HADES:
Hot And Dusty Environment Survey.

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Abstract.

The possibility of future military conflicts in geographical regions that could be classified as 'desert' was, and remains, of growing concern to all NATO nations. The major concern related to military operations in desert environments was the effect of 'obscuration' caused by an increased dust loading of the atmosphere – the increased dust loading being primarily due to the movement of personnel and vehicles, the impact of artillery barrages, and the detonation of explosive devices such as mines.

The duration of the increased atmospheric dust loading depends on prevailing ambient conditions and the characteristics of the dust such as particle size. The effect of the suspended dust is to reduce the ability of electro-magnetic energy to propagate through the atmosphere and has the capability of denying 'lines of sight' between opposing forces thereby reducing the effectiveness of military sighting systems and communication links.

This paper is based on a joint survey called HADES, (**H**ot **A**nd **D**usty **E**nvironment **S**urvey),which was initiated by the delegates of the former Research Study Group RSG 15 of NATO (DRG) Panel 4. The aim was to review and, where possible, assess the effect of desert environments on military operations. Systems operating at wavelengths ranging from the visible through the infrared out to the milli-metric frequencies were of greatest concern.

1. Introduction.

This paper describes a survey that was conducted during 1994 and 1995 by the members of the former NATO Research Study Group AC/243 (Panel 4/RSG 15) on 'the characterisation of battle effects and related measurement techniques'. The group was concerned that the designers, evaluators, and users of military systems had insufficient information that related military electro-optical systems to their performance in hot and dusty environments. A survey, called HADES (**H**ot **A**nd **D**usty **E**nvironment **S**urvey), was initiated by the group and an overview of it is now reported.

During the course of the survey, possibly hundreds of documents were examined and their salient features used during the compilation of the final report. Classified reports were intentionally not reviewed, from the outset of the survey it was decided that the report should not contain any classified material. It was considered that this, acceptable omission, would enable the report and its findings to be distributed to the widest possible NATO audience without undue difficulty. Additionally, all of the references that have been quoted should be straightforwardly available.

The HADES report has been designed to present information primarily to the following groups of people: the Defence Research Group (DRG), Ministries and Departments of Defence, scientists, and military users.

2. Survey Rationale.

The possibility of future military conflicts in geographical regions that could be classified as 'desert' (hot and dusty rather than polar deserts) was, and remains, of concern to all NATO nations. The major concern related to military operations in desert environments was the effect of obscuration that is caused by an increased dust loading of the atmosphere. The increased amount of dust being primarily due to the movement of personnel and vehicles, the impact of artillery barrages, and the detonation of explosive devices such as mines. All of these rudimentary military activities have the capability of generating large quantities of dust which is subsequently lofted into the air. The dust can remain suspended in the atmosphere for varying amounts of time. The period of suspension depends on the prevailing ambient conditions, including meteorology, and the characteristics of the dust such as its particle size. The suspended dust reduces the propagation of electromagnetic energy through the atmosphere and has the capability of denying lines of sight between opposing forces thereby reducing the effectiveness of military sighting, aiming, tracking systems, and other 'communication' links.

The joint survey was designed to review existing material, and where possible assess the effects of desert

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environments on military electro-optical systems. In particular, systems operating at wavelengths ranging from the visible through the infrared out to the millimetric wavelengths were of greatest concern.

3. Objectives of HADES.

The broad objectives of HADES were as follows:

- To characterise the desert (hot and dusty) environment in terms of its meteorology, and locate regions which exhibit such characteristics.
- To study the effects of desert environments on military electro-optical systems.
- To review the military implications of operations in desert environments.
- To identify where there is currently a lack of data available for desert environments and to indicate possible studies to help resolve the lack of appropriate data.

4. Scope of the Survey.

HADES was conducted over a two year period and involved Denmark, France, Germany, the Netherlands, United Kingdom and the United States.

Apart from the reviewing and assessment of many technical reports during the survey, detailed discussions were held with 'military advisors', primarily from the UK, who had direct experience of military operations in deserts. The results from these discussions, where relevant to the survey, have been included in the report. However some of the information that was provided can only be classified as 'anecdotal' and cannot be numerically substantiated.

It was immediately apparent, at the outset of the survey, that a considerable amount of relevant experimentation had already been conducted by various organisations. During the survey details of the majority of this experimentation was reviewed and reported on. In addition equations and models that had been developed were also reported and, where appropriate, examples of their use are given.

The report contains details of what constitutes a desert, and examples of the variability of different meteorological effects, such as temperature, humidity, visibility, atmospheric transmission etc, that can be expected in several specific locations are given.

Sections of the report are devoted to the characteristics of: desert environments, terrain and backgrounds, the natural (desert) atmosphere, and the battlespace atmosphere. Details of models for the prediction of desert related effects, and details of previous measurement programmes are also reported. However the three most important sections are the Conclusions, Military Implications, and the Recommendations. Only details of these sections are given in this overview paper.

5. Conclusions.

The two most important conclusions that were drawn from the survey are:

1. Military operations in desert regions will be severely hampered by the environment. Although the above statement is perhaps obvious its importance is fundamental and should not be either taken for granted or underestimated.

   Loose, dry surface dust will be lofted into the air by wind, vehicular movement (ground and low flying air activities), explosions or shockwaves from gunfire and missile launch. The atmospheric dust loading will be increased – all aspects of electro-optical system performance that rely on the propagation of electromagnetic energy through the atmosphere will be degraded.

   In addition abrasion will occur to the optical surfaces of the sensors which are being deployed. Heat, dust and temperature changes will also have adverse effects on equipment reliability and will reduce the effectiveness of personnel.

2. Experimentation has shown that the effects of dust can be very different in areas that initially appear to be similar.

   The dust which is produced, generally, has a broad particle size distribution however this distribution will greatly vary in different geographical areas. This variation will alter the obscuration characteristics of the atmosphere in terms of increased absorption and scattering which reduces atmospheric transmission.

   Some locations although not explicitly considered to be desert (hot and dusty) can exhibit such characteristics under exceptional conditions, such as drought. Conditions such as these were experienced during the NATO BEST TWO trial which was conducted during August 1990 at Camp Mourmelon (150 km North East of Paris), France. During the trial dust conditions were unexpectedly experienced that were equal to any of the trials that were specifically designed for dust evaluations. These locations were not explicitly considered during this survey due to their unpredictability, although they should not be forgotten as their potential impact on any military operations in such areas could be severe.

6. Military Implications.

The most important military implications of the effect of dust are:

a. The loss of target acquisition capability – targets will be masked inside and behind dust clouds in the visual and thermal wavebands.

b. The loss of guided munition line of sight – increased dust loadings will reduce atmospheric transmission which will lead to a degradation of system performance.

However there is also a positive effect of vehicular dust; the long range detection of moving targets can be enhanced due to the cueing effects of the dust clouds that are created. For the shorter range detections it has been observed that the contrast of targets in front of the dust cloud is sometimes enhanced. The visualisation of the effect is different in the 3 to 5 μm and the 8 to 12 μm wavebands.

Although conditions that lead to increased dust loadings and the subsequent possible reduction in system performance are commonly found in desert type environments, such conditions can be found elsewhere. On many occasions, significant dust loadings can occur unexpectedly in non-desert locations (even in Europe), and it is essential that such eventualities are not underestimated.

Examination of experimental results indicates that due to the broad range of particle sizes contained within a dust cloud, all of the wavelengths from the visible to the far infrared will be similarly affected. However, under some conditions the longer wavelengths will be advantageous in desert environments.

Millimetre wavelength systems are only momentarily affected during the initial stages of an explosion when there are large particles present in the atmosphere. The larger particles quickly 'precipitate' from the dust cloud and at that time propagation through the cloud, at millimetre wavelengths, returns to normal.

Climatic conditions can be severe. Day time temperatures can be in the order of 40 to 50°C and the annual diurnal variation can vary by up to 80°C. Fierce winds can reach 35 m/s causing sand storms. The effects of such storms can be extensive and visibility impaired for significant periods of time. Dust storms can render all ground movements and low flying activities difficult and often impossible.

Dust can reduce the cross-country capability of combat vehicles and can damage weapons and equipment. The ingress of dust can significantly increase wear and tear on assemblies and sub-assemblies which leads to a need for more frequent technical servicing, and this, together with the logistic difficulties, imposes enormous demands on maintenance, and technical support. There is therefore an increased premium on equipment reliability and self sufficiency.

7. Recommendations.

The final objective of HADES was to identify where there is currently a lack of data available for desert environments, and to indicate where future experimentation is necessary in order to resolve the omissions. The following recommendations are considered to be appropriate:

- In order to provide the military user with the necessary information on the characteristics and the consequences of increased atmospheric dust loadings, it is recommended that studies should be conducted to characterise the different soil and dust types that are found in different geographical areas and to relate them to propagation effects in different wavebands. Ideally such a survey should cover world wide locations but could be realistically restricted to potential areas of conflict. It is considered that some of the required data are already available, albeit in many different reports.

- The potential exists for incorporating such characterisation data in Tactical Decision Aids (TDAs) which would aid the military users to assess their vulnerability to dust effects. With military assistance and guidance a Handbook on 'out-of-area' operations, in desert environments which would augment such TDAs could be developed.

- Collaboration is required for the evaluation of the operational performance of the next generation thermal imaging equipment and laser systems against increased atmospheric dust loading and other obscurants.

- Advances in weapon system technology may require more sophisticated models to assess their theoretical performance. In particular, an increased knowledge of multiple scattering, absorption, and emission within obscurant clouds will most likely be necessary.

- There is a need to establish the effects of obscurants on the electro-optical detection of moving targets. In particular there is a need to determine the search effectiveness of electro-optic sensors obscured environments. Data is required that allow search models to be further developed and validated. Data is also required for the analysis of the probability of detection, recognition and identification of targets moving in and out of defilade in clear and obscured environments.

- Many studies and experiments have been conducted that might partially resolve current and future requirements. It is considered essential that the data and subsequent results from those studies are not lost during the current reductions in defence spending. The effective use of data

repositories, such as the Atmospheric Aerosols and Optics Data Library (AAODL), should be encouraged.

8. HADES Report Availability.

The HADES report has been issued by NATO, the reference number is AC/243 (Panel 4) TR/19. Copies of the HADES report are available to NATO countries and requests for further information should be made directly through the appropriate national delegates.

Acknowledgements.

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DISCUSSOR'S NAME: D. Clement

COMMENT/QUESTION:

Your message is clear. Implications appear to be significant. Could you report on any responses you received from the user community?

AUTHOR/PRESENTER'S REPLY:

The majority of responses have come from the weapon system community. Their interest was how much will the performance of systems be degraded in desert type climates.

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DISCUSSOR'S NAME: G. P. Anderson

COMMENT/QUESTION:

Are there any implications from the HADES study regarding the development and/or advantages for dust mitigation?

AUTHOR/PRESENTER'S REPLY:

The HADES report does not include information on dust mitigation. However, during the survey we found that some "traficability" trials had been conducted. The results from these trials are outlined and referenced in the final report.

There appears to be two related problems:

1. If you minimize the amount of dust generated/lofted into the air the visual/thermal signature becomes clearer and easier to acquire and recognise the target.

2. If you allow the dust to be naturally lofted into the air the detection of the vehicle improves.