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THE NATO CCMS WORKING GROUP ON NOISE FROM WEAPONS - AN OVERVIEW

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ABSTRACT
As part of a follow up to a study on aircraft noise NATO CCMS (Committee on the Challenges of Modern Society) has established a working group to consider "Noise from Weapons and Sonic Booms and the Impact on Humans, Wildlife, Domestic Animals and Structures". The study covers shooting noise, blast and sonic boom but excludes noise from vehicles, aircraft and helicopters. The terms of reference required the group to carry out a literature review into weapons noise measurement, metrics and emission characteristics, acoustic modelling of weapons noise propagation and the effects of weapons noise and sonic boom on animals, humans and structures. The prime objectives of the study were to determine the levels of current knowledge and areas where further work might be required.

1 - INTRODUCTION

The armed forces of the various North Atlantic Treaty Organisation (NATO) member nations practice weapons training at a large number of sites throughout the NATO area. Many of these sites are in remote areas but some are close to large communities, some are close to or in nature reserves where wildlife may reside and some are on farmland where domestic animals are reared. Given the nature of the weapons training, small arms, missiles and artillery and in some cases sonic booms from over-flying military jet aircraft, it is of little surprise that the impact of impulse noise on the communities is of great concern. It has been accepted for a long time that there is a need to set sensible limits on activities to minimise the effects on the communities in terms of human annoyance, structural response and animal reaction. Although several NATO countries have studied the effect of shooting noise for many years there has been no formal forum within NATO for sharing the results. The NATO Committee on Challenges of Modern Society (NATO CCMS) study group on "Noise from Weapons and Sonic Booms and the Impact on Humans, Wildlife, Domestic Animals and Structures" was established in 1994 as part of the follow-up programme on aircraft noise. Together with two other working groups, "Effects of Topography on Propagation of Noise in the Vicinity of Airfields" and "Helicopter Noise Prediction Modelling" it forms the current CCMS work programme on noise.
The terms of reference were agreed at the first meeting and are as follows:

- Review the existing literature for the five subject areas:
  - Weapons measurements, emissions, metrics etc
  - Acoustic modelling
  - Effects on animals
  - Effects on humans
  - Effects on structures
- Evaluate the literature review findings to determine what still remains to be accomplished.

- Suggest other species to be studied. The list of species should include threatened and endangered species, noise-sensitive animals and animals of special interest.
- Investigate and make recommendations on methodologies for research on the impact of noise from weapons and sonic booms on wildlife, humans and structures.
- Establish an international database/bibliography on findings, surveys and scientific research on those subjects and determine how it can be run and maintained
- Make conclusions and recommendations for further work in a final report.

The working group are currently finalising the report on their studies. This paper provides an overview of the content and the likely conclusions.

2 - REVIEW OF DATABASES

The databases on weapons noise and the different metrics used, on acoustic models and studies and records of weapons noise effects on humans, wildlife, domestic animals and structures were each studied by the participating experts in their own countries and an overview prepared for the report. It became apparent that the amount of effort put into the previous research in NATO countries on the environmental impacts of shooting noise in particular, appeared to relate to the amount of training and population density within those countries - the greater the amount of training, the denser the population, the greater the effort. It was also apparent that there was no general consensus on the way that weapons noise should be evaluated and in particular it was discovered that medium and heavy weapons were evaluated in some countries with C-weighting metrics and in others with A-weighting metrics. The question of weapons noise measurement had been addressed by an ad-hoc working group in a series of workshops and a standard test plan for such measurements has now been published by them [1]. In addition the ad-hoc working group undertook a major trials programme in Norway to provide a database for studies into long range impulsive noise propagation. The conditions covered included propagation through and over forests in summer and winter conditions [2].

Databases on propagation modelling were also varied and illustrated specific concerns within member countries arising from national and local noise control guidelines and legislation.

Many countries had considered noise from small arms and from large weapons as different entities and had specific methods of calculation for each. The USA, who had pioneered the use of such prediction models to assess noise from ranges, had also developed a prediction model for sonic boom propagation. In the main, models either did not account for prevailing meteorological conditions or they only covered "nearly worst case downwind" conditions. The UK and lately the Netherlands had developed prediction programs that take full account of the meteorology. The UK in particular had used a meteorological based noise prediction model to control noise around some of its firing ranges since 1981 [3]. Many countries had undertaken studies into the prediction of annoyance from shooting noise but national requirements and ordinances again influenced the studies.

Few countries had studied and subsequently compiled a database on the effects of impulse noise on animals. Of those that had, Germany had made specific studies on birds and animals in tidal flatlands subjected to noise from both gunfire and helicopter overflights. Norway was in the process of developing a methodology for studying the effect of military activity on wildlife but Canadian studies had been confined to the effects of noise from aircraft. The USA had conducted a large program of research into the effects of different types of military noise on wildlife following a report by the US Environmental Protection Agency that recognised that little was known in this area. Subsequent studies on specific species have generally indicated that the breeding and living habits are little affected by military noise. Although the animals show some reaction they quickly return to their pre-event activity. Studies have covered noise on bombing ranges, from low level, high-speed military jets and from aircraft induced sonic booms and special projects have focussed on endangered species such as the desert tortoise.

The USA has also carried out extensive studies on noise effects on structures especially those induced by sonic booms. The USAF is currently developing a simulation system that can evaluate the structural response of historical and unconventional structures to sonic booms. This section also contains a report from Portugal on the structural response to artillery, cannons and plastic explosives and data from a German funded study into noise reduction by specially designed retrofit windows.

3 - REGULATIONS, GUIDELINES, CONSTRAINTS & PROCEDURES

The reviews of databases from individual countries are complimented in the report by a comprehensive section covering current and recent research activities into the nature and effects of impulse noise from

military activities and by detailed listing of references. Of particular relevance to the work of the group is a short section describing the U.S. Air Force citation database called CITASAN which includes relevant literature in the field of noise and sonic boom effects on humans, animals and structures. It has recently been modified to include weapon noise sources and is now incorporated in the International Bibliography on Noise (IBON).
There is a section covering regulations, guidelines, constraints and procedures in individual NATO countries included in the report. This again clearly shows the diversity that exists between countries. It also underlines the potential difficulties that can arise during the preparations for joint training exercises where it may be necessary to appraise the environmental impact of visiting forces' weapons.
There are appendices covering the definitions of impulse noise and comments on ISO activities relevant to impulse noise such as the work of TC43/SC1 working group 40 on "impulse noise propagation" and working group 51 on "shooting noise".

4 - CURRENT STATUS

The working group recommends that when possible any database on weapons noise should contain time histories and spectra. This will allow countries to make calculations for their own assessments. However time histories also provide a ready means of checking the integrity of data, avoiding reflections and allowing separation of ballistic wave and muzzle blast. Spectra are now being used in propagation programs and in targeting specific effects in animals. Obtaining good and accurate data is both time consuming and expensive and creating a common database will allow sharing of data. A relational database, which is suitable for holding the above information, and is specific to weapons noise, has been developed in Germany [4].
Recent advantages in computer technology have reduced considerably the time and cost of obtaining accurate predictions of blast noise. Several researchers have exploited this and designed user-friendly PC based prediction models capable of interfacing with graphical mapping data. There are three classes of models that might prove to be of value when assessing the effects of impulse noise. Single event models are used for identifying situations where firing might lead to complaints, and take into account prevailing meteorological conditions. Cumulative dose models predict average noise exposure for environmental assessments and land use planning. Statistical models predict the range of possible levels at a receiver position. Currently there are several models available in each class and the working group feels that rather than developing additional ones, the effort should be concentrated on validating existing models. For this purpose the group recommends the use of the database produced during the studies undertaken in Norway by the ad hoc group. Although the Norwegians largely financed this work, the database is available for use by other researchers.
Several countries now use permanent or semi-permanent monitors to assist in the operation of ranges. These can give on-line feedback of current blast levels or be used as post blast verification to confirm that guidelines were not breached. A third and cost effective use is in the verification of models. Recent developments in computer software and sensor technology have resulted in blast monitors capable of detecting blasts during adverse weather conditions where, in the past, a high percentage of readings would be wind induced and false.
The working group has reviewed the current status of the large body of work on the effects of noise on humans. Much is applicable to impulse noise from military sources but the special characteristics, such as rapid rise, high energy and low frequencies must be properly taken into account when assessing such effects. NATO research study group (RSG) 29 is currently investigating the auditory effects of weapons noise. The results of an earlier NATO study can be found in [5]. There is some evidence to show that non auditory effects may occur as a result of exposure to certain noise, however data specific to impulse noise is sparse and there is a need for further high quality studies in this complex area. The acoustic startle effect is well known and little understood but the question of whether an additional rating criterion should be included in shooting noise assessment has been studied in the Netherlands. The conclusion was that since startle and annoyance ratings were highly correlated there was no additional advantage in having such a rating. The working group also reviewed the use of adjustment factors for impulse noise in annoyance rating and the interaction of sound and vibration and in particular the response of people in their homes to rattle induced by gunfire and sonic boom. The group concluded that additional work is required especially in relating dose to annoyance and that the considerable influence of non-acoustic factors should be considered in surveys.
There is a requirement for more understanding of noise effects on wildlife in general and on specific species in particular. There is little current data on the effects of impulse noise and sonic booms. The aural response of animals is different to that of humans and standard sound level meters and human

orientated metrics, including the A-weighting, cannot be used. This section in the report considers the requirements for studies on noise and animals and outlines the pitfalls that should be avoided. It is suggested that field studies of the in-situ responses of actual animal to actual noise event are essential but it is accepted that there are difficulties in working in the field with threatened and endangered species and that such difficulties are compounded by the many ecological and behaviour variables. There are few studies on the effects of military noise and domestic animals and in the USA the emphasis has been placed on those species which create damage and litigation claims. Aircraft flyovers (both fixed and rotary wing) rather than weapons noise are the primary sources.
No standard methodology for the study of weapons noise effects on structures currently exists. A current concern, especially in the USA, is that modern thermal windows might be more readily damaged than glazing studies covering traditional windows would indicate. In general, because of the varying methods of home building that exist in the world, for instance brick or timber frame, it is difficult to generalise and read across from specific damage assessment studies to other cases. Therefore some caution must be exercised when specifying damage limits. Owners are naturally concerned about the effects of vibration on their homes and there is a need for better dissemination of information.

5 - RECOMMENDATIONS

The working group has not yet finalised its recommendations but they are likely to be taken from the following:

- A new literature database on the impact of noise from weapons and sonic booms should be set up. The U.S. Air Force, IBON (International Bibliography on Noise) is a likely candidate.
- NATO adopts a relational database in which to store weapons noise data such as that proposed in [4] and that its upkeep is financed by subscription.
- The basic procedure to be adopted when obtaining such data in the field is that defined in "Standard Method to Measure the Sound Exposure Emissions and Immissions from Large Weapons" [1]. Additional information pertaining to the measurements such as prevailing weather, topography etc. and frequency spectra and waveform data should be included, where possible.
- Single event prediction models should be verified under a wide range of environmental and atmospheric conditions. The database obtained by the Norwegian Defence Construction Service [5] provides a ready source of data for part of that task.
- Annoyance studies should be funded to determine:
  - the relationship between annoyance and individual events
  - the annoyance of high energy impulsive sounds
  - clarification of the relative importance of vibration/rattle and loudness and ratings
- Sleep disturbance studies specific to impulsive noise should be undertaken.
- A general protocol for measuring the effect of noise on animals, which will ensure adequate quality assurance in studies especially those involving rare and endangered species and selective domestic animals, should be developed.
- The effect of weapons noise on the structural integrity of thermal glazing should be investigated.

Data sheets for public use describing the nature of weapons noise and sonic boom, its effects and means of mitigating annoyance aspects should be developed.

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