of 5 mSv (500 mrem) for the public. The total investment is planned at 60 million French Francs (approximately US$ 10 million) over a period of 15 years.

Re-enrichment

Surprisingly, the recovery of the residual uranium-235 contained in the depleted uranium no longer is a matter of the future: it has been practised for several years now.

Depleted uranium from European uranium enricher Urenco (with plants operating in the United Kingdom, The Netherlands, and Germany) and others is now being enriched in Russia. The centrifuge enrichment plant of Minatom's Ural Electrochemical Integrated Plant (UEChK, formerly Sverdlovsk-44) at Novouralsk near Ekaterinburg is enriching tails for Urenco. Minatom, while further depleting ("stripping") Urenco's depleted uranium, produces uranium of natural contents (0.71%) in uranium-235. It thus *re-enriches* or *upgrades* the tails to natural uranium-235 grade. This product is then delivered back to Urenco for further enrichment to reactor grade. In 1996 alone, more than 6,000 metric tonnes of tails were upgraded. [*Nuclear Fuel,* October 6, 1997]

In the case of Figure 2 (see page 7):

- 9.5% of Urenco's initial natural uranium feed is recovered, thus lowering the need to mine fresh uranium,
- the recovery rate of natural uranium is 1.57 kg U per Separative Work Unit (SWU) spent at Minatom, and
- the amount of the depleted uranium tails decreases by 11%, not exactly an impressing figure.

The economics of tails re-enrichment

Assuming 1997 world market prices for uranium and enrichment services, the break-even point for tails upgrading according to the assumptions made above would be reached at a recovery rate of "natural" uranium of 2.63 kg U/SWU at Minatom. The obtained recovery rate of 1.57 kg U/SWU only reaches 60% of this value. So additional factors must be taken into consideration to understand the economics of re-enrichment.

1) Minatom possibly does not charge the full enrichment cost

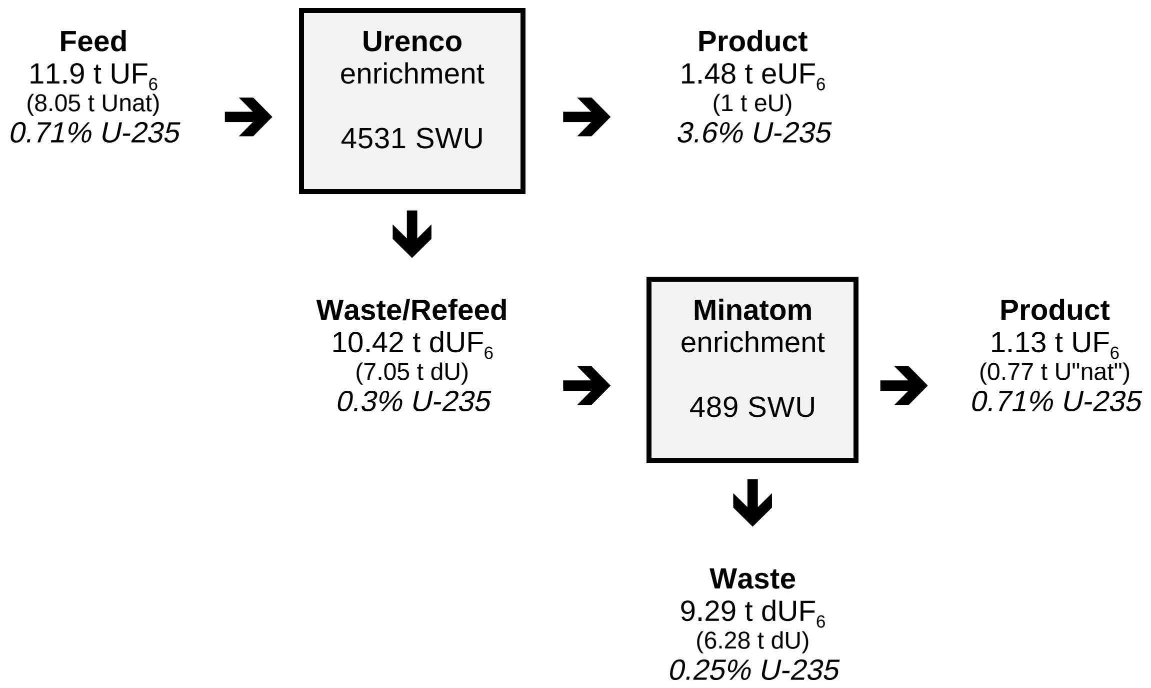
Minatom has an estimated 9 million SWU/year of enrichment capacity in excess of Russia's needs [*Nuclear Fuel* Oct. 19, 1998]. It is therefore possible that Minatom does not charge the full enrichment cost, but its operating cost only. The US DOE's *Engineering Analysis Report for the Long-Term Management of Depleted Uranium Hexafluoride* of May 1997 estimates operating costs of $20-$30/SWU for centrifuge enrichment plants (there are no such plants in the US though). With US$30/SWU, for example, the break-even point would be reached at 0.88 kg U/SWU. The obtained recovery rate is 78% higher for the case shown above. The highest absolute cost savings would be obtained at a tails assay of 0.21% at Minatom, in this case.

2) Minatom possibly strips the tails further than contracted

In case of Minatom not quoting the full enrichment cost, also another consideration can be made: According to George White, a consultant with Uranium Exchange Co., it is likely the Russians have contracted with Urenco to strip tails from 0.3% to 0.25% U-235. But the Russians are then probably stripping the tails further to 0.12% U-235 to produce uranium for their own account, White has suggested [*Nuclear Fuel*, Oct. 19, 1998].

Mass balance of re-enrichment
(per metric tonne of enriched uranium)

Assumptions:
- Urenco: 3.6% product assay, 0.3% tails assay
- Minatom: 0.25% tails assay



If Russia used all of its excess 9 million SWU/year to strip Urenco's tails in the described way from 0.3% to 0.12% U-235, then 7,290 tonnes/year of uranium of natural isotope composition would be recovered, 4,680 tonnes of which would be on Russia's own account.

In this case,
- 26.7% of Urenco's initial natural uranium feed would be recovered,

- the recovery of "natural" uranium were 0.81 kg U per SWU spent at Minatom, only slightly below the break-even point, assumed above for enrichment costs of 30 US$/SWU, and
- the mass of the depleted uranium tails would decrease by 30.5%.

This procedure also would be an explanation why Russia's uranium stockpile doesn't expire...

3) Urenco's avoided disposal cost

The new tails produced during the upgrading process remain in Russia, according to the answer of the German government to a parliamentary question in 1997. This, together with the fact that the upgrading process results only in a minor reduction of the amount of tails, gives reason to have a look at Urenco's avoided disposal cost.

Assuming market conditions, the tails upgrading does not make an economic sense, if the recovery of the uranium were its only purpose: the recovered uranium would be 68% more expensive than fresh uranium.

The re-enrichment does, however, make sense, if the avoided disposal cost for the tails are taken into consideration. For the German branch of Urenco, for example, disposal in the proposed Gorleben HLW deposit must be assumed, since the German LLW deposits don't allow for storage of such amounts of uranium.

The excess upgrading cost over the market value of the uranium recovered would be about 10% only of the storage cost at Gorleben.*1

Urenco's main purpose of the deal, therefore, seems to be to "solve" its waste management problem by transferring the depleted uranium to Russia.

The German Federal Government, however, stresses the results of an investigation it has conducted together with the governments of the United Kingdom and The Netherlands. The study has approved that the re-enrichment in Russia is not connected to a management of residues violating international rules, standards, or obligations.

Re-enrichment would also be an option for the management of the depleted uranium stockpile of the US DOE - in particular, since roughly 30% of the DOE inventory has a rather high tails assay in the 0.3 - 0.4% range. But, since there exist no low-cost enrichment plants such as centrifuge plants in the US, this option is not seen viable at present.

*1- These figures are based on 1997 market prices for uranium (11 US$/lb U_3O_8 and 34.2 US$/kg U as UF_6), and enrichment services (90 US$/SWU), a product assay of 3.6% (PWR grade) and a tails assay of 0.3% at Urenco, and an assumed tails assay of 0.25% at Minatom. The storage cost for a 200-liter barrel at the proposed Gorleben HLW deposit is estimated at 15,000 DM; the volume needed for disposal of the tails as UO_2 after cementation in barrels is estimated at 550 litre/t UO_2.

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Depleted Uranium Weapons: Lessons from the 1991 Gulf War

By Dan Fahey

The 1991 Persian Gulf War included an array of the twentieth century's most frightening and devastating weapons. Nuclear, chemical, and biological weapons were all poised for use, each with the ability to cause massive casualties among friend and foe alike. When hostilities subsided in March, 1991, the world breathed a collective sigh of relief that weapons of mass destruction had not been used. Or had they?

During the Gulf War, American and British forces introduced armor-piercing ammunition made of depleted uranium, a radioactive and toxic waste. By war's end, more than 290,000 kilograms (640,000 pounds) of depleted uranium contaminated equipment and the soil on the battlefields of Saudi Arabia, Kuwait, and southern Iraq.[1] Though investigations are ongoing and additional research is needed, it now appears that some veterans and civilians exposed to depleted uranium contamination are suffering health problems including kidney damage and cancers.

The use of a radioactive and toxic waste in ammunition heralds a dangerous new era in land warfare, one in which the line between conventional and unconventional warfare is irreversibly blurred. The increasing proliferation and use of depleted uranium weapons ensure their part in armed conflict for the foreseeable future. Accordingly, we must learn from the lessons of the use of depleted uranium weapons in the Gulf War and take steps to minimize and prevent the adverse effects on soldiers, civilians, and food and water supplies.

Depleted uranium (DU) is the waste product of the process to enrich uranium ore for use in nuclear weapons and reactors. Depleted uranium is chemically toxic like other heavy metals such as lead, but it is also primarily an alpha particle emitter with a radioactive half-life of 4.5 billion years.[2] The U.S. Army Environmental Policy Institute states "DU is a low-level radioactive waste, and, therefore must be disposed in a licensed repository."[3]
In the 1950's, the United States Department of Defense became interested in using depleted uranium metal in weapons because it is extremely dense, pyrophoric, cheap, and available in huge quantities in the United States.[4] During the 1960's and 1970's, research and open-air testing at various locations in the United States demonstrated the effectiveness of using depleted uranium in kinetic energy penetrators, which are rods of solid metal shot from guns. Kinetic energy penetrators do not explode; they fragment and burn through armor "due to the pyrophoric nature of uranium metal and the extreme flash temperatures generated on impact."[5] In the 1980's, depleted uranium was also developed for use in tank armor.

During Operation Desert Storm, American M1A1, M1, and M60 tanks and British Challenger tanks fired thousands of large caliber depleted uranium penetrators.[6] American A-10 and AV-8B aircraft shot hundreds of thousands of small caliber depleted uranium rounds.[7] American snipers shot 7.62mm and possibly .50 caliber depleted uranium bullets.[8] In addition, one-third (654) of the American tanks used in the war (2,054) were equipped with depleted uranium armor.[9] Depleted uranium penetrators enhanced the tactical advantage of American and British forces over the Iraqi Army's inventory of tanks, but the effectiveness of depleted uranium tank armor was never tested on the field of battle.[10] Iraq did not have DU armor or munitions in its inventory.[11]

Amidst post-war hype over the success of expensive, high tech weaponry, depleted uranium weapons received surprisingly little public praise from Pentagon and U.S. defense industry officials. A possible motivation for this cautious silence is expressed in pre-war U.S. Army reports which warned the use of DU weapons could have severe health and environmental consequences and create "adverse international reaction."[12] However, post-war reports have promoted a policy of "proponency" to guarantee the unrestricted use and proliferation of depleted uranium weapons. The Pentagon's focus on proponency has forestalled investigation and research of illnesses among veterans of the American-led expeditionary force and populations in southern Iraq possibly related to exposure to depleted uranium.

The lessons of the use of depleted uranium weapons in the Gulf War are unsettling, but understanding them will enable us to prevent or minimize the effects of depleted uranium weapons in the future.

LESSON 1: Depleted uranium weapons contaminate impact areas with extremely fine radioactive and toxic dust. U.S. Army testing found that 18 to 70% of a depleted uranium penetrator rod burns and oxidizes into extremely small particles during impact.[13] The impact of one 120mm depleted uranium penetrator fired from an American Abrams tank therefore creates between 900 and 3,400 grams (roughly 2 to 7 pounds) of uranium oxide dust. U.S. Army testing further found "[t]he DU oxide aerosol formed during the impact of DU into armor has a high percentage of respirable size particles (50 to 96%)," and 52 to 83% of those respirable size particles are insoluble in lung fluids.[14] Respirable size particles (less than 5 microns in diameter) are easily inhaled or ingested. Insoluble particles are not readily excreted from the body, and may remain in the lungs or other organs for years.[15]

U.S. Army research recently found that some respirable size uranium dust remains suspended in the air for hours after an impact.[16] As demonstrated in the 1970's by the release of depleted uranium during the manufacture of DU ammunition near Albany, New York, depleted uranium dust can be carried downwind for 40 kilometers (25 miles) or more.[17] Most of the dust created by an impact comes to rest inside, on, or within 50 meters of the target. However, U.S. Army testing also discovered depleted uranium dust can be resuspended by the wind, or the movement of people and vehicles.[18]

The long-term dangers of depleted uranium contamination are discussed in a U.S. Army Chemical School training manual:

> DU's mobility in water is due to how easily it dissolves. Soluble compounds of DU will readily dissolve and migrate with surface or ground water. Drinking or washing or other contact with contaminated water will spread the contamination . . . The end result of air and water contamination is that DU is deposited in the soil. Once in the soil, it stays there unless moved. This means that the area remains contaminated, and will not decontaminate itself.[19]

No cleanup of depleted uranium in the soil has taken place in Iraq or Kuwait. Surprisingly, the U.S. Department of Defense claims it tested soil in Kuwait and found no presence of depleted uranium contamination.[20] However, in 1995 and 1997, documentary film teams detected depleted uranium contamination on destroyed vehicles and in the soil in southern Iraq.[21]

In addition to the fine uranium dust created by impacts, depleted uranium fragments and intact DU penetrators also pose a hazard. In March, 1991, an internal U.S. Defense Nuclear Agency memorandum noted: "Alpha particles (uranium oxide dust) from expended rounds is a health concern but Beta particles from fragments and intact rounds is a serious health threat, with a possible exposure rate of 200 millirads per hour on contact."[22] One depleted uranium penetrator found in April, 1991 at the Port of Dammam, Saudi Arabia had a radiation reading of 260-270 mrad/hour.[23] The corrosion rate for a DU penetrator in soil depends upon the chemical makeup of the soil and other environmental conditions. Weathered DU penetrators principally corrode into uranium dust that is soluble in water.[24]

Established limits on intake of depleted uranium dust attest that just a small amount poses a serious health threat. The limit for intake by an occupational worker has been set at 0.01 gram/one week (U.S. Nuclear Regulatory Commission) and 0.008 gram/one year (UK Ministry of Defense). The limit on intake for a member of the public is set at 0.002 gram/one year (UK Atomic Energy Authority).[25]

The route of depleted uranium in the body depends upon the method of exposure (inhalation, ingestion, implantation, or wound contamination), and the size and solubility of the particles. Recent research found depleted uranium particles may remain in the lungs if inhaled, or travel in the bloodstream and deposit in the brain, kidney, bone, reproductive organs, muscle and spleen.[26] Insoluble depleted uranium particles (up to 83% by volume of the total dust created by an impact), if inhaled, "pose primarily a radiological, as opposed to a chemical, toxicological hazard."[27] In 1997, depleted uranium was found in the semen of five out of twenty two American veterans who had been wounded by depleted uranium fragments in 1991.[28]

Though additional studies on depleted uranium's health effects are needed, internalized DU is acknowledged to cause kidney damage, cancers of the lung and bone, non-malignant respiratory disease, skin disorders, neurocognitive disorders, chromosomal damage, and birth defects.[29] A July, 1990 report from the U.S. Army Armament, Munitions, and Chemical Command notes depleted uranium is a "low level alpha radiation emitter which is linked to cancer when exposures are internal, [and] chemical toxicity causing kidney damage."[30] In August, 1993, the U.S. Army Surgeon General's Office confirmed the "[e]xpected physiological effects from exposure to DU dust include possible increased risk of cancer (lung or bone) and kidney damage."[31] A June, 1995 U.S. Army Environmental Policy Institute report adds: "The radiation dose to critical organs depends upon the amount of time that DU resides in the organs. When this value is known or estimated, cancer and hereditary risk estimates can be determined."[32]

The end result of the use of depleted uranium weapons is contamination of damaged equipment and the environment with dangerous levels of depleted uranium dust and debris. Respirable size particles formed during impacts and soluble uranium oxide dust formed by corroding penetrators may be transported by the wind or water, and may contaminate food and water supplies. Friend and foe alike may inhale or ingest depleted uranium dust and suffer severe short and long term health problems.

LESSON 2: Armed forces are unlikely to be protected from exposure to depleted uranium contamination. As far back as 1974 – seventeen years before depleted uranium weapons were used in the Gulf War – a U.S. Department of Defense study group predicted: "In combat situations involving the widespread use of DU munitions, the potential for inhalation, ingestion, or implantation of DU compounds may be locally significant."[33] In July, 1990, a U.S. Army contractor further warned: "Aerosol DU exposures to soldiers on the battlefield could be significant with potential radiological and toxicological effects . . . Under combat conditions, the MEI's [most exposed individuals] are probably the ground troops that re-enter a battlefield following the exchange of armor-piercing munitions, either on foot or motorized transports."[34]

Despite the blunt admonitions of pre-war U.S. Army reports, no warnings about the dangers of depleted uranium were provided to the U.S. and coalition forces expected to encounter DU contamination on Gulf War battlefields. Combatants and support person-nel were not informed of the need to check soldiers' wounds for depleted uranium contamination, or told of the requirement to don full protective suits during contact with contaminated equipment and soil.[35] In violation of operative U.S. Army and U.S. Nuclear Regulatory Commission regulations, no medical testing or follow-up was provided to soldiers who were wounded by depleted uranium fragments, or who may have inhaled or ingested DU dust.

Though American military commanders have never offered an explanation for their failure to warn troops about the hazards of depleted uranium weapons, it appears their inaction was inspired by a desire to avoid creating concern within the ranks and among the public. After a 1992 inquiry, U.S. General Accounting Office investigators reported that "[U.S.] Army officials believe that DU protective methods can be ignored during battle and other life-threatening situations because DU-related health risks are greatly outweighed by the risks of combat."[36] When it became clear U.S. military commanders disregarded all DU protective methods during and after the Gulf War, the U.S. Army Environmental Policy Institute expressed concern about the costs of providing medical care to exposed veterans: "When DU is indicted as a causative agent for Desert Storm illness, the Army must have sufficient data to separate fiction from reality. Without forethought and data, the financial implications of long-term disability payments and health care costs would be excessive."[37]

In January, 1998, the U.S. Department of Defense expressed its first and only admission of responsibility for Gulf War depleted uranium exposures:

> Our investigations into potential health hazards of depleted uranium point to serious deficiencies in what our troops understood about the health effects DU posed on the battlefield . . . Combat troops or those carrying out support functions generally did not know that DU contaminated equipment, such as enemy vehicles struck by DU rounds, required special handling . . . The failure to properly disseminate such information to troops at all levels may have resulted in thousands of unnecessary exposures.[38]

A map released by the U.S. Department of Defense in November, 1998 shows both the primary areas where depleted uranium was released during the Gulf War, and the movements of hundreds of thousands of American and coalition fighting forces through these contaminated areas.[39] Though the U.S. Department of Defense admits "thousands" of American forces may have been unnecessarily exposed to depleted uranium contamination, it also asserts that not even one American veteran could possibly be sick from a depleted uranium exposure.[40]

The case of the July, 1991 munitions fire at the U.S. Army base in Doha, Kuwait illustrates the hazards of accidental releases of depleted uranium. Among the large quantity of equipment and munitions destroyed in the twenty-four hour fire were 660 tank rounds containing 3,200 kg (7,000 lbs) of depleted uranium. While the fire raged, the U.S. Central Command acknowledged that "…burning depleted uranium puts off alpha radiation. Uranium particles when breathed can be hazardous. 11ACR [The U.S. Army command at Doha] has been informed to treat the area as though it were a chemical area, i.e. stay upwind and wear protective mask in the vicinity."[41] Despite this and other warnings, U.S. soldiers were not informed of DU's hazards or instructed to wear protective gear, even during post-fire cleanup operations.[42] Further, the smoke from the fire drifted toward nearby Kuwait City, potentially exposing downwind populations to airborne depleted uranium.[43]

Adequately protecting armed forces from exposure to depleted uranium contamination requires training, use of protective suits in a contaminated environment, and distribution of radiation detection devices to medical personnel. Unfortunately, since cancers and other health problems related to a depleted uranium exposure may not develop until after a battle or war is over, military commanders have little incentive to adhere to safety procedures which could impinge on a soldier or Marine's battlefield performance. The Gulf War proved that military commanders will not be held accountable for the uncontrolled release of a radioactive and toxic waste, or for violating safety regulations requiring medical testing and care of exposed troops.

The 1991 Gulf War demonstrated that members of armed forces are unlikely to receive adequate protection from exposure to depleted uranium during or after future conflicts or accidental releases. In addition, governments are unlikely to provide long-term medical care for depleted uranium-related health problems among war veterans.

LESSON 3: Local civilian populations are unlikely to be warned when depleted uranium weapons are used – even if depleted uranium contaminates their food or water supplies. Prior to the Gulf War, the U.S. Army was aware of the potential for depleted uranium contamination to cause health problems among civilian populations. However, during and after the Gulf War, the U.S. Department of Defense took no steps to warn the inhabitants of Kuwait, Saudi Arabia and Iraq about depleted uranium contamination on their lands. In contrast, U.S. Army reports express more concern about public outcry and future restrictions on the use of depleted uranium weapons than with contaminating foreign lands and poisoning civilians.

A July, 1990 U.S. Army report predicted: "Following combat, the condition of the battlefield, and the long-term health risks to natives and combat veterans may become issues in the acceptability of the continued use of DU kinetic energy penetrators for military applications."[44] This concern was reiterated in March, 1991 just as the war was ending: "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 . . . I believe we should keep this sensitive issue at mind when after action reports are written."[45]

Once hostilities subsided and the scale of the depleted uranium contamination in southern Iraq and Kuwait became known, further concern was expressed by the U.S. Defense Nuclear Agency: "As Explosive Ordnance Disposal (EOD), ground combat units, and the civil populations of Saudi Arabia, Kuwait, and Iraq come increasingly into contact with DU ordnance, we must prepare to deal with the potential problems. Toxic war souvenirs, political furor, and post conflict clean-up (host nation agreement) are only some of the issues that must be addressed."[46]

In April, 1991, the United Kingdom Atomic Energy Authority also expressed concern about depleted uranium contamination in Kuwait:

> It would be unwise for people to stay close to large quantities of DU for long periods and this would obviously be of concern to the local population if they collect this heavy metal and keep it. There will be specific areas in which many rounds will have been fired where localized contamination of vehicles and the soil may exceed permissible limits and these could be hazardous to both clean up teams and the local population. . .Furthermore, if DU gets into the food chain or water then this will create potential health problems.[47]

Potential political problems were also noted:

> "The whole issue of contamination in Kuwait is emotive and thus must be dealt with in a sensitive manner. It is necessary to inform the Kuwait Government of the problem in a tactful way and this . . . is probably best done in conjunction with the UK Ambassador to Kuwait."[48]

The United States established a precedent during the Gulf War which permits an armed force to use depleted uranium weapons without warning civilian populations about contamination of the land. The United States is continuing this practice in the Kosovo war. Nations involved in conflicts in which depleted uranium weapons are used may find themselves faced with the "excessive" costs of long-term health care for exposed soldiers and civilians. The health and environmental consequences of depleted uranium weapons will likely receive less attention in nations where the populations are unaware of its use, or unable to voice their concerns and assert their rights.

LESSON 4: Depleted uranium weapons are proliferating and are likely to become commonly used in land warfare. A 1995 U.S. Army Chemical School training manual notes: "The United States' success with using DU in combat leads us to conclude that other nations, not all of them friendly, will be using DU in the future."[49] Further, "it is likely that DU may also become the primary tank-killing munition for our potential enemies . . . in the next battle, potentially all stricken tanks or fighting vehicles will possibly contain DU contamination."[50]

Another 1995 U.S. Army report notes: "Since DU weapons are openly available on the world arms market, DU weapons will be used in future conflicts . . . The number of DU patients on future battlefields probably will be significantly higher because other countries will use systems containing DU."[51] American soldiers and Marines are likely to be among the DU patients on future battlefields, as noted in a 1998 U.S. Department of Defense report: "DU's battlefield effectiveness has encouraged its steady proliferation into the arsenals of allies and adversaries alike. There is little doubt, therefore, that DU will be used against our troops in some future conflict."[52]

Since 1991, the United States has led the world in using and proliferating depleted uranium weapons. After Operation Desert Storm, the U.S. started using depleted uranium rounds in the M2 and M3 Bradley Fighting Vehicles (25mm), the Light Amphibious Vehicle (25mm), the Apache attack helicopter (30mm), and the AH-1W "Whiskey Cobra" helicopter gunship (20mm). In 1994 and 1995, American fighter planes fired depleted uranium rounds against Serb targets in Bosnia, and during training near Okinawa, Japan.[53]

In April, 1999, the US Department of Defense would neither confirm nor deny the use of depleted uranium ammunition by the A-10 aircraft in Kosovo.[54] Interestingly, however, the US Army stated the Apache helicopter would not fire depleted uranium rounds because their analysts determined high explosive rounds were sufficient to destroy Serb tanks.[55] Increased public and media interest in the use of DU weapons in the Kosovo war has evidently forced military commanders to reconsider their use of depleted uranium ammunition.

The growing list of nations possessing or manufacturing depleted uranium weapons includes the United States, the United Kingdom, France, Russia, Greece, Turkey, Israel, Saudi Arabia, Kuwait, Bahrain, Egypt, Kuwait, Thailand, Taiwan and Pakistan.[56] The 'interoperability' of NATO military forces could also enable armed forces throughout Europe to obtain and use depleted uranium weapons.

With little discussion or fanfare, depleted uranium weapons have found their way into the arsenals of nations powerful and poor in some of the world's most volatile regions. The U.S. Department of Defense anticipates the use of depleted uranium weapons in future conflicts, and increasing numbers of depleted uranium exposures among friend and foe alike. Long after the guns fall silent and the survivors march home, the casualties and costs of using depleted uranium weapons will continue to mount.

LESSON 5: Depleted uranium contamination is unlikely to be cleaned up by victor or vanquished because of the extreme cost and the prospect of further environmental damage. As noted by the U.S. Army, "[DU] contaminated soil . . . should be scraped up and containerized for removal as radioactive waste."[57] This is the procedure used in the United States during cleanup of depleted uranium contamination at the Starmet plant in Concord, Massachusetts (where DU penetrators are manufactured), and at Sandia National Laboratory and Kirkland Air Force Base in New Mexico (where DU penetrators were test fired).[58]

The U.S. Army states cleanup involves removing the "the top layer of soil,"[59] which could be potentially devastating to an environment, especially if depleted uranium contaminates arable land or wetlands. Further, the cost involved in removing the topsoil from contaminated areas could be astronomical. As an example, the cost of cleaning up and disposing of the estimated 69,000 kg (152,000 lbs) of depleted uranium dust and debris on 200 hectares (500 acres) of the U.S. Army's Jefferson Proving Ground in Indiana has been placed at $4 to 5 billion (U.S.$).[60] The cost of cleaning up 290,000 kg (640,000 lbs) of depleted uranium on thousands of hectares in Saudi Arabia, Kuwait, and Iraq could therefore easily be tens of billions of dollars (U.S.$).

A July, 1990 U.S. Army report warned: "Assuming U.S. regulatory standards and health physics practices are followed, it is likely that some form of remedial action will be required in a DU post-combat environment."[61] However, once the scale and cost of cleaning up depleted uranium in the Persian Gulf region became clear, the U.S. Army Environmental Policy Institute informed American policymakers that "no international law, treaty, regulation, or custom requires the United States to remediate the Persian Gulf War battlefields."[62] As the most powerful nation in the world today, the United States established a standard of behavior in the Gulf War which allows nations and armed forces to use depleted uranium weapons without taking any responsibility for cleanup, environmental restoration, or provision of health care to exposed combatants or civilians.

In the last hundred years since the first The Hague conference, the devastating results of war have been multiplied in proportion to the increased mobility of armed forces, and the unparalleled destructiveness of the weapons used. In the conflicts of the next century and beyond, huge expanses of land and countless numbers of soldiers and civilians may be poisoned by radioactive and toxic waste shot from armored vehicles, aircraft, small arms, and ships. Depleted uranium weapons are the offspring of nuclear weapons, and the newest weapon capable of causing mass destruction. If the international community accepts the use of depleted uranium weapons in warfare, it must also accept the moral obligation to fully address the health and environmental consequences, regardless of the cost.

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Gulf War Veterans and Depleted Uranium

By Dr. Rosalie Bertell, Ph.D., G.N.S.H.

Source of Exposure:

Uranium metal is autopyrophoric and can burn spontaneously at room temperature in the presence of air, oxygen and water. At temperatures of 200-400 degrees Centigrade, uranium powder may self-ignite in atmospheres of carbon dioxide and nitrogen. Oxidation of uranium under certain conditions may generate sufficient energy to cause an explosion (Gindler 1973). Friction caused by bullet or missile entry into a tank or armored car, for example, can cause the uranium to ignite, forming a concentrated ceramic aerosol capable of killing most personnel in the vehicle. Depleted uranium was used extensively in place of thungsten for ordnance by the US and UK in the Gulf War.

There is no dispute of the fact that at least 320 tons of depleted uranium (DU) was "lost" in the Gulf war, and that much of that was converted at high temperature into an aerosol, that is, minute insoluble particles of uranium oxide, UO_2 or UO_3, in a mist or fog. It would have been impossible for ground troops to identify this exposure if or when it occurred in war, as this would require specialized detection equipment. However, veterans can identify situations in which they were likely to have been exposed to DU. Civilians working at military bases where live ammunition exercises are conducted may also have been exposed.

Uranium oxide and its aerosol form are insoluble in water. The aerosol resists gravity, and is able to travel tens of kilometres in air. Once on the ground, it can be resuspended when the sand is disturbed by motion or wind. Once breathed in, the very small particles of uranium oxide, those which are 2.5 microns or less in diameter, could reside in the lungs for years, slowly passing through the lung tissue into the blood. Uranium oxide dust has a biological half life in the lungs of about a year. According to British NRPB experiments with rats, the ceramic or aerosol form of uranium oxide takes "twice as long" or about a two year biological half life in the lungs, before passing into the blood stream. [Stradling et al 1988]

Because of coughing and other involuntary mechanisms by which the body keeps large particles out of the lungs, the larger particles are excreted through the gastro-intestinal tract in feces. The uranium compounds which enter the body either through the wall of the gastro-intestinal tract or the lungs, can be broken down in the body fluids, and tetravalent uranium is likely to oxidize to the hexavalent form, followed by the formation of uranyl ions. Uranium generally forms complexes with citrate, bicarbonates or protein in plasma, and it can be stored in bone, lymph, liver, kidney or other tissues. Eventually this uranium which is taken internally is excreted through urine.

Presence of depleted uranium in urine seven or eight years after exposure is sufficient evidence to substantiate long term internal contamination and tissue storage of this radioactive substance.

Uranium is both a chemical toxic and radioactive hazard:

Soluble uranium is regulated because of its chemical toxicity, measured by damage to the kidney and tubules. Uranium is a heavy metal, known to cause uranium nephritis. Insoluble uranium, such as was released in the Gulf War, is regulated by its radiological properties, and not its chemical properties. Because of its slow absorption through the lungs and long retention in body tissues, its primary damage will be due to its radiological damage to internal organs rather than chemical damage to the renal system.

Obviously, both types of damage occur simultaneously, therefore it is a matter of judgement which severe damage, radiological or chemical, occurs at the lowest dose level. However, with the lengthening of the time during which the contaminant resides in the body and the low overall dose, the risk of cancer death becomes greater than the risk of significant damage to the renal system.

Uranium decays into other radioactive chemicals with statistical regularity. There-fore, in its natural and undisturbed state, it always occurs together with a variety of other radioactive chemical, some of the best known being thorium, radium, polonium and lead.

Natural uranium in soil is about 1 to 3 parts per million, whereas in uranium ore it is about

1,000 times more concentrated, reaching about 0.05 to 0.2% of the total weight. Depleted uranium concentrate is almost 100% uranium. More than 99% of both natural and depleted uranium consists of the isotope U-238. One gram of pure U-238 has a specific activity of 12.4 kBq, which means there are 12,400 atomic transformations every second, each of which releases an energetic alpha particle. Uranium 238 has a half life of 4.51 E+9 (or 4.51 times 10^9, equivalent to 4,510,000,000 years). Each atomic transformation produces another radioactive chemical: first, uranium 238 produces thorium 234, (which has a half life of 24.1 days), then the thorium 234 decays to protactinium 234 (which has a half life of 6.75 hours), and then protactinium decays to uranium 234 (which has a half life of 2.47E+5 or 247,000 years). The first two decay radioisotopes together with the U 238 count for almost all of the radioactivity in the depleted uranium. Even after an industrial process which separates out the uranium 238 has taken place, it will continue to produce these other radionuclides. Within 3 to 6 months they will all be present in equilibrium balance. Therefore one must consider the array of radionuclides, not just uranium 238, when trying to understand what happened when veterans inhaled depleted uranium in the Gulf War.

It should be noted that uranium 235, the more fissionable fraction which was partially removed in enrichment, makes up only 0.2 to 0.3% of the depleted uranium, whereas it was 0.7% of natural uranium. It is this deficit which enables one to use analytical methods to identify the uranium found in veteran’s urine as depleted and not natural uranium. The U 235 was extracted for use in nuclear weapons and nuclear reactor fuel. Depleted uranium is considered nuclear waste, a by-product of uranium enrichment.

The difference in radioactivity between natural and depleted uranium is that given equal quantities, depleted uranium has about half the radioactivity of the natural mixture of uranium isotopes. However, because of the concentration of the uranium in the depleted uranium waste, depleted uranium is much more radioactive than uranium in its natural state.

Uranium and all of its decay products, with the exception of radon which is a gas, are heavy metals. Unlike some other heavy metals which are needed in trace quantities by the human body, there is no known benefit to having uranium in the body. It is always a contaminant. Ingesting and inhaling some uranium, usually from food, is inescapable however, in the normal Earth environment, and we humans basically take in, on average, 5 Bq per year of uranium 238 in equilibrium with its decay products. This gives an effective radiation dose equivalent to the whole body of 0.005 mSv. Using a quantitative measure, we normally ingest about 0.000436 g a year.[UNSCEAR 1988, 58-59] This is a mixture of soluble and insoluble compounds, absorbed mostly through the gut.

Regulatory limits recommended by the International Commission on Radiological Protection [ICRP] assume that the maximum permissible dose for members of the public will be the one which gives the individual 1 mSv dose per year. This is in addition to the natural exposure dose from uranium in the food web. Assuming that this dose come entirely from an insoluble inhaled uranium oxide, and using the ICRP dose conversion factor for uranium 238 in equilibrium with its decay products, one can obtain a factor of 0.84 mSv per mg, or a limit of intake of 1.2 mg (0.0012 g) per year for the general public.

This would give an added radiation dose of 1.0 mSv from uranium, and an increase of almost 2.75 times the natural uranium intake level. Nuclear workers would be allowed by the ICRP maximum permissible level, to reach an annual dose of 20 mSv, comparable to an intake of 24 mg of uranium, 55 times the normal yearly intake.

The US has not yet conformed to the 1990 international recommendations which were used for this calculation, and it is still permitting the general public to receive five times the above general public amount, and the worker to receive 2.5 times the above occupational amount. The US may have used its domestic “nuclear worker” limits during the Gulf War, if it used any protective regulations at all. The military manual discusses the hazards of depleted uranium as less than other hazardous conditions on an active battle field!

The maximum dose per year from anthropogenic sources can be converted to the maximum concentration permissible in air using the fact that the adult male breathes in about 23 cu m air in a day [ICRP 1977]. The maximum permissible concentration in air for the general public would be: 0.14 microgram per cu metre, and for workers: 2.9 micrograms per cu m assuming the Gulf War situation of continuous occupancy rather than a 40 hour work week, and 8 hour day.

It is common in the US and Canada to refer to 2000 pounds as a "ton", whereas the British "ton" is 2240 pounds. Both are roughly 1000 kg. Just in order to understand the scale of the ceramic uranium released in Desert Storm, at least 300 million grams were "lost", and breathing in only 0.023 g would be equivalent to the maximum permissible inhalation dose for a nuclear worker to receive in a year under the 1990 recommendations of ICRP.

Medical Testing for Depleted Uranium Contamination:

Potential testing includes: chemical analysis of uranium in urine, feces, blood and hair; tests of damage to kidneys, including analysis for protein, glucose and non-protein nitrogen in urine; radioactivity counting; or more invasive tests such as surgical biopsy of lung or bone marrow.

Experience with Gulf War veterans indicates that a 24 hour urine collection analysis shows the most promise of detecting depleted uranium contamination seven or eight years after exposure. However, since this test only measures the amount of depleted uranium which has been circulating in the blood or kidneys within one or two weeks prior to the testing time, rather than testing the true body burden, it cannot be directly used to reconstruct the veteran's dose received during the Gulf War. However, this seems to be the best diagnostic tool at this time, eight years after the exposure.

Feces tests for uranium are used for rapid detection of intake in an emergency situation, and in order to be useful for dose reconstruction, must be undertaken within hours or days of the exposure. Blood and fecal analysis are not advised except immediately after a known large intake of uranium.

Whole body counting for uranium, using the sodium iodide or hyper pure germanium detectors, is designed to detect the isotope uranium 235, the isotope of uranium partially removed from depleted uranium. For lung counting, again it is the uranium 235 which is detected, and the minimum detection limit is about 7.4 Bq or 200 pCi. Since normally humans take in only 5 Bq per year, this is not a very sensitive measure. Seven or eight years after the Gulf War exposure, this method of detection is most likely useless for veterans.

Routine blood counts shortly after exposure, or during a chelating process for decontamination of the body are useful. This is not a search for uranium in blood, but rather a complete blood count with differential. This is done to discover potentially abnormal blood counts, since the stem cells which produce the circulating lymphocytes and erythrocytes are in the bone marrow, near to where uranium is normally stored in the body. The monocyte stem cells in bone marrow are known to be among the most radiosensitive cells. Their depletion can lead to both iron deficient anemia, since they recycle heme from discarded red blood cells, and to depressed cellular immune system, since monocytes activate the lymphocyte immune system after they detect foreign bodies.

Hair tests need to be done very carefully since they tend to reflect the hair products used: shampoos, conditioners, hair coloring or permanent waves. Pubic hair would likely be the best material for analysis. I am not aware of good standards against which to test the Uranium content of hair, or how the analysis would differentiate between the various uranium isotopes.

Testing of lymph nodes or bone on autopsy would be helpful. However, invasive biopsies on live patients carry no benefit for the patient and are usually not recommended because of ethical considerations about experimentation on humans. If a veteran is recommended for bronchoscopy for medical reasons, it would be advisable to also take tissue samples for analysis for depleted uranium.

When chelation processes have been initiated the rate of excretion of uranium in urine will be increased and there is a risk of damage to kidney tubules. Therefore careful urine analysis for protein, glucose and non-protein nitrogen is important. Some researchers have also reported specifically finding B- 2-microglobulinuria and aminoaciduria in urine due to uranium damage.

Relating Depleted Uranium Contamination with Observed Health Effects in Veterans:

There are two ways of documenting the radiological health effects of a veteran's exposure to depleted uranium. The first, and the one usually attempted in a compensation argument, would be to reconstruct the original dose and then appeal to regulatory limits or dose-response estimates available in the scientific literature. This methodology is not recommended for the Gulf War veterans, because the uranium excretion rate seven or eight years after exposure cannot be used to estimate the original lung and body burden of depleted uranium. Moreover, no dose-response estimates for the chronic health effects of such exposure are available from the literature, as will be seen later in this paper. Recognized dose-response estimates for radioactive materials are unique to fatal cancers (and even these are disputed). It is not clear whether regulatory limits for exposure to ionizing radiation apply in a war situation, or, if they do, whether the veteran should be considered to have been "general public" or a "nuclear worker". Beyond this, the question of whether international or US standards should be used for a multinational situation needs to be addressed.

The second methodology would require ranking veterans on an ordinal scale for their original exposure, based on their current excretion rate of depleted uranium. This involves the reasonable assumption that the original contamination, although not precisely measurable, was proportional to the current excretion rate. The analysis of a 24 hour urine sample, for example, could be rated on a specific research scale as having "high", "medium" or "low" quantities of the contaminate. By collecting detailed health and exposure data on each veteran, one can use biostatistical methods to determine firstly, whether any medical problems show an increase with the ordinal scale increase in exposure, determined through urine analysis; and secondly, whether there is a correlation between the descriptive accounts of potential depleted uranium exposure and the assigned ordinal scale determined on the basis of the urine analysis.

Using Non-Parametric Statistics one could determine the statistical significance of various medical problems being depleted uranium exposure related. This would undoubtedly eliminate some medical problems from consideration and highlight others. It could point to future research questions. It could also provide a fair method of dealing with the current suffering of the veterans using the best scientific methodology available at this time. Risk estimates based on radiation related cancer death are obviously unable to provide a reasonable response to current veteran medical problems.

Known Occupational Health Problems Related to Uranium Exposure:

In Volume 2 of the *Encyclopaedia of Occupational Health*, under uranium alloys and compounds, page 2238, it reads:

> "Uranium poisoning is characterized by generalized health impairment. The element and its compounds produce changes in the kidneys, liver, lungs and cardiovascular, nervous and haemopoietic systems, and cause disorders of protein and carbohydrate metabolism....... Chronic poisoning results from prolonged exposure to low concentrations of insoluble compounds and presents a clinical picture different from that of acute poisoning. The outstanding signs and symptoms are pulmonary fibrosis, pneumoconiosis, and blood changes with a fall in red blood count; haemoglobin, erythrocyte and reticulocyte levels in the peripheral blood are reduced. Leucopenia may be observed with leucocyte disorders (cytolysis, pyknosis, and hyperseg-mentosis). There may be damage to the nervous system. Morphological changes in the lungs, liver, spleen, intestines and other organs and tissues may be found, and it is reported that uranium exposure inhibits reproductive activity and affects uterine and extra-uterine development in experimental animals. Insoluble compounds tend to be retained in tissues and organs for long periods."

Human and Animal Studies on Uranium Exposure:

In a study of uranium toxicity by the US Agency for Toxic Substances and Disease Registry [ATSDR 1998], released for public review and comments by 17 February 1998, exposure times were divided into three categories: acute, less than 15 days; intermediate, 15 to 365 days; and chronic more than a year. Most of the Gulf War Veterans would have had chronic duration exposure from the point of view of the length of time the material remained in the body.
However, this ATSDR division was based on the duration of the presence of the external source of contamination, not its residence time in the body, therefore it would, in most cases be considered intermediate duration exposure. There is very little human research available to clarify the effects of intermediate duration exposure to humans.

It should not be assumed that lack of research implies lack of effect on that particular system. It should also be noted that although one or more paper may exist for acute and chronic duration exposures, these do not necessarily cover the questions which one might like to raise. No comments on the quality or extent of the research is implied by this table.

Health Effects which have been associated with inhalation of uranium:

The more soluble compounds of uranium, namely, uranium hexafluoride, uranyl fluoride, uranium tetrachloride, uranyl nitrate hexahydrate, are likely to be absorbed into the blood from the alveolar pockets in the lungs within days of exposure. Although inhalation products also are transported through coughing and mucocilliary action to the gastro-intestinal tract only about 2% of this fraction is actually absorbed into the body fluids through the intestinal wall.

Therefore all of the research papers on acute effects of uranium refer to these soluble uranium compounds via inhalation. The main acute effect of inhalation of soluble uranium compounds is damage to the renal system, and the main long term storage place of these compounds in the body is bone. These research findings do not apply easily to the insoluble uranium compounds to which the Gulf Veterans were exposed when the depleted uranium ordnance was used in battle.

The uranium compound used for ordnance is DU-metal. When it burns it forms uranium dioxide or less likely, uranium trioxide. Particles of these compounds smaller than 2.5 microns are usually deposited deep in the lungs and pulmonary lymph nodes where they can remain for years. According to research done in the UK by the NRPB, the ceramic uranium formed when uranium ignites through friction, as happened in the Gulf War. In this form, it is twice as slow to move from the lungs to the blood than would be the non-ceramic uranium dioxide. Of the portion of inhaled uranium oxide which passes through the gastro-intestinal tract, only 0.2% is normally absorbed through the intestinal wall. This may be an even smaller portion for ceramic uranium. This fraction of the inhaled compound can, of course, do damage to the GI tract as it passes through because it emits damaging alpha particles with statistical regularity. The residence time of the insoluble uranium compounds in the GI tract (the biological half life) is estimated in years.[ibid.]

The **chemical** action of all isotopic mixtures of uranium (depleted, natural and enriched) is identical. Current evidence from animal studies suggests that the chemical toxicity is largely due to its chemical damage to kidney tubular cells, leading to nephritis.

The differences in toxicity based on the **solubility** of the uranium compound (regardless of which uranium isotope is incorporated in the compound) are more striking: water soluble salts are primarily renal and systemic chemical toxicants; insoluble chemical compounds are primarily lung chemical toxicants and systemic radiological hazards. Once uranium dioxide enters the blood, hexavalent uranium is formed, which is also a systemic chemical toxicant.

It is important to note that there is no scientific evidence which supports the US Veteran Administration claim that the insoluble uranium oxide to which the Gulf War Veterans were exposed will be primarily a renal chemical toxicant. Yet this is the criteria which the VA proposes for attributing any health problems of the Veteran to depleted uranium. Intermediate and chronic exposure duration to insoluble uranium is regulated in the US by its radiological property. The slow excretion rate of the uranium oxide allows for some kidney and tubule repair and regeneration. Moreover, because of the long biological half life, much of the uranium is still being stored in the body and has not yet passed through the kidneys. The direct damage to lungs and kidneys by uranium compounds is thought to be the result of the combined radiation and chemical properties, and it is difficult to attribute a portion of the damage to these separate factors which cannot be separated in life.

There is human research indicating that inhalation of insoluble uranium dioxide is associated with general damage to pulmonary structure, usually non-cancerous damage to alveolar epithelium. With acute duration exposure this can lead to emphysema or pulmonary fibrosis (Cooper et al, 1982; Dungworth, 1989; Saccomanno et al, 1982; Stokinger 1981; Wedeen 1992). Animal studies demonstrate uranium compounds can cause adverse hematological disturbances (Cross et al. 1981 b; Dygert 1949; Spiegel 1949; Stokinger et al 1953).

Important information from a chart developed by ATSDR [referenced earlier] is reproduced here, the reader will find all of this information and the references in the original document.

With respect to ORAL exposure, there is no human data but a great deal of animal data. This was not as likely a pathway in the Gulf War as was inhalation, but possible contamination of food and water can not be totally ignored. DERMAL exposure was researched in humans only in the acute duration of exposure case. Animal studies on dermal exposure include acute, intermediate and chronic duration of exposure, and immunologic/-lymphoreticular and neurologic effects.

Availability of Human (H) or Animal (A) Data for the Presence of a Particular Health Effect after Exposure via Inhalation to Insoluble Uranium

Effect on body system studied:	Effects of acute duration exposure (less than 15 days)	Effects of intermediate duration exposure (15 days to 1 year)	Effects of chronic duration exposure (more than 1 year)
Respiratory	H: rales, slight degeneration in lung epithelium; hemorrhagic lungs [1] A: severe nasal congestion, hemorrhage; gasping in 100% [2]	A: slight degenerative changes in lung;[3] pulmonary edema; hemorrhage; emphysema; inflamation of the brochi; bronchial pneumonia; alveoli and alveolar interstices; edematous alveoli; hyperemia and atelectasis.; lung lesions; minimal pulmonary hyaline fibrosis and pulmonary fibrosis.[2]	A: minimal pulmonary fibrosis [3] Lung cancer in dog [3]
Hepatic		A: moderate fatty livers in 5 of 8 animals that died; focal necrosis of liver.[3]	A: increased bromosulfalein retention [2]
Hematological	A: increased macrophage activity; increased plasma prothrombin and fibrinogen.[3]	A (increased percentage myeloblasts and lymphoid cells in bone marrow; decreased RBC; increased plasma prothrombin and fibrinogen; increased neutrophils ; decreased lymphocytes)	A: lengthened blood clotting time, decreased blood fibinogen [2]
Gastro-intestinal	H: anorexia, abdominal pain, diarrhea, tenesmus or ineffective straining, and pus and blood in stool [1]		A: anorexia; vomited blood; ulceration of caecum.[1],[6]
Renal	H: proteinuria, elevated levels of NPN, aminoacid nitrogen/creatinine, abnormal phenol-sulfonphthalein excretion. Increased urinary catalase; diuresis.[1] A: Proteinuria, glucosuria and polyuria; severe degeneration of renal cortical tubules 5-8 days post exposure. [2]	A: diuresis, mild degeneration in glomerulus and tubules. [3] proteinuria, increased NPN.[3] minimal microscopic lesions in tubular epithelium [1]	A: slight azotemia [4] slight degenerative changes [3] minimal microscopic lesions [1], [5],[6] tubular necrosis and regeneration [6]
Cardiovascular			
Musculo-skeletal		A: severe muscle weakness; lassitude [3 with F].	
Endocrine			
Metabolic			
Dermal			
Ocular	A: conjunctivitis [2]	A: eye irritation [2]	

Body Weight		A: 26% decrease in body weight; 14% decrease at 22 mg / cu m air; [1], [3] 12% decrease at 2.1 mg/cu m air.[2] 2.9 to 27.9% decreased body weight guinea pig [6]	
Other Systemic		A: weakness and unsteady gate, [1] minimal lymph node fibrosis.[3] rhinitis [1]	A: minimal lymph node fibrosis [3] lung cancer (dog) [3]
Mortality	A: 20% for dogs at 2 mg per cu. m air [2] A 10% rat and guinea pig [4] 17% dog [4] 60% rabbits [3] 67% rabbits [4]	A: 4.5% mortality dog [3]	

[1] Uranium tetrafluoride, UF_4, insoluble in water.
[2] Uranium hexafluoride, UF_6, soluble in water, highly chemically toxic.
[3] Uranium dioxide, UO_2, insoluble in water, highly toxic and spontaneously flammable, used in ordnance in place of lead in the Gulf War.(Also called uranium oxide.)
[4] Uranium trioxide, UO_3, insoluble in water, poisonous, decomposes when heated. (Also called uranium oxide.)
[5] Uranyl Chloride, UO_2Cl_2, uranium oxide salt.
[6] Uranium Nitrate, $UO_2(NO_3)_2.2H_2O$, soluble in water, toxic and explosive.

Mortality Within 30 Days of Exposure:

The lowest acute duration lethal dose observed, with exposure to the soluble uranium hexafluoride, was 637 mg per cu metre of air. No acute dose deaths were found using insoluble compounds. Since there were acute deaths in the Iraqi tanks in persons not directly hit, one can assume concentrations of uranium aerosol were greater than this amount. It should also be noted that it was the radiation protection units of the military which designated these contaminated tanks off bounds. They were acting because of radiological (not chemical) properties of the aerosol.

The intermediate duration exposure, 15 to 365 days, dose level for mortality with insoluble uranium oxide, was 15.8 mg per cu metre of air. With soluble uranium hexachloride it was much lower, 2 mg per cu metre air. The dose resulting in lung cancer in the dog study, with chronic duration inhalation of the insoluble uranium oxide, was 5.1 mg per cu metre air, for 1 to 5 years, 5 day a week and 5.4 hours a day.

Systemic Damage:

Damage to body organs occurred with intermediate or chronic exposure at doses as low as 0.05 mg per cu metre air. A generally sensitive indicator of exposure seems to be loss of body weight. However this finding is sometimes attributed to the unpleasant taste of the uranium laced food given to animals. There is also damage to the entrance portals: respiratory and gastro-intestinal systems; and the exit portals: intestinal and renal systems. Uranium oxide was associated with fibrosis and other degenerative changes in the lung. It was also associated with proteinuria, and increased NPN (non-protein nitrogen) and slight degenerative changes in the tubules. The more severe renal damage was associated with the soluble compounds uranium tetrafluoride and uranium hexafluoride (not thought to have been used in the Gulf War ordnance).

Focal necrosis of the liver was only associated with uranium oxide. This may be a clue to one of its storage places in body tissue. Uranium oxide is also associated with hematological changes, lymph node fibrosis, severe muscle weakness and lassitude at intermediate or chronic dose rates in 0.2 to 16 mg per cu metre air.

None of the uranium research dealt with the synergistic, additive or antagonistic effects potentially present in the Gulf War mixture of iatrogenic, pathological, toxic chemical and electromagnetic exposures.

Potential US Government administration of radio-protective substances to combat military:

It is obvious that the US had some expectation of the health effects related to using depleted uranium ordnance in the Gulf War. This is evident based on military research and manuals. They would also have had access to information on chemical and biological agents which could protect against some of the harmful side effects. These agents might also "confuse" the toxicology of this exposure. Some potential radio-protective agents are thiols (also called mercaptans, these are organosulfur compounds that are derivatives of hydrogen sulfide), nitroxides (used as a food aerosol and an anesthetic), cytokines (non-antibody proteins released by one cell population, e.g T-lymphocytes, generating an immune response), eicosanoids (biologically active substances derived from arachidonic acid, including the prostaglandins and leukotrienes), antioxidants and modifiers of apoptosis (fragmentation of a cell into small membrane bound particle which are then eliminated by phagocytes).

Just in case this is the reality and not merely a suspicion, it would be good to examine the after effects of exposure to ceramic depleted uranium in Iraqi veterans and in the survivors of the El Al crash near Schiphol Airport, Amsterdam. It is unlikely that these two populations were given any protective agents.

Proposal for assisting the Gulf War veterans:

In keeping with the above findings, it is proposed to undertake an analysis of both questionnaire and clinical data for a sample of each of the following populations: US, Canadian and British Gulf War veterans or civilian base workers exposed to DU; US, Canadian and British military personnel not exposed to DU; Iraqi Veterans exposed to DU; Iraqi Veterans not exposed to DU; and firemen and civilians exposed to the El Al crash.

Sampling strategy and sample size to be determined.

Each participant should complete a questionnaire covering general background variables, exposure profile and medical problems and symptoms. Each participant will agree to collect a 24 hour urine sample for analysis, and to take 500 mg blue-green algae (Spirulina) 48 hours before beginning the collection. This is a mild chelating agent. Each participant will agree to the analysis of this data for the benefit of all exposed persons, and to the release of the results of the analysis without identifying characteristics for individuals.

All questionnaire data will be entered into computer using Epi Info Software (WHO) and transferred on disc to the Biostatistical Support Unit of the University of Toronto for analysis.

Research Hypotheses to be tested: (to be written as a null hypothesis)

> There will be a high correlation between the questionnaire exposure estimates and the level of depleted uranium found in urine.
>
> Medical problems related to damage of the blood and/or hepatic systems will show an association with exposure data and urine sample analysis for depleted uranium.

Preliminary work to be accomplished:

- Identification of principal investigators for each identified study group.
- Development of a Grant Proposal, including the null hypotheses and protocols.
- Development of a budget for each population study group.
- Agreement of the Research team to undertake the study.
- Raising of funds or assignment of costs for the study.
- Identification and training of data entry processors for each group.

Benefits for Participants:

In addition to the general benefits to be obtained by clarifying the health effects of exposure to this toxic material, especially in the ceramic form experienced in the Gulf War, each participant testing positive for DU in a urine analysis will be assisted to enter a chelating process to remove as much as possible of the contaminant from the body.

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The next testing site for Depleted Uranium weaponry

By Daniel Robicheau, Desert Concerns

During the Gulf War, munitions and armour made from depleted uranium (DU) were used for the first time in military action. Since they proved unmatchable in their armour piercing capacity and are very cheap, uranium waste, they became the weapon of choice. They were further used in Bosnia and presently in Yugoslavia.

The US military, like the British military, do not hide the fact that they use DU weapon systems. The US Army has the A-10 Thunderbolt II, nicknamed "the Warthog", responsible for most of the fired DU munitions during the Gulf War. They have the M1A1 Abrams tank and the new M1A2 Abrams tank, the Marines the M-60, the Navy the Phalanx missile. Many cruise missiles contains DU balance weights. The British have the Challenger tank. And now for their latest testing scenario for DU weapons systems in the Balkans, British Harriers can fire DU. The US F-16 has been modified to fire DU. The increasing number of US Apache helicopters deployed to the region can now fire DU rounds. Most of these weapons systems are now deployed in the neighbouring countries around Yugoslavia.

No, the use of DU weaponry is not being covered up. What is being covered up are the effects of DU on the health of people and their environments. The Clinical Chief of the Department of Nuclear Medicine of the US Veterans Administration, Dr. Asaf Durakovic, was terminated from his position after diagnosing DU contamination of some of the 24 sick US Gulf War Vets sent to him by the military soon after the war ended in 1991; two of the soldiers who were referred to him for observation later died from unknown causes. In December 1998, the homes of two British Gulf War Vets were raided by the Ministry of Defence Police and their computer equipment confiscated. The apparant object for the raid was a search for documents obtained by the Vets that showed that the Ministry of Defence was carrying out its own research into the effects of DU contamination of Gulf Vets which it did not want the general public know about.

Throughout 1998 and into 1999, Dr. Hari Sharma of the University of Waterloo, Ontario, Canada, conducted tests using new techniques for the presence of DU in Gulf Vets and found DU contamination in the urine of his subjects 8 years after the end of the war, contrary to the MoD and DoD'd assertion that DU passes through the body very quickly. And recently, representatives from the Defense Departments of five countries (England, US, Australia, New Zealand and Canada) coordinated their enquiries and jointly interviewed Sharma, intent on knowing what techniques he had used in testing for DU, his methodology of analysis, and findings.

In the Gulf more than a million rounds were fired, between 300-800 tons being consumed in 1991 alone. When a DU penetrator hits its target, it explodes and vaporises. From 10-70% burns up and forms micrometer-size uranium oxide particles that can be inhaled or ingested. The fall-out of uranium aerosol is virtually unlimited. In the fine sand of the Gulf, uranium micro-particles, because they are electrically charged attach themselves to the sand, and remain suspended in the air for very long periods. Wind storms will resuspend the settled particles and transport them to new locations far and wide. There is a noted massive rise in cancers in Saudi-Arabia, in most of the Emirates all the way to Bahrain. Incalculable collateral damage to veterans, civilians, and neighbouring countries, now and for all future generations is the result of using radioactive weapons. Nuclear explosions cause massive damage at the time, while radioactive weapons cause more prolonged devastation to humans and the environment for tens of years, or maybe till the end of time, since the half life of DU is the life of the solar system.

All over Iraq but especially in the South, there has been a sixfold rise in cancers of all kinds, but especially leukaemias and lymphomas. Birth defects from being a rarity have become so common that there can be three children in one family with birth defects. Plants and animals are also showing signs of genetic mutations. British and American veterans show very similar disorders.

In a veterans community in Mississippi, 67% of the children were born without eyes, ears, brain, thyroid and other organ malformations. In Bosnia after the NATO war, there was a massive rise of instant deaths for huge numbers of people in the war zone (acute radiation poisoning). Alterations in plant, animal and a horrendous rise of birth defects has been reported. Veterans with Gulf War Syndrome report symptons similar to the Iraqi and Bosnian groups, namely multiple organ failure, AIDS like syndrome with very low immunity. There are multiple causes from chemical and bacteriological pollutants in the war zone, but definitely DU with its radiological and chemical toxicity is one of the main culprits.

Knowing that DU on exposion forms insoluble particles of uranium oxixe that can be inhaled, the particles would lodge in the lung for long periods of time (depending on the biological half life). Uranium and its daughter products radiate the lung killing and mutating neighbouring cells. Some particles get washed into the blood, causing devastating effects all over the body but mainly to the reproductive system and the bone marrow (rapidly dividing cells). This results in the birth defects and the anaemias, leukaemias and immune deficience disorders.

We tested urine samples from 30 veterans from the USA, UK, Canada and Iraq. Their locations covers the whole of the ground war region. The samples were analysed for isotopic composition of uranium isotopes by the delayed neutron activation method and confirmed by surface ionization mass spectometry.

All those tested showed DU in their urine with values ranging between 3-18 micrograms for a 24 hour period. The values collorated positively with where they were located, whether their job entailed travelling between sites (more exposure) and how long they stayed in the Gulf. It also matches perfectly the morbidity and mortality picture.

Samples from the population of Baghdad and Basra were also tested. They also show the presence of DU in the urine over the whole geographical regions. The risk factor from exposure to the oxide inside the lungs depends on the biological half life (time tissues remain irradiated). The half life seems much longer that suggested by the DoD.

It is more likely 10 years or longer instead of the mentioned 500 days. Six to ten percent, ie. 36,000 of the 600,000 veterans exposed would succumb to fatal cancers. In Basra the percentage could be much higher since people are continuing to breath, drink and eat radio-active material. The risk factor could be 20% or even higher. The tests were carried out in three labs.

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Depleted Uranium

The thoughts of the first British Gulf War Veteran to be tested for, and found to be poisoned with depleted uranium.

By Ray Bristow

On learning that I had tested positive for depleted uranium not only was I devastated but my wife and family too, it was like having a real smack on the chin. Quite naturally I imagined all sorts of cancers etc. developing; I have seen some horrendous carcinomas in the 20 years that I have worked in Operating Theatres as a Technician.

After the initial shock, it sank in, and I was horrified at what has actually happened. To some it up; the Coalition Forces stood shoulder to shoulder against a tyrannical regime, a regime that we were aware had an arsenal of weapons of mass destruction together with the knowledge that not only had those weapons previously been used, but used against their own people. A committee of the United Nations has already declared that depleted uranium is a weapon of mass destruction.

The British and American Forces were the only forces during the Persian Gulf War to use depleted uranium to increase the effectiveness of their armour piercing shells. This has not only left a terrible legacy of cancers with the Iraqi casualties who survived conventional wounds. The contamination of thousands of our own troops with depleted uranium must make this the Greatest Friendly Fire incident in the history of warfare. It has also left a terrible legacy much worse than any land mine for the civilian population.

It is an outrageous scandal that depleted uranium was ever used, it was not necessary, it was over-kill, and was not worth the cost to the Soldiers Health. I cannot in any way accept that the Ministry of Defence (MoD) would not have been aware of the consequences following the use of depleted uranium. In my eyes this puts the British and American Governments in the same league as the regime we were sent to fight, one that is willing to use a weapon of Mass Destruction that has serious heath consequences against their own people and for what? To stabilise the price of oil, that's what! Just what kind of society is Britain? I don't know anymore.

Veterans now require the Medical Practitioners of the National Health Service to take their illnesses seriously and not to discount everything unknown as psychological. Veterans are being denied the health care to which they are entitled because Medical Practitioners are being deliberately misled and having vital information withheld by the MoD.

It is about time that those responsible for this continuing outrage in the MoD are held accountable and the Gulf Veterans Illness Unit is run by civilians and overseen by Professor Malcolm Hooper, one of the few people Gulf Veterans trust. I would also like to see that both the MoD and the War Pensions Agency stop the deliberate bullying of ill veterans and ensure that they receive their full pension entitlements. Also an apology from the MoD, DoD, British and American governments wouldn't come a miss either.

Raymond Bristow, Former Warrant Officer, 1st Field Surgical Team, 32 Field Hospital, Royal Army Medical Corps, Saudi Arabia, January to March 1991.

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The health of the Iraqi people

Felicity Arbuthnot, journalist

United Nations sanctions imposed on Iraq since August 1990 are described even by UN officials as unique in ferocity. Prior to 1990, according to World Health Organization figures, the population had 92% access to high quality free health care in some of the finest hospitals in the Middle East, 93% access to clean water, high nutritional status and a free education system described as unique by UNESCO, since of standard such that a child born into abjects poverty could leave graduate school as a doctor, engineer or architect. Nine years on, the human toll taken by the sanctions is on a unparallelled scale. "We have a new phenomenon", remarked one doctor. "People are just dying, they are not ill, they just give up - especially young men between the ages of about 30 to 35, their youth has been sacrificed to the sanctions, and they see middle age approaching with no hope, dreams, aspirations or ability to provide for those they love."

I had telephoned Mustafa from Jordan, old friend, gentle academic, whose childlike joy of life illuminated every experience. During the December 1998 bombing his voice broke as he described the destruction of some of the most ancient buildings - world heritage sites - in his beloved Baghdad. Mustafa always celebrated my arrival with an aubergine dish to dream of. Surprisingly the call connected immediately and Doha, his daughter, answered: "I'm on my way, get the aubergine ready...". There was a silence, then: "We have had a catastrophe, Mustafa is dead." He had died five minutes earlier. A month before he had undergone a full medical and been told he had 'the heart of lion'. "He was haunted by the thought we would be bombed again after the Ramadan and he had no way to protect us" said Nasra, his wife. He died on 17th January, the anniversary of the start of the Gulf War.

He was buried within twelve hours in accordance with Islam. Since the bus from Amman took 20 hours (flights are vetoed by the UN Sanctions Committee), I could only attend the mourning - a four day grieving of an intensity defying description. Friends, relatives colleagues called, shared the pain. When Nasra, feisty, gutsy, witty, beautiful and beloved friend entered, she was unrecognisable: 'the weight of grief' encapsulated. "It is killing us all, one by one', she gasped, "we lost five friends this year." All were under forty, all had 'just died'.

Bashir. Where ever one looked was the manifestation of his statement. Six month old Yacoub Yusif, with his small hand twisted at the right angle, with no thumb on his small foreshortened right arm, was comparitively lucky. Six year old Mustafa Ahmed with his bright, intelligent face and great dark eyes had gross deformities of all his stick like limbs, of his facial bones, his hands pathetically turned. Sitting on the examination table like a frail broken doll he said: "I van write." Hunched over, a tiny piece of pencil (pencils are vetoed by the Sanctions Committee, since they contain graphite) and minute square of paper (also vetoed) he wrote, the stub clutched between his knucles, in beautiful Arabic, laughing with triumph at his achievement.

Ali Samir, seven, shuffled in like a tiny, bird like old man, the expression in his eyes was of one who has seen all the trials of the world. He was covered with head to toe ulcerations which as they healed tightened his skin - or ruptured. His fingers were turned inwards, seared in to his palms, he had no toes. When his gay 'Route 97' top was liften up, the terrible, searing ulcerations on his back brought tears to the eyes. "Surgery is counter indicated, since he won't heal - this is a genetic malformation caused by environmental changes in pregnancy' said Consultant, Dr. Harith. The Zafaranya district of Baghdad where he lives was bombed relentlessly in the Gulf War and a nuclear reactor reportedly hit. It was bombed again in 1993 and Ali was still recovering from this terror in the December bombings when the district was hit again. He too could write and did so with pride - but he was unable to tell us - he had no tongue.

In the southern, beautiful, relentlessly bombarded city of Basrah where the biblical Tigris and Euphrates rivers meet the Shat Al Arab, the state of health takes another dimension again. One doctor has completed a thesis comparing the congenital abnormalities, cancers and malignancies since the Gulf War with Hiroshima. Dr. Jenan Ali has been keeping a record of 'mysterious' congenital anomalies. Her photographs for 1998 were chilling. Full term babies undeveloped, the so-called 'bunch of grapes' babies reminiscent of the nuclear testing areas of the South Pacific. A baby with no face, another with no eyes, twisted limbs, or no limbs. A tiny mite with a huge head - and no brain. Page after page of tragedy. "All young parents, with no history of abnormalities in the family as far as we can tell - since we have few laboratory facilities now" further, many she felt "not recorded in the text books - but we cannot be sure since we have had no text books since 1990." (Text books and medical journals are vetoed by the UN Sanctions Committee.)

There were haunting human tales of the December bombing. Jameel, father of Zena a teenager who has severe psychological problems linked to her terror in the Gulf War, when she was six, recountered another tragedy. Zena was inseperable from her cat Sudar (Sugar). It slept by her, ate with her, followed her every move. Sudar shared her most intimate secrets, quietly purring with pleasure at every contact. When the bombing started, Sudar lost her mind, tearing around the garden, attacking, defying all attempts to catch and comfort, tearing and scratching at Zena in her terror. Sudar is still mindless and Zena inconsolable.

"There is something else, which I hope won't affend you", said Jameel. "We had seven children in out house during the bombing, the youngest 6 months, the oldest 7 years. Their terror was such that when the bombs stopped, we were left in the dark (the electricity sub-station was reportedly hit again) with great pools of urine and faeces."

At the Saddam Paediatric Hospital Sahara, aged 3, was dying. She had acute myeloid leukaemia and was bleeding internally from the nose and gums. She needed 10-15 units of platelets a day - the doctors could obtain just one. "In the UK and US leukaemia is a treatable disease, yet due to a lack of chemotherapy we have not achieved one cure - only some remissions - in the last eight years" said Dr. Rad Aljanabi, Chief Resident. "In '94, '95 and '96, we had no treatment at all, so every single patient died." Iraq's cancer, leukaemia and malignancy rate has risen up to sevenfold since the Gulf War, a rise associated with the depleted uranium weapons used primarily by the US and UK, which left a residue of radioactive dust throughout the country, which according to studies, including by John Hopkins University in the US has entered the food chain via the water table and soil.

Leukaemias were a rarity prior to 1991: "This is my first residency" said one doctor. "I saw 39 new cases in three months. I admitted eight in the last month, I remember all their names. We are suffering, the patients are suffering - I cry so often." He wrote down their names: Hussein, Tuness, Mahmood, Tabarik - 11 months old - Lara, Hussan and Sahira. The oldest was 4 years. There were other horrors. Heider Latif, 5 years old, weighing just 13 kgs. Starvation, multiple congenital abnormalities, cancers, heart defects, leprosy, water borne diseases: death stalks Iraq's children from the moment of birth.

Cases at the Centre for Reconstructive Surgery would break a heart of stone. "We are seeing an astonishing rise in even the rarest of abnormalities' said British trained plastic surgeon Professor Ala. "I can show you a baby born one hour ago if you are strong and not prone to fainting" said Dr. Janeen.

A nurse brought in a small bundle wrapped in cloth - sterile wrappings, baby clothing is just a memory in another formerly internationally renowned hospital. Unwrapped the tiny being, making a little bleating noises, had no eyes, no nose, a sweet little mouth, but no tongue or osophegus, no hands or genitalia. Hopelessly twisted small legs were joined together from the knees upwards by a thick 'web' of flesh. "We see many similar" commented Dr. Janeen.

In the maternity unit, midwife Bushra Nasser said: "My colleague delivered the baby you saw, I am frightened of what I might deliver." With no ultra sound or scanning facilities (vetoed) there is no knowledge until birth. "Sometimes the mothers attack us in their agony." In the event, the baby we watched born was a healthy eight pounds - but the conditions so insanitary, without hot water, with cockroaches crawling over the metal of the delivery bed - disinfectant is vetoed, electricity and thus water heating off eighteen hours a day - odds were stacked against him from the moment of birth. When mothers ask: "Is it alright?" there is terror in the question. Some soil samples in areas of Basrah show 84 times (sic) background radiation from uranium elements.

Twentyfive percent (sic) of babies are now born prematurely or of premature weight due to malnutrition and/or environmental factors. There is no oxygen, no incubators working at optimum capacity, no rehydration, no gastronasal nutrition. As we stood in the premature unit, containing 17 babies the doctor remarked: "We have not had one premature weight birth survive since 1994." I looked round the ward at each small life, at twins sharing an incubator, noted each face and tiny form. Each is by now almost certainly now another statistic in embargo-related deaths.

There are three unforgettable incidents. A doctor running up and saying: "Do any of you" (photographer Karen Robinson, myself and our interpreter) "have O-negative blood?" A newly born baby, bright yellow, with acute jaundice would die without an exchange transfusion. There was no blood. I thought I might have the blood type, but then was unsure if it was positive or negative. "Test me" I said. There were no laboratory facilities to do so. If I was wrong, the baby would die anyway.

The 23 day old baby which died two minutes before we reached the ward. His mother had run, inconsolable, screaming, from the hospital. The grandmother, upright, proud, Shia, in her black abaya, tears streaming down her face, stood by his cot, as I vainly stroked his small, perfect head and face, so warm, feeling somehow he could be brought back. All he had needed was oxygen. There was none.

The two doctors and the soldier who screamed at us as we left: "You want a story, you want pictures: there is a two year old baby dead on the sixth floor - the doctors did everything they could, all he needed was oxygen - two years old. What more do you want of us?"

As we left, Dr. Ali - Glasgow trained, world renowned surgeon: "I still have a bank account in the Bank of Scotland, but it is frozen under sanctions", shook hands. "You have seen the state of our hospitals, what will we do if they bombed again?" The hospital, founded by British General Maude, had been hit in the Iran/Iraq War and two doctors killed. In the Gulf War, it was pounded so relentlessly people often were unable to col-lect the dead said Dr. Ali: "Dogs were eating bodies in the street." I said it was impossible to believe it could happen again. For what? We left Basra and returned to Baghdad. The following morning Basra was bombed.

There is a monument in Basra to Iraqi Airways. It reads: "Iraqi Airways, 1947 - 1990." It could be a metaphor for Iraq.

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Uranium Pollution from the Amsterdam 1992 Plane Crash

Risk of depleted uranium exposure admitted by the Parliamentarian Inquiry Commission probe

By Henk van der Keur, Laka Foundation

On October 4, 1992, an El Al Boeing 747 crashed in Amsterdam's Bijlmermeer, killing 43 people. In recent years questions have remained about the cause of the crash, health problems among citizens and rescue workers, the exact cargo, depleted uranium counterweights, and other issues. Last year a Parliamentarian Inquiry (called Commission Meijer, after its chairman) was started to resolve these questions. On 22 April 1999 the Commission Meijer published its results.

One of the Bijlmer crash issues was the presence of depleted uranium (DU) in the plane's counterweights. A total of 282 kilograms was constructed in the plane's tail wings. Laka made this public in October 1993[1] after which a discussion started on the potential burning of DU and the risks for citizens and rescue workers.

From the beginning, Laka pointed out emphatically that bystanders and Bijlmer residents ran potential health risks as a result of airborne uranium from the burning wreck. The presence of DU is among others based on a publication by Paul Loewenstein[2], then technical director and vice-president of the American company Nuclear Metals Inc. (currently named Starmet), the supplier of the DU to Boeing. Loewenstein says in this document that each Boeing 747 contained DU in the form of counterweights. Loewenstein says in his article that "large pieces of uranium will oxidize rapidly and will sustain slow combustion when heated in air to temperatures of about 500 degrees celcius".

The great danger from this chemical reaction is that the escaping cloud of dust with thousands of microparticles of uranium oxide can be inhaled or swallowed by bystanders. The American physicist Robert L. Parker wrote in *Nature*[3], in a worst-case scenario involving the crash of a Boeing 747, that about 250,000 people would run health risks (or near-poisoning) as a result of inhalation or swallowing of uranium oxide particles. Parker's conclusion assumed the presence of 450 kilos of DU in a Boeing 747. He says: "Extended tests by the American Navy and NASA showed that the temperature of the fireball in a plane crash can reach 1,200°C. Such temperatures are high enough to cause very rapid oxidation of depleted uranium."

Paul Loewenstein said that DU would disperse particles in a fire, depending on the following factors: temperature, the surface condition of the fragments (a measure of the accessibility of the metal to surrounding oxygen), and wind speed. This means that the weather at the time of the Bijlmer crash was conducive to the dispersion of burning uranium and that there was every reason for concern. The temperature of the jet fuel fire apparently went higher than 500°C, sufficient for the likely combustion of the outer surfaces of the DU fragments. Moreover, there was a strong northeast wind blowing at the time (windspeed 7). People should have been concerned because a big part of the uranium in the form of dust clouds could have spread across the area, especially towards the southwest. It is known that dust particles can be blown by the wind for kilometers[4].

To calm troubled minds in the Amsterdam suburb Bijlmermeer, the radiation expert A.S. Keverling Buisman of the Energy Research Center (ECN) issued a press release[5] the same day that the news of the uranium contamination swept the world. He confirmed the presence of DU in the wrecked plane, but denied any hazard to public health or the environment. He declared that the uranium remained intact. A day later, the same expert spoke in the town hall in the Zuidoost (Southeast) district, where the Amsterdam Research Service on Environmental Protection and Soil Mechanics (Omegam) presented a definitive version of its investigation on the polluted soil in the immediate surroundings of the flats named Kruitberg and Groeneveen where the plane crashed. Throughout the hearing, Keverling Buisman was pressed to answer all kinds of questions about uranium, and to calm the uneasiness of the Zuidoost population.

Neither the Zuidoost council nor the Amsterdam Environmental Service nor Omegam was aware at that time of the extent of the presence of DU in the accident. The clearly nervous radiation expert did not convince the neighborhood people that uranium carried no risks. The Bijlmer working group on Air Traffic and associated neighborhood groups like Service Platform and Sounding Board were already in possession of a variety of documents in which it was clear that depleted uranium in a jet fuel fire is definitely harmful to public health and the environment. The district council had obviously not grasped the message from the information, because in cooperation with the ECN the next day (October 14), a letter[6] was carried door-to-door with the advice that all was well and that there was not a single reason for concern: "It is possible that recent publications on the presence of uranium-bearing materials in the unfortunate plane crash have led to unease among neighborhood residents. The concern is misplaced. From the information of the Dutch Aviation Administration it was already known that depleted uranium metal is used as a ballast in airframes. About 400 kg of uranium metal was incorporated into the unfortunate Boeing plane for this purpose. The uranium metal was simultaneously removed with other fragments from the plane crash in the week after the accident. Uranium metal is not dangerous to the public health. The surrounding effects were therefore not influenced by the accident."

Spokesmen for Boeing, El Al, the Dutch Ministry of Traffic and Water Supply, and the Dutch Aviation Administration admitted immediately that there were DU counterweights in the tail rudder of the ill-starred aircraft. They claimed that the plane contained 390 kg of DU. El Al declared that during the maintainance work on the plane, 45 kg of a total of 435 kg of DU was replaced by tungsten[7]. Last year it appeared that the total amount of DU at the crash time must be 282 kg rather than 390 kg, because of measurement faults. The 90 kg of DU retrieved from the wreckage by KLM was transported in the eginning of 1993 to COVRA, the Dutch national agency for radioactive waste management. After the October 1993 media attention, a new search started into the missing DU. In the remaining wreckage a counterweight of 37 kilograms was found and on a polluted-soil repository, another broken weight of 3 kilograms was found. No search was conducted at the waste repository, where a lot of debris from the flats and cargo was dumped after the crash[8].

On September 13, 1994, the Amsterdam Health Service (GG and GD) declared that effects on the health of neighbors by the DU are unlikely. In a letter to the city council of Zuidoost, the Health Service wrote: "The complaints which were put forward by a group of residents were not such as these that a relationship was acceptable with the plane crash." The physicians of the municipal service based this conclusion on information of family doctors in this part of the city and on declarations of industrial doctors. Additionally they mentioned that the service personnel who were thrown into gear for the rescue work had also experienced no disadvantageous consequences. Even when small particles of DU oxides have been spread by burning, the Health Service said, nobody would run any risk to inhale or to ingest the radioactive particles, because "the airstream is always directed to the seat of fire".[9]

The research results of the Health Service made part of the final report on the DU by the city council of Zuidoost, published on October 4, 1994. On a public hearing about this report, Laka made many critical comments on the function of the Dutch Aviation Administration (RLD), the city council, the Environment Service of Zuidoost and the Amsterdam Health Service. Especially the last service had to pay to it. Together with Bijlmer residents and the Dutch Greens, Laka called for a long-term in-depth epidemiological search for the presence of uranium in the bodies of the service personnel and residents.

Since the publication of the final report from the city council, which strongly played down the health and environmental effects of DU, Laka has obtained more and more documents which strongly emphasized the chemical and radiological toxicity of DU. One interesting aspect about this particular case is probably the report, “Health risks during exposure of uranium”, made by radiation expert Leonard A. Hennen from the Dutch Ministry of Defense. By accident, this report was published just a week after the final report on DU from the city council of Zuidoost. The author is very thorough about the radiotoxic nature of DU in the human body.

The findings of Hennen strongly contradicts the findings in the final DU report of Zuidoost. He said that people in a DU crash site are running risks. In his report, he proposed the taking of urine samples and in vivo measurements when there is suspicion of internal contamination of the DU. This is exactly what Laka has been insisting upon. In the last six years, Laka has continuously referred to the possibility that DU had been burned, causing a potential risk for people. Besides, Laka repeated the need to conduct medical tests to get clearance on the relation with observed health problems[10].

The ongoing publications and rumors on the plane crash, also called "the disaster after the disaster", was reason to appoint a Parliamentarian Inquiry Commission in September 1998. This Commission had to give clarity on questions about the cargo, the exact cause of the crash, the depleted uranium issue, observed men in white protective suits, etc. The Parliamentarian Inquiry Commission investigated the DU issue intensively. On request of the commission, research was conducted and people were heard (among them from Laka).

From the Parliamentarian Inquiry Commission Bijlmer Disaster, chaired by the Christian-Democrat Meijer, it appeared that some authorities were aware of the DU issue but never informed responsible ministers and others. For instance, the Dutch Aviation Administration found DU weights at the third day after the crash but failed to inform rescue workers at the crash site. For as long as a year, the Ministry of Environment's Inspection Environmental Health failed to inform its own minister on the presence of the DU weights in the plane. From October 7, 1993, three days after the disaster, the Inspection knew about the presence of DU, but didn't forwarded it to the fire brigade, the police and the people on the place of the disaster. As well as the Minister for Environment, the chiefs of the fire brigade and the police and others only learned about it after media publications one year after the crash. The Commission called this "inconceivable" and "negligent". In their final conclusions, the Commission stated: "The risks of DU were not recognized sufficiently."[11]

Apart from the finding and recognition of DU weights three days after the crash, it also became clear that one day after the crash, the possible presence was already recognized by the Dutch Royal Airways (KLM). From maintainance manuals, the KLM knew about DU weights in 747s and informed the Dutch Aviation Administration and the Ministry of Environment (likely the Environmental Health Inspection) immediately. So, one day after the crash, safety measures could have been taken when people at the crash site were informed. This information was given directly by the KLM to Laka, which informed the Inquiry Commission about it. However, in its final report the Commission did not mention this[12].

Another remarkable absence in the report of the Commission is the discussion about the behavior of DU in a fire. In fact, the heart of the whole matter. Until last year, all concerned ministers repeated again and again the statement of the radiation expert Keverling Buisman that the DU could not have been burned, and thus therefore no health risks were present. After repeated claims by Laka and others that temperatures of a few hundred degrees would be sufficient to cause rapid oxidation and dispersion, the Minister of Traffic announced a new research on this matter[13].

The research was conducted by ECN and Laka acted as an advisor on request of the Minister. The outcome, mainly based on US Army research[14], confirmed low-temperature burning. Between 350 and 600 degrees Celsius DU will oxidize and loosen it as fine powder. From 650 to 800 degrees, however, the formed oxides mainly stuck to the surface of a weight. At higher temperatures, the counterweights would oxidize completely. The day the report was published, a lot of media attention was given to a conflict that had risen between Laka and ECN on the final text of the conclusions that could be made from the study. This conflict is said to be the reason to undertake a full Parliamentarian Inquiry, instead of a much smaller "Parliamentarian Research"[15].

As DU was found in dust in the hangar, where the plane’s remains were stored, the Commission concluded that: "In the crash, particles of depeleted uranium were formed and released. The Commission expects that a release of DU particles has taken place at the crash site and in hangar 8. In all probability, the particles had been inhaled by rescue workers and citizens."

But the Commission refers to scientific research reports that state that inhaled particles does not necessarily mean that people are at great risk, as the exact radiation dose is related to the amount of DU inhaled. Apart from the cancer risk, the Commission refers to the possible relation between uranium and the observed increase in auto-immune diseases. Pathologist Weening of the Academical Medical Center mentioned uranium one of the possible causes for this disease.

The final conclusion on the health aspects of DU:
Although the Commission thinks that the partly or total oxidation and dispersion of the DU could be real, it concludes: "Based on exsisting scientific literature, research on the Bijlmer crash, its

hearings and own research, that it is unlikely that big groups of citizens and rescue workers have contracted a uranium poisoning." But: "The Commission explicitly states that it can not be excluded that in specific circumstances, some individuals have inhaled that much respirable uranium oxide particles that a contamination has taken place."[16]

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Military Toxics Project

The mission of the Military Toxics Project is to unite activists, organizations, and communities in the struggle to clean up military pollution, safe-guard the transportation of hazardous materials, and to advance the development and implementation of preventative solutions to the toxic and radioactive pollution caused by military activities. MTP's mission is based on mutual respect and justice for all peoples, free from any form of discrimination or bias.

The purpose of the Military Toxics Project is to provide information, education resources, community and political organizing resources to the public, the MTP networks and membership. MTP serves as a bridge and facilitator for interorganizational cooperation around military pollution issues. MTP's relationship is one of mutual respect and support with it's membership, networks, and collegial campaigns around the country. MTP works to assist local communities, not for them but with them. MTP activities will focus on both service and organizing efforts. MTP helps member organizations and networks to project their individual voices nationally and internationally.

The *DU Case Narrative* by Dan Fahey (first edition: March 2, 1998) was co-produced by MTP along with Swords to Plowshares and the National Gulf War Resource Center. Case Narratives are reports of what we known today about specific events that took place during the Gulf War. This particular case narrative focusses on exposures to DU.

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CADU

Greater Manchester CND (Campaign for Nuclear Disarmament) launched the Campaign Against Depleted Uranium Weapons (CADU) in January, '99. The main reasons which prompted the launch at this time were:
* Information was received from the Ministry of Defence that depleted uranium weapons had definitely been used in the Gulf War by both the UK and the USA.
* There had been a number of disturbing reports, from both eye witness journalists and Iraqi doctors, about the increase of birth defects and cancers, particularly leukaemia and childhood cancers, in the population of Southern Iraq where most of the shelling took place in the Gulf War.
* Gulf War veterans, suffering from what has come to be called Gulf War syndrome ie chronic states of ill-health leading to almost complete incapacity, finally managing to get tests for radiation poisoning tested positive.
* An increase in childhood leukaemia and cancer in the surrounding villages of the test firing area for du weapons in South West Scotland. The shells were test fired from a firing range into the Solway Firth. Continued representations by concerned residents, who had kept careful records, have been completely ignored by the government Scottish Office.
* A lack of knowledge about the health effects of low-level radiation. Not only the nuclear industry but one or two so-called 'independent' scientists keep repeating that du does not emit any dangerous radioactivity because it is low-level and has a long half-life.
* Already the United Nations Commission on Human Rights Sub-Commission on Prevention of Discrimination and Protection of Minorities has depleted uranium weapons as weapons of 'mass destruction and indiscriminate effect.' A report is being prepared by the Colombian rapporteur to be published later in 1999.

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International Action Center

The IAC was initiated in 1991 by former U.S. Attorney General Ramsey Clark and other anti-war activists who had rallied hundreds of thousands of people in the United States to oppose the U.S./UN war against Iraq. It incorporates the demand to end racism, sexism, homophobia and poverty in the United States with opposition to U.S. militarism and domination around the world.

The IAC coordinated an International War Crimes Tribunal that held hearings in twenty countries and thirty U.S. cities probing the Pentagon's systematic destruction of Iraq. In 1992, the IAC published the ground-breaking book, *The Fire This Time*, which reports the evidence presented at the tribunal implicating the U.S. government for gross violations of international law. In it, Clark discusses the military use of depleted-uranium weapons during the Gulf War and its danger to both Iraqis and Gulf War veterans. For the last five years the IAC has been a leader of the movement to unconditionally end U.S./UN sanctions against Iraq.

In mid-1996 the IAC initiated the Depleted Uranium Education Project to fight against radioactive waste, contamination and nuclear testing. This led to the September 12, 1996 meeting of Non-Governmental Organizations at the United Nations Church Center to expose the health and environmental consequences of DU weapons and eventually to the book, *Metal of Dishonor*.

The International Action Center is a volunteer activist organization. In its campaigns opposing U.S. intervention, the center relies totally on the donations and assistance of supporters around the country.

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Swords to Plowshares

A veteran's rights organisation

Swords to Plowshares is dedicated to restoring dignity, hope, and self-suffiency to veterans in need.

To fulfill this mission, Swords to Plowshares
- Provides direct services to assist veterans with post-military transition to civilian life,
- Educates the general public about the needs of veterans, and
- Networks on behalf of veterans' issues.

Swords to Plowshares is a public-benefit, tax-exempt organization. Born out of the pain and dislocation of the Vietnam War, Swords started in 1974 by a group of veterans and volunteers at the Veterans Administration in San Francisco - vets who wanted to help their peers and themselves through the difficult readjustment to civilian life. After a decade, the focus shifted to homeless veterans, those who had not found a way to settle down after their military experience.

In recent years Swords has been tracking developments concerning veterans suffering from Gulf War Syndrome. Because of the experience assisting Vietnam veterans exposed to Agent Orange, many Gulf War veterans have contacted Swords for help in getting compensation for debilitating illnesses. Swords is at the forefront in educating the public about the widespread harm caused by the military's use of DU during the Gulf War

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Laka Foundation

Laka has its roots in the Dutch antinuclear movement. Since 1981 Laka collects information on nuclear energy and related issues. The archives accommodate an extensive collection of newspaper clippings (250,000), books (7,500), TV documentaries (several hundreds), professional journals, technical literature, antinuclear magazines and posters.

Until the late 1980's, Laka was mainly focussed on nuclear energy in the Netherlands. Due to increased information requests from abroad and cooperation with the international organised World Information Service on Energy (WISE-International, Amsterdam) the center oriented more and more internationally.

The answering of information requests is considered as the most important task. Institutes, researchers and journalists are charged with an hourly research wage; individuals only pay the copies and forwarding-charges; organizations and persons without means have no costs. Laka is doing research on own initiative or on request.

Since spring 1992, one of Laka's main projects is the depleted uranium issue. The documentation center contains about 5,000 articles and tens of books. In 1992, a staff member visited Iraq in a fact-finding mission. Since 1993, Laka plays an important role in the discussion about the El Al 1992 airplane crash in Amsterdam and the presence of depleted uranium in the plane. Laka published several articles in Dutch and foreign newspapers and magazines on the civil and military uses of depleted uranium. It also contributed to many (international) book-projects, tv-documentaries and attended numerous international conferences on the issue of depleted uranium, and it published several research-papers on the consequences of the Amsterdam-crash. Laka is considered widely to be one of the most important sources for information in Europe on depleted uranium.

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