

INTERNET DOCUMENT INFORMATION FORM

A . Report Title: Non-Lethal Weapons Activities at ICT

1998

B. DATE Report Downloaded From the Internet 8/18/98

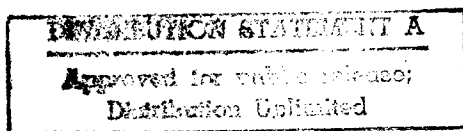
Report's Point of Contact: (Name, Organization, Address, Office
Symbol, & Ph #): Dr. Klaus-Dieter Thiel
Fraunhofer - Institut fur Chemische
Technologie ICT
76327 Pfinztal(Germany)

D. Currently Applicable Classification Level: Unclassified

E. Distribution Statement A: Approved for Public Release

F. The foregoing information was compiled and provided by:
DTIC-OCA, Initials: UM Preparation Date: 8/19/98

The foregoing information should exactly correspond to the Title, Report Number, and the Date on the accompanying report document. If there are mismatches, or other questions, contact the above OCA Representative for resolution.



19980819 060

DTIC QUALITY INSPECTED 1

Non-Lethal Weapons Activities at ICT

Dr. Klaus-Dieter Thiel

Fraunhofer - Institut für Chemische

Technologie ICT

76327 Pfinztal (Germany)

phone: 01149 - 721 - 4640 - 375

fax: 01149 - 721 - 4640 - 575

e-mail: KDT@ict.fhg.de

AQ 98-11-2283

Non-Lethal Weapons Activities at ICT

by Dr. Klaus-Dieter Thiel

Fraunhofer-Institut für Chemische Technologie, 76327 Pfinztal, Germany

1. German Definition of Non-Lethal Weapons(Slide 1)

At first I want to inform of the German definition of NLW:

Non-Lethal Weapons are:

„Technical means whose intention is to obviate (prevent or stop) hostile operations without causing death or lasting injury to human beings.

In addition, secondary effects caused by the use of those means to innocent people, property, and environment shall be minimised“.

This refers to the basic study of DASA.

2. Activities on Non-Lethal Weapons in Germany(Slide 2)

Slide 2 gives an overview about the activities. These activities started in the end of 1993 when German MOD placed an order with DASA for working out a study on NLW. It was followed by the foundation of a BWB-study group in 1995 and a presentation on NLW in the test area of the German army in Hammelburg which was organised also by BWB in 1996.

In the middle of the last year BWB placed three orders, first the development of a Ranging Gun and additional an Effector Net, second an Infra Sound Generator and third an Audible Irritating Sound Machine.

3. Activities on Non-Lethal Weapons at ICT(Slides 3 & 4)

As mentioned previously main area of working fields of ICT concern technological tasks. Based on a technological approach main competencies of ICT must be taken as a basis for a conception as to the topic of Non-Lethal Weapons.

For this the scientific and technological basis concern:

- Particle Technology
- Polymer Technology
- Gas-Generator Technology
- Combustion Technology

Developing several Project-Ideas is resulting in concrete tasks, projects or conceptions on Non-Lethal Technologies. In this case the tasks include a project on Infra Sound and conceptions on foams and entanglements.

4. Infra Sound Project(Slides 5 & 6)

The goal of this project is the development of an Infra Sound-generator.

It started in May 1997.

* In phase 1 first step was the modification of an existing acoustic modulated Jet-burner. For the generation of higher infra sound levels there is a substantial need of energy required. For this purpose particularly oscillating combustion processes are preferred because - determined by characteristic features of system - a certain part of energy is being converted in acoustical fluctuations of pressure. Our first goal concerned of the generation of a continuous combustion process. Heart of the technical equipment has been an acoustical modulated Jet-burner of type Gluareff operating with a gas mixture of propane/air.

* Second step included following series of tests:

- determination of the frequency spectrum of the original combustion chamber
- investigation of the frequency spectrum as for variable lengths of the resonant pipe,
- investigation of the frequency spectrum caused by modulation of fuel supply

These tests have been carried out.

* Making use of the results of these experiments and as planned in phase 2 to develop and construct a new demonstration model, we have come to the decision that this one will be based on a system of generating acoustic pressure waves. Our goal concerns sufficient high energy in combination with frequencies lower than 20 Hz.

* A look at our time-schedule presented by slide 6 shows that we will finish this project in November 98.

5. Concepts (Slides 7 - 16)

5.1 Materials

At this time the following material will be applied

Polyurethane

Polyamide

Polyester

Thermoplastic Elastomers

Phenolic Resins and will be thought about

Biodegradable Substances

With regard to the application of biodegradable substances there could be solved problems like cleaning-up.

5.2 Principally Characteristics of the Technologies

Before the description starts there is to point out some main differences between the technologies which are of interest.

* The polymer or the polymer mixture can be commercial available as a finished product like a granulate (one Container system), or it has to be developed from basic materials on the basis of a polymeric process which results in a reaction polymer.

I prefer the second way because the reaction process is exothermic, so the course of reaction does not depend on any additional energy supply, the resulting material is a molten mass.

However using a granulate there has to be an energy transfer to the material in order to become molten. As the thermal conductivity of polymers is rather low there is some time to spend on it. Only the employment of micro waves would make sense.

* Differences between processes which use a solvent and processes which are solvent-free, are to separate. It is my intention to make more use of solvent-free operations.

* With regard to the energy supply for dispensing, pressure can be inside the material system as a system parameter for instance in case of a super critical fluid or the generation of pressure takes place using pumps or gas-generators.

On this occasion there will be a short description of the following four basic processes:

- Solvent-Process
- Super Critical Fluid-Process (SCF)
- Reaction Injection Moulding (RIM)
- Gas Generator-Process

5.3 Basic-Technologies

• Solvent-Process

Two polymeric substances are dissolved for instance by hydrochlorofluorocarbon (one-container system) and are under a certain pressure for dispensing.

• Super Critical Fluid-Process (SCFP)

Two basic materials are dissolved for instance by a fluid like carbon dioxide under super critical conditions (one container system). Although there is a molecular contact between the both substances, no chemical reaction results of it. As soon as the pressure will be reduced leaving the super critical region it occurs a chemical reaction and the formation of a new polymer.

It should be mentioned that the basic products also could be separated from each other in different containers including different solvents.

- Reaction Injection Moulding (RIM)

This equipment is more complex and includes the following components:

- two vessels contain the basic materials
- two high-pressure pumps
- a mixing-chamber

- some control-valves and nozzles and finally
- a dispenser.

RIM is a batch operation. The both basic materials are liquid and are stored, separated from each other, in heated vessels. The liquids are pumped under high pressure into the mixing-chamber, the heart of RIM-process.

What takes place here is called „high jet velocity impingement mixing“ and is characterised by a very strong intensity. As a rule the reaction rates are so high that the reaction takes place even when the monomers are being mixed. The reaction product can be dispensed immediately.

- Gas Generator-Process

The operation is similar to the one described before. More or less only the both pumps will be exchanged for one or several gas-generators. This means there is a formation of a reaction polymer.

There is an alternative option using gas-generators. Instead of manufacturing a reaction polymer, a finished polymer could be employed as a basic material. Polymer granulate will be solved by a solvent to create a solution of high viscosity.

Under circumstances the solution and the nozzles have to be heated up.

- Unexpanded thermoplastic spheres

Compared to all processes described before the following method is rather different. Unexpanded polymeric spheres (beads) which consist of tiny liquid gas droplets encapsulated in a thermoplastic polymeric shell will be used. Under exposition of hot gases caused by gas generators, the thermoplastic shells soften at the same time as the liquid gas vaporises. The increased pressure causes expansion of the spheres to more than 60 times of their initial volume.

A large number of these spheres is inside a bag like an air-bag which is being blown up by several gas-generators and is being filled up. Due to closed contact between all the spheres the result is a cellular foam.

I want to add my personal view about these technologies .

RIM- and Gas Generator-Process show a very important advantage, because these processes are solvent-free. Therefore both operations are point of main efforts of our concepts at ICT. Nevertheless I will speak about examples including all described technologies.

5.4 Examples of Basic-Technologies in combination with special Materials

- Solvent-Process

At this time there are applicable blends of elastomers and thermoplastic resins dissolved by hydrochlorofluorcarbon (HCFC) and used for the generation of sticky foams. HCFC is an acceptable interim solution.

This is a one container system under pressure.

Also thermoplastic elastomers being mixed with HCPC show an additional option, this could be a Co-Polymer like for instance TPE-O or TPE-E.

However to find the right solvent could be a problem.

- Super critical Fluid Process (SCFP)

Polyol and Diisocyanate are the liquid raw materials. Both will be dissolved by Carbon Dioxide (CO₂) characterised by super critical conditions. As soon as there is a reduction of the pressure leaving the super critical region, it starts a chemical reaction which results in the formation of polyurethane.

Probably this process can be applied to further basic materials.

Application is to the manufacture of foams and entanglements.

- Reaction Injection Moulding (RIM)

In this case Polyol and Diisocyanate are basic materials again. The reaction rates are so high that reaction takes place even when the monomers are being mixed (In situ Polymerisation) and result in polyurethane.

This process also can be applied to the manufacture of further polymers like Polyamide or Polyester.

Applicable to the manufacture of foams and entanglements.

- Gas Generator-Process

- Reaction Polymers like a Polyurethane and a Polyamide can be manufactured, applicable to make foams and entanglements.
- On the basis of a Phenol and an Aldehyde, both in aqueous solution, there is a preparation of a Reaction Phenolic Resin as a result of a polycondensation.
An important goal is to create a biodegradable foam.
- Small not expanded beads made of polystyrene have been known for some time. At this time there are available further thermoplastic polymers which can be applied to build up foams within big bags.
- Cyanogen Acrylate could be an interesting one-component for spraying of entanglements.

6. Potential Operational Areas (Slides 17 & 18)

There are many optional applications of Non-Lethal Weapons, particularly as to Peace Operations under command of the United Nations.

Several studies on NLW have been carried out, very important are the extensive investigations of FINABEL, AGARD and DRG. Each study includes information on scenarios, range of applications, where Non-Lethal Weapons could be applicable. The following both slides give information of FINABEL and AGARD, that is to say the Non-Lethal Technologies with regard to appropriate operational areas. The study of DRG only makes difference between Anti-Personnel and-Material Weapons, nevertheless it supports the tendency of the other mentioned reports.

7. Optional Carrier Systems (Slide 19)

Slide 19 shows some examples of optional carrier systems which includes helicopters, missiles, land crafts and persons. There will be a comment on suitability being connected with technologies described before.

A Gas Generator is more qualified for small scale operations/area and as an instant energy source for the carrier units missile and person. On the other hand RIM-technology is more suitable for large scale operations/area and for land

crafts which can meet requirements as to size and volume of the technical equipment.

8. Combination of NLWs (Slide 20)

A combination of different Non-Lethal-Technology makes a lot of sense, to make sure that the effect for instance on crowds is as extensive as possible. It has been known for a long time that the effect on human beings depends on several parameters.

Basically there are material technologies like Sticky Foam and immaterial ones like High Power Micro Waves.

There are several strategies to employ NLTs. Technologies can work simultaneous, one after another or as peaks.

Slide 20 shows some examples of combined technologies.

9. Future study (Slide 21)

At last a comment on possible future trends with regard to described technologies. At this time at ICT there is a discussion on two ideas:

- Development of biodegradable foams and
- Development of an environmental friendly process on the basis of normal air as a blowing agent

Following slide shows the way as for the first task.

Definition

Non-lethal Weapons are: Technical means whose intention is to obviate (prevent or stop) hostile operations without causing death or lasting injury to human beings.

In addition, secondary effects caused by the use of those means to innocent people, property, and environment shall be minimised.



Review on Activities in Germany

11/93- 4/95 MOD -> Study to DASA



8/95 Establishment of a BWB Study Group



9/96 Presentation in Hammelburg
(Training Area of the German Army)



5/97-11/98 BWB -> 3 Projects:



Ranging Gun, Effector Net



Infra Sound



Audible Irritating Sound

Non-Lethal Weapons

Technological Approach



Main Competencies at ICT



Scientific/Technological Basis of NLWs

- Particle Technology
- Polymer Technology
- Gas-Generator Technology
- Combustion Technology



Project-Ideas



Concepts of NL Technologies

- Infra sound
without/with
Irritant Materials
- Foams
- Entanglements

Anti-Personnel Technologies

- Infra Sound without/with Irritants
- In-Situ Entanglements

Anti-Material Technologies

- Foams (sticky or rigid)



Acoustic Infra Sound Project

Power -> Fuel

A Combustion driven Acoustic Generator, Type Gluareff

Phase 1:

1. Step: Modification of an Pilot Plant
2. Step: Realisation of a series of tests

Phase 2:

3. Step: Development and Construction
of a new demonstration model





Non-Lethal Weapons

- Working Schedule of the Infra Sound-Project

Task \ Month	1997												1998								
	04	05	06	07	08	09	10	11	12	01	02	03	04	05	06	07	08	09	10	11	
Preparations + Planning																					
Modification of the existing Pilot Plant																					
Concept and Construction of the new acoustic Demonstration Model																					
Setting up and Setting to work of the Demonstration Model																					
Project Controlling and Documentation																					
Workshops																					

Legend:

 Planned Period of the described Tasks

 Possible additional Time for the respective Tasks

 Project Controlling

10.WL.WF06.DOC



Fraunhofer
Institut
Chemische Technologie

15.1.98/KDT

Materials

- Polyurethane
- Polyamide
- Polyester
- Thermoplastic Elastomers (Co-Polymers)
- Phenolic Resins
- Biodegradable Substances

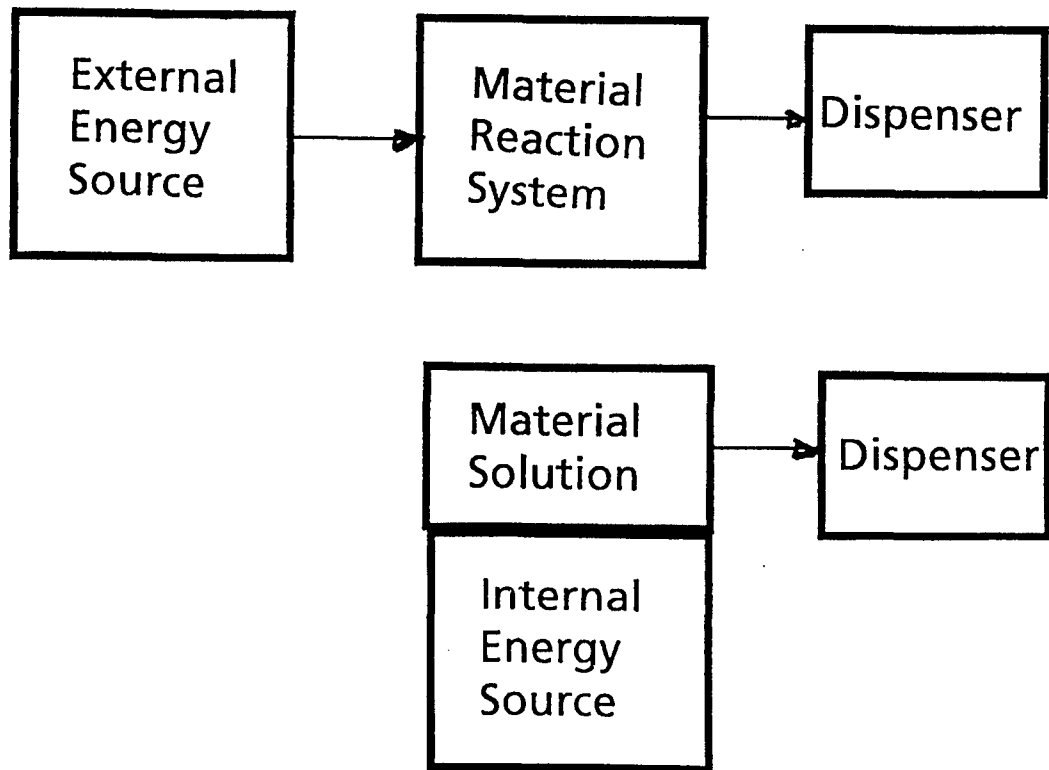


Principally Characteristics of potential Technologies

- Finished Polymer <-> Reaction Polymer
- Solvent <-> Solvent-free
- Internal Pressure <-> External Pressure

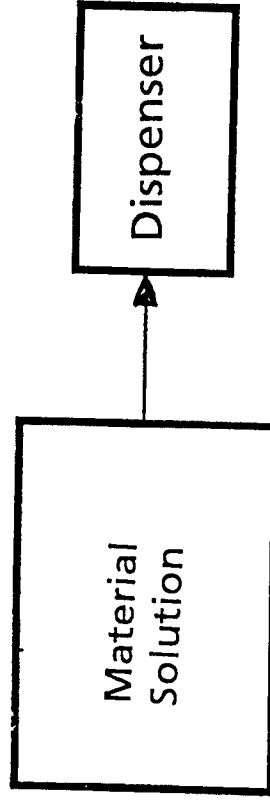


Principally Structure of Technologies



Non-Lethal Weapons

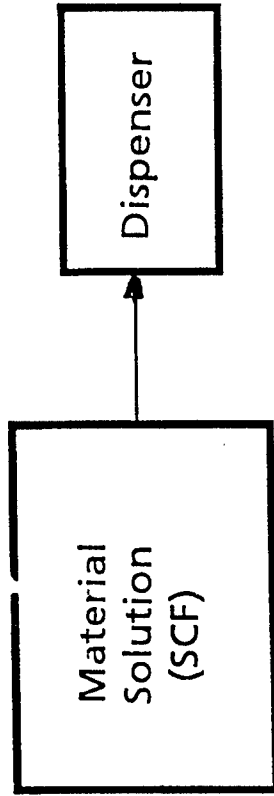
Solvent-Process



HCFC



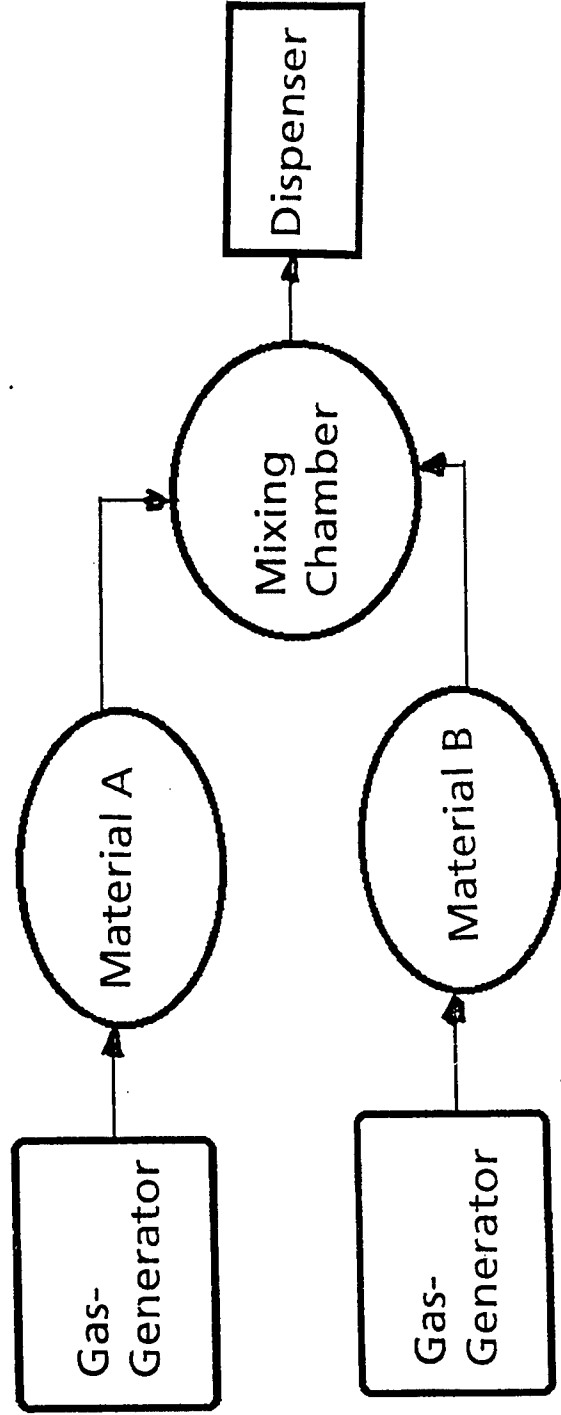
Super Critical Fluid Process (SCFP)



Carbon Dioxide



Gas Generator-Process

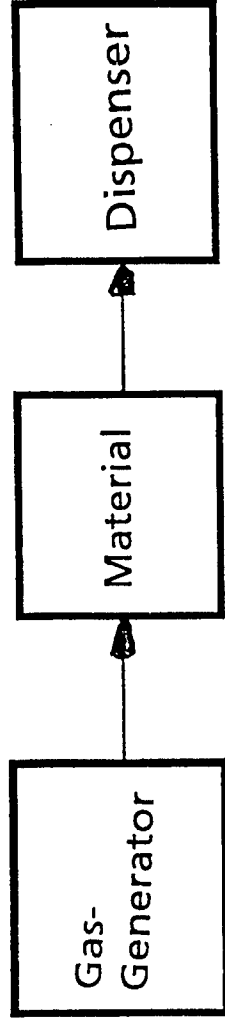


Basic-Technologies

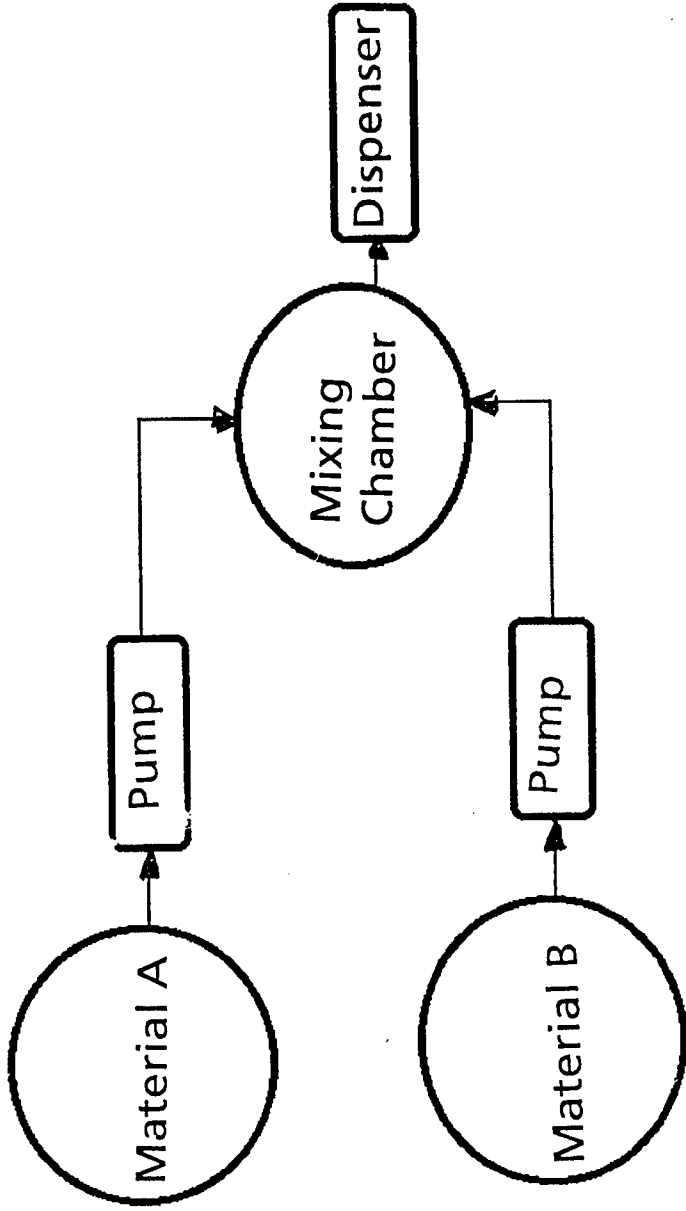
- Solvent-Process
- Super Critical Fluid-Process (SCFP)
- Reaction Injection Moulding (RIM)
- Gas Generator-Process



Gas Generator-Process



Reaction Injection Moulding (RIM)



Non-Lethal Weapons

Technology	Material	Application
->Solvent-Process	Thpl & Elast.	Foams
->Super critical Fluid Process (SCFP)	PU/R/.....	Entanglements, Foams,
->Reaction Injection Moulding (RIM)	PU/R/ PA/R/PES/R/ PU/R/	Entanglements Foams



Technology	Material	Application
->Gas Generator- Process	PU/R/, PA/R/ PU/R/ Phenolic Resin/R/	Entanglements Foams Foam
->Not expanded Spheres-Process	Thermoplastics	Foam in Bag
->One Component Process	Cyanogen Acrylate	Entanglements



Applications recommended by FINABEL

Crowds Terrorists Soldiers Immobilization Electronics of Vehicles

Technology

Infra Sound ⊗

⊗

Foams ⊗

⊗

Entanglements ⊗

⊗

⊗

⊗



Applications recommended by AGARD-AAS 43

Large Crowds Personnel in Foxhole Roman Bridge

Technology

Infra Sound ⊗

Foams ⊗

Entanglements ⊗

⊗

⊗



Non-Lethal Weapons

Examples of potential

Carrier Systems

Technology	Helicopter	Missile	Land Craft	Person
RIM	⊗	---	⊗	---
Gas-Generator	X	⊗	X	⊗
SCF	X	---	X	X
Solution	X	---	X	X

⊗ especially favourable

X favourable



Examples of Combined Technologies material immaterial material/immaterial

Strategy	material	immaterial	material/immaterial
Simultaneous	IP / ET	IS / SS	IP / IS
One after another	CW / IG	IS / HPM	SF/ IS
Some Peaks	CW / IG	IS / PE	IG/ PE

IP: Irritant Particles; IG: Irritant Gas/Spray; IS: Infra Sound;

SS: Super Sonic; CW: Coloured Water; HPM: High Power Micro Waves;

SF: Sticky Foam; ET: Entanglement; PE: Pulsed Energy;



Usual Foams



Foams which fill up Bags



Biodegradable Foams

