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NORTH ATLANTIC TREATY ORGANISATION

RESEARCH AND TECHNOLOGY ORGANISATION

BP 25, 7 RUE ANCELLE, F-92201 NEUILLY-SUR-SEINE CEDEX, FRANCE

RTO TECHNICAL REPORT 40(I)

Alternatives to Anti-Personnel Landmines

(Solutions de remplacement aux mines antipersonnel)

Military Application Study on Alternatives to Anti-Personnel Landmines by the RTO Studies, Analysis and Simulation Panel (SAS).

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- AVT Applied Vehicle Technology Panel
- HFM Human Factors and Medicine Panel
- IST Information Systems Technology Panel
- NMSG NATO Modelling and Simulation Group
- SAS Studies, Analysis and Simulation Panel
- SCI Systems Concepts and Integration Panel
- SET Sensors and Electronics Technology Panel

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Alternatives to Anti-Personnel Landmines

(RTO TR-040(I) / SAS-023)

Executive Summary

Background

Since its inception in December 1997, seventeen of the nineteen NATO nations have signed the Ottawa Convention. The Convention entered into force in March 1999. Consequently, most of the NATO nations are actively considering alternative means of providing the capabilities that APMs give to the warfighter. SHAPE requested assistance from the Research and Technology Board (RTB) with assessing the impact on NATO operations of losing the APM capability. The RTB, in turn, asked the Studies, Analysis and Simulations (SAS) Panel to perform a Military Applications Study on Alternatives to Anti-Personnel Mines. The study was actually conducted over seven sessions between September 1999 and May 2001.

Anti-Personnel Mine (APM) Capability

APMs enable economy of force in operations, provide force protection and shaping of the battlefield. They assist in fixing, turning, blocking and disrupting the progress of the attacking force. The uses of APMs in tactical and protective minefields help influence and obstruct the direction of enemy movement. APMs protect defending forces and guard flanks during attacks. APMs inflict direct damage on the enemy and reinforce natural barriers and obstacles for defensive positions. APMs provide friendly force alert of a dismounted threat presence, disrupt the advancing attacking force, produce psychological effects and, generate surprise against attacking dismounted threat personnel.

APMs have a number of positive and negative characteristics. Typical positive APM system characteristics include their ability to be produced cheaply, provide continuous coverage in all weather and terrain conditions, require minimal training to employ, light weight and small volume, and, logistically non-burdensome. Typical negative characteristics are their indiscriminant targeting (i.e. their immediate lethal response once tripped), potential obstacles to friendly mobility of dismounted infantry, inflexible active life and not tactically amenable to easy or efficient attempts to reuse. Current long-duration APMs and imprecise location and registration of entire fields of APMs present a potential for a continuing residual hazard after hostilities have ended.

Summary of Modeling and Analysis Results

The panel examined summary descriptions of 15 national studies related to the impact of APMs and alternatives. Results indicate that NATO forces fighting without APMs provide the enemy with significant military advantages in most operations. Study results also demonstrated it is possible to compensate for some of the lost APM capabilities by employing different mixes of weapons at the small unit level but such alternatives come with heavy logistical increases and operational risks to NATO forces. In addition, qualitative assessments by all study group members indicate that at least one of five key tactical situations would be severely impacted due to the loss of APMs. Therefore, from both the quantitative and qualitative analyses and at both the tactical and operational levels of conflict, the removal of APMs from the NATO fighting forces inventories were viewed as presenting increased mission risk to the allies. The risks were measured in increased casualties, increased loss of military equipment, increased probability of loss of key battlefield terrain, and increased time to regain the initiative and accomplish mission objectives.

The Alternatives

Although one-for-one replacements of APMs were not identified and do not seem to be obtainable, the study was able to identify several potential alternatives that can replace some of the capabilities provided by APMs. Near-term solutions include the French MODER and MODER Plus, various nations' man-controlled directional-fragmentation device (claymore-like munitions), the Norwegian Area Denial Weapon System (ADWS) and the Canadian Auto Grenade Launcher. Possible non-lethal alternatives for near-term include nets and caltrops. However, employment of different weapons and alternatives at the small unit level in many cases results in increased uncertainty and risk on the mission outcome. Mid-term alternatives

include the French SUZON 1 and SPECTRE, the Norwegian OPAK plus ADWS, the Canadian Directional Fragmentation Device with remote control and the US Non-Self Destruct Alternative (NSD-A) and the US Track III systems/concepts. Non-lethal alternatives include better wire and glue-like materials. Long-term alternatives include the French SUZON 2, the US Self-Healing Minefield and US Tags/Minimally Guided Munitions.

Non-Materiel alternative concepts considered as part of this study included changes in doctrine, organization, training, leadership and personnel. Recommendations included doctrine reviews of: (1) force protection; (2) dedicated indirect and naval fire support; (3) Tactical Air Support and reserve employment; (4) reduction of the latency in sensor-to-trigger decision cycles; (5) task organization of engineers, patrols, and Intelligence Surveillance Targeting Acquisition and Reconnaissance (ISTAR) assets; (6) increasing the close-in lethality of tactical units; and, (7) streamlined information dissemination procedures.

Combinations of materiel and non-materiel alternatives were postulated as a result of the study group's separate evaluation of materiel and non-materiel alternatives. Combined materiel/non-materiel alternative concepts of augmenting directional fragmentation devices with long range control and remote sensor fields or remote sensor fields directly linked to dedicated indirect fire support are examples of concepts that require further definition and evaluation. Non lethal weapon technologies were not assessed exhaustively as part of this effort.

Recommendations

The SAS Panel should conduct a follow-on study to examine the benefits and complexities associated with the combination of both materiel and non-materiel APM alternatives. The SAS Panel Study Group on Non-lethal Weapons (NLW) (SAS 035) should specifically address the use of NLW as alternatives to APMs. NLW will become an important replacement, as they do not require man-in-the-loop or confirmation of combatant or non-combatant.

The SAS Panel Study Group on Human Factors and Medicines should address and try to quantify the psychological effects of APMs in order to assist in the assessments of concepts as adequate replacements.

The Systems Concepts and Integration (SCI) Panel should address the technological areas identified on the General APM-A Concept Classifier/Generator Matrix.

The NATO Standardization Agency (NSA) should examine more closely the non-materiel alternatives including changes in Tactics, Techniques and Procedures (TTP). The Engineer Working Party must consider the very important issue of interoperability in the hand-over of sectors that have been mined by a non-signatory nation to the Ottawa Convention.

The NATO Army Armaments Group (NAAG) should take the lead in finding materiel alternatives for APMs. These alternatives especially affect the mission areas of Engineers, but also many of the missions of Land Forces on the battlefield such as manoeuvre, countermobility and protection. The NAAG should generate a NATO Staff Target (NST) to identify the specific requirements of APM-A.

The NATO Industrial Advisory Group (NIAG) should conduct discussions and solicit ideas from Industries to address this very important issue and explore if there are any opportunities to further NATO armaments cooperation.

Finally, it is the recommendation of this Study Group to share the findings of this Study with other International Groups that are also addressing this very important area. See Chapter 4 for a complete list of recommendations and conclusions.

Solutions de remplacement aux mines antipersonnel

(RTO TR-040(I) / SAS-023)

Synthèse

Généralités

Depuis son adoption en décembre 1997, la Convention d'Ottawa a été signée par 17 des 19 pays membres de l'OTAN. La Convention est entrée en vigueur en mars 1999. Par voie de conséquence, la plupart des pays membres de l'OTAN étudient activement d'autres moyens de fournir au combattant les capacités que lui donnent les mines AP. Le SHAPE a demandé au Comité pour la recherche et la technologie (RTB) de l'aider à évaluer l'impact sur les opérations de l'OTAN de la perte de la capacité offerte par les mines AP. Le RTB a demandé à la Commission études, analyse et simulation (SAS) de conduire une étude en vue d'applications militaires consacrée aux solutions de remplacement aux mines antipersonnel. Cette étude a été réalisée dans le cadre de sept sessions tenues entre septembre 1999 et mai 2001.

Capacité de mines antipersonnel

Les mines AP permettent des économies de forces dans les opérations, assurent la protection des forces et modèlent le champ de bataille. Elles aident à fixer, détourner, bloquer et perturber la progression d'une force attaquante. L'utilisation de mines AP dans le cadre de champs de mines tactiques et de protection contribue à influer sur la direction du mouvement ennemi et à y faire obstruction. Les mines AP protègent les forces en défense et les flancs au cours des attaques. Elles infligent des dommages directs à l'ennemi et renforcent les barrières et obstacles naturels protégeant les positions défensives. Elles alertent la force amie de la présence d'une menace de troupes à pied, perturbent l'avance de la force attaquante, produisent des effets psychologiques et provoquent un effet de surprise sur les combattants de la menace menant une attaque à pied.

Les mines AP présentent un certain nombre de caractéristiques positives et négatives. On peut citer, parmi les caractéristiques positives type des systèmes de mines AP, la possibilité de production à faible coût, la couverture continue tous temps et dans toutes les conditions de terrain, le fait que leur emploi n'exige qu'une formation minime, la légèreté et le faible encombrement, et les faibles contraintes sur le plan logistique. Les caractéristiques négatives type sont, entre autres, l'absence de discrimination entre les cibles (réaction létale immédiate dès qu'elles sont déclenchées), le risque de constituer un obstacle pour la mobilité de l'infanterie amie débarquée, le caractère rigide de la durée de vie active, et le fait qu'elles ne se prêtent pas, sur le plan tactique, à des tentatives simples ou efficaces de réutilisation. La longue durée de vie des mines AP actuelles et le manque de précision quant à l'emplacement ou l'enregistrement de champs entiers de mines AP font qu'il peut subsister un risque résiduel après la fin des hostilités.

Synthèse des résultats de la modélisation et de l'analyse

La Commission a étudié les résumés de 15 études nationales se rapportant à l'impact des mines AP et aux solutions de remplacement. Les résultats montrent que l'ennemi dispose, dans la plupart des opérations, d'avantages militaires significatifs lorsque les forces de l'OTAN combattent sans mines AP. Les résultats ont également montré qu'il est possible de compenser une partie des capacités de mines AP perdues en employant différentes combinaisons d'armes au niveau des petites unités, mais de telles solutions de remplacement ont un prix : elles sont plus pesantes sur le plan logistique et impliquent des risques opérationnels pour les forces de l'OTAN. En outre, les évaluations quantitatives réalisées par tous les membres du groupe d'étude montrent que la perte des mines AP aurait de graves conséquences dans l'une au moins de cinq situations tactiques clés. Ainsi, les résultats des analyses quantitatives et qualitatives sont concordants : au niveau tactique comme au niveau opérationnel d'un conflit, la suppression des mines AP de l'arsenal des forces de combat de l'OTAN présente, du point de vue de la mission, des risques accrus pour les alliés. Ces risques ont été mesurés en fonction de plusieurs paramètres : augmentation du nombre de victimes, augmentation des pertes en matériel militaire, probabilité accrue de perte de terrain essentiel sur le champ de bataille, et augmentation du temps nécessaire pour reprendre l'initiative et accomplir les objectifs de la mission.

Les solutions de remplacement

Bien qu'aucun moyen de remplacement unité pour unité des mines AP n'ait été identifié, et que cet objectif ne semble pas réalisable, l'étude a permis de recenser plusieurs solutions potentielles qui permettraient de remplacer certaines des capacités offertes par les mines AP. On trouve, parmi les solutions à court terme, les systèmes français MODER et MODER Plus, les dispositifs à fragmentation directionnelle télécommandés mis au point par divers pays (munitions de type Claymore), le système norvégien de munitions d'interdiction de zone (ADWS), et le lance-grenades canadien. Filets et chausse-trapes pourraient s'inscrire, à court terme, dans la catégorie des solutions non létales. Dans de nombreux cas, toutefois, l'emploi d'armes et de solutions différentes au niveau des petites unités se traduit par une augmentation de l'incertitude et du risque quant à l'issue de la mission. Parmi les solutions de remplacement à moyen terme figurent les systèmes français SUZON 1 et SPECTRE, le système norvégien de munitions d'interdiction de zone OPAK plus, le dispositif canadien à fragmentation directionnelle télécommandé, le système américain Non-Self Destruct Alternative (NSD-A), et les systèmes/concepts américains Track III. Dans la catégorie des systèmes non létaux, on peut citer des améliorations des matériaux de type câble et colle. Parmi les solutions à long terme, on citera le système français SUZON 2, le champ de mines autorégénérant des Etats-Unis, et les munitions à guidage minimal des Etats-Unis.

D'autres concepts, non matériels, ont été envisagés dans le cadre de cette étude, comme les changements dans la doctrine, l'organisation, la formation, la direction et le personnel. Les recommandations portent notamment sur le réexamen de la doctrine sur les points suivants : (1) protection de la force; (2) appui-feu spécialisé indirect et naval; (3) appui aérien tactique et emploi des réserves; (4) réduction du temps d'attente dans les cycles de décision capteur-déclenchement; (5) organisation des tâches du génie, des patrouilles, et des moyens de renseignement, surveillance, acquisition d'objectif et reconnaissance (ISTAR); (6) augmentation de la létalité en combat rapproché des unités tactiques; et (7) rationalisation des procédures de dissémination de l'information.

Le principe de combinaisons de solutions matérielles et non matérielles a été retenu parmi les résultats de l'évaluation séparée, par le groupe d'étude, des solutions matérielles et non matérielles. Certains concepts exigent une définition et une évaluation plus poussées; on citera, par exemple, les concepts combinant des solutions matérielles et non matérielles comme le renforcement des dispositifs à fragmentation directionnelle par un contrôle à longue distance et des champs de télécapteurs, ou des champs de télécapteurs directement liés à des systèmes d'appui-feu spécialisé indirect. Les armes non létales n'ont pas fait, dans le cadre de cette étude, l'objet d'un examen exhaustif.

Recommandations

La Commission SAS devrait mener une étude de suivi afin d'examiner les avantages et les difficultés associés à la combinaison de solutions matérielles et non matérielles pour le remplacement des mines AP. Le groupe d'étude de la Commission SAS sur les armes non létales (SAS 035) devrait en particulier étudier l'utilisation des armes non létales (ANL) comme moyen de substitution des mines AP. Les ANL deviendront un moyen de remplacement important, puisqu'elles n'exigent pas d'homme dans la boucle, ou de confirmation de statut combattant/non-combattant.

La Commission facteurs humains et médecine (HFM) devrait tenter de mesurer les effets psychologiques des mines AP à titre de contribution à l'évaluation de concepts en tant que moyens de remplacement adéquats.

La Commission concepts et intégration des systèmes (SCI) devrait aborder les domaines technologiques recensés dans le tableau général (APM-A) de classification/production de concepts de mines AP.

L'Agence OTAN de normalisation (AON) devrait procéder à un examen plus attentif des solutions de remplacement non matérielles, et notamment les changements dans les tactiques, les techniques et les procédures. Le groupe de travail sur le génie doit examiner la question, très importante, de l'interopérabilité dans le transfert de secteurs qui ont été minés par un pays non-signataire de la Convention d'Ottawa.

Le Groupe OTAN sur l'armement des forces terrestres (NAAG) devrait jouer un rôle pilote dans la recherche de solutions matérielles de remplacement aux mines AP. Ces solutions ont une incidence toute particulière sur les domaines de mission du génie, mais aussi des missions des forces terrestres sur le champ de bataille comme la manœuvre, la contre-mobilité et la protection. Le NAAG devrait élaborer un objectif d'état-major OTAN (NST) afin de recenser les exigences spécifiques de l'APM-A.

Le Groupe consultatif industriel OTAN (NIAG) devrait mener des discussions avec les industries et solliciter leurs idées sur cette très importante question et rechercher les possibilités de faire progresser la coopération dans le secteur des armements de l'OTAN.

Enfin, le groupe d'étude recommande de partager les conclusions de la présente étude avec d'autres groupes internationaux également concernés par ce très important domaine. On trouvera au Chapitre 4 une liste complète des recommandations et des conclusions.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

1.1.1 The Ottawa Convention

Since its inception in December 1997, seventeen of the nineteen NATO nations have signed the Ottawa Convention. The Convention entered into force in March 1999. As a result, the signatory nations have a little more than ten years to completely phase out the use of Anti-Personnel Mines (APMs). Consequently, most of the NATO nations are actively considering alternative means of providing the capabilities that APMs give to the warfighter. SHAPE requested assistance from the Research and Technology Board (RTB) with assessing the impact on NATO operations of losing the APM capability. The RTB, in turn, asked the Studies, Analysis and Simulations (SAS) Panel to perform a Military Applications Study on Alternatives to Anti-Personnel Mines. The study was actually conducted over seven sessions between September 1999 and May 2001.

1.1.2 The Impact for NATO

APM have been an important asset for most NATO nations for many years. They currently played key roles in many aspects of land operations, principally providing force protection and battlespace shaping capabilities. During the March 1998 Research and Technology Board (RTB) meeting, Supreme Headquarters Allied Powers Europe (SHAPE) requested assistance with understanding and assessing the impact on NATO operations of losing the APM capability. The results of such a study were viewed as critical to the defence planning process. The possibility of identifying viable APM alternatives was also determined to be of importance. The RTB, in turn, asked the Studies, Analysis and Simulations (SAS) Panel to perform a Military Applications Study on Alternatives to Anti-Personnel Mines. The SAS Panel approved the formulation of study group SAS-023 (the Study Group). The TOR for SAS-023 was approved during the SAS Panel November 1998 meeting.

1.1.3 Conduct of the Study

The SAS Panel approved a 12-month study effort entitled *Military Application Study on Alternatives to Anti-Personnel Mines* on 10 February 1999. The study was granted (in May 2000) a six month extension and actually conducted over seven sessions between September 1999 and May 2001. The extension was necessary in order to complete the results of the war gaming models and further investigate the characteristics and implications of the non-material alternatives. The US accepted leadership of the study; a co-chairman system was instituted. The other participants were taken from 11 volunteer NATO nations and several defence organizations and HQs (see Annex A). The co-chairmen provided the SAS Panel with regular updates during the period of deliberations. The initial study schedule and the objectives for each of the meetings conducted is provided in Chapter I, Section 5.

1.2 BENEFITS OF THE STUDY

The study results have obvious military benefit, as they supply NATO with a thorough analysis of military characteristics and capabilities that are lost when APMs can no longer be employed. It also provides a full description of potential alternative systems (current) and concepts (future) complete with preliminary evaluations of the suitability of these alternatives when measured against certain constraints and other criteria. The study leaves the final analysis to the individual nations to weigh these alternatives against national constraints to determine which systems or concepts are most relevant to the particular nation. The study provides the opportunity to examine the interoperability benefits gained by having NATO nations work collectively on acceptable alternatives.

1.3 SCOPE OF THE STUDY

1.3.1 Study Objectives

The study was tasked to consider the impacts of no longer having APM available to the NATO warfighter, and to consider alternative systems and/or concepts for replacing any resulting capability shortfall. The systems and concepts were to be either materiel (technological solutions) or non-materiel (doctrinal or procedural) in nature. The Study Group was to identify the most promising concepts and provide recommendations for further research and analysis, thereby providing key advice to RTB in support of SHAPE's Defence Requirements Review (DRR) process (see Annex B).

1.3.2 Study Goals

The key goals of the study were to:

a. Generate a list of roles or capabilities that APM provide and the specific missions (Article V and Crisis Response Operations) in which APM are currently used.
b. Investigate the impact that the lack of APM has at the tactical and operational levels. (Consider the impact on force power requirements in the context of the DRR process).
c. Identify capabilities that alternative systems and concepts should possess to compensate for the loss of APM.
d. Identify potential alternative concepts and associated research efforts by country. Consider ongoing national activities in the near, mid and long term and conduct additional brainstorming. Include materiel (hardware systems, including both current systems and research areas into future concepts) and non-materiel (doctrine and procedures) solutions.
e. Develop a list of common constraints by which to measure the political and military acceptability of any given alternative (e.g. binding regulations and cost).
f. Measure the acceptability of the alternatives against the common constraint list.
g. Report the outcome of the study and provide recommendations for possible further analysis and study.

1.3.3 Study Constraints

The Study Group listed a number of APM tactical employment situations covering a range of potential NATO missions (Article V and non-Article V). The group concentrated its scenario development and analysis efforts however on a subset of key missions within this larger list of potential missions. The group considered alternatives for APM only and did not address alternatives to Anti-Tank (AT) or mixed AP/AT systems[1]. However, the role of the APM in protecting AT mines was considered. Finally, the impact of the loss of APM at the strategic level was not investigated (since it is political by nature); the study group concentrated its efforts on the operational level and tactical levels only.

1.3.4 Assumptions

It was assumed that alternative concepts were to be consistent with applicable international regulations. It was also assumed that consensus could not be achieved on all aspects of the effort; individual national policy constraints, and other limitations would be captured in appropriate annexes of the report. Finally, it was agreed that no single solution would be acceptable to all nations, so that a list of alternatives, from which nations could choose to investigate further, would be the best possible output of the study.

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[1] For the Signatory nations, AP/AT systems or Mixed Munitions are considered as APM.

1.3.5 Definitions

All definitions, acronyms, and abbreviations used in this report are provided in Annexes C and D.

1.3.6 Terms of Reference

The SAS Panel provided Terms of Reference (TOR) for the study; these were refined at the first Study Group session and subsequently approved by the Panel (see Annex E).

1.3.7 Program of Work

Based on the TOR, the Study Group also produced the following Program of Work (POW).

a. Describe what conventional APM contribute to the battlefield.
b. Investigate the impact that the lack of APM has at the tactical and operational levels.
c. If impacts exist at the tactical level, do these impacts affect the operational level?
d. Consider ways to accurately aggregate impacts in NATO models.
e. Determine if increases in force power can compensate for lack of APMs at the standard brigade / division structure.
f. Develop the common constraint list from national inputs.
g. Identify and categorize potential alternative concepts and associated research efforts.
h. Conduct additional brainstorming.
i. Develop list of necessary capabilities, characteristics and battlefield effects.
j. Measure alternatives against the common constraint list, desirable capabilities, characteristics and effects.
k. Report results of analysis and indicate areas for further study or research.

1.4 METHODOLOGY

1.4.1 The Role of APM

In order to determine what the APM does for the warfighter, the Study Group decided to break the battlefield into three traditional areas: deep operations, the close battle and rear area operations. Using current doctrine and military judgement, the study group developed the situations within these three battle zones where one normally encountered APMs. To make deliberations more manageable, the Study Group decided to use only the top five situations to further refine the role, and consequently, the capabilities of APMs (see details in Chapter 2).

1.4.2 The Impact Statements

Knowing what capabilities the APM brings to the battlefield, it was decided that the impact of their loss at the tactical and operational levels was best determined through scenario modeling and war-gaming techniques. The Study Group was convinced that if the results of the modeling showed no significant impact, then the remaining study objectives were unnecessary.

The Tactical Level Impact Statement

The scenario modeling and war gaming was easier to do at the tactical level, because it is better understood. Several nations did studies involving company, battalion, and brigade level forces. All studies more or less indicated a significant impact. However, it was the Lawrence Livermore National Laboratory (LLNL) study using Joint Conflict and Tactical Simulation (JCATS) that proved to be the most comprehensive in execution and definitive in its results. It is offered as the most reliable evidence that the (NATO) loss of APMs will result in higher NATO casualties and reduced success at winning the tactical level battles (see detailed results in Chapter 2, Sections 3 and 4). The Study Group believes that the results obtained at the brigade level (using the JCATS model) can be iteratively examined and “rolled upwards” to Corps level to achieve a reliable amalgamation. This would enable the measurement of the impact at the highest NATO Article V tactical levels (i.e., normally Corps).

<u>The Operational Level Impact Statement</u>

The Study Group first had to determine what made the operational level (for NATO Article V operations this is normally the Combined Joint Task Force [CJTF] e.g. Regional Commands) different from the tactical level. Then it was necessary to decide whether the operational level impact could be just a further amalgamation of Corps level results. In the end, it was decided that Deep Operations was the peculiar aspect of the CJTF domain that made it unique. Additionally, the group also agreed that a simple multiplication of brigade level results would not suffice as an indication of the impact on the division or Corps levels. Unfortunately, none of the models used in the tactical level studies could quickly manage something as large and complex as a theatre level analysis. Therefore, the group based their initial operational level impact statement on military judgement extrapolated from the tactical level close battle results supplemented with results of scenario vignettes extracted from a CJTF level Deep Battle (see Chapter 2,Section 4).

1.4.3 Necessary APM Capabilities and Characteristics

Having been convinced by the war gaming results that APM have a significant effect on the battlefield, the Study Group proceeded with the next logical step from the assigned portfolio of study goals (Chapter 1, Section 3). It developed a list of the capabilities and characteristics of APMs that were most worthy to be duplicated by alternative systems and future concepts (see details in Chapter 3, Section1). The intent was to use this list to supplement the common constraints list in order to describe and assess the proposed alternatives.

1.4.4 The Proposed Alternatives

A lengthy list of generic, unconstrained alternatives was produced in accordance with tactical situations (dismounted attack, key point defence), intended battlefield effects (block, turn) and other contributions (psychological effects, surprise). While this list may be of some use to nations when evaluating which system or concept is best for them, it was not used to develop the list of actual systems and concepts. The process to explore and define APM alternatives employed data that addressed: warfighter APM missions, APM functions, and the developed APM-A general functional description. This collection of data was subjected to the APM-A general concept classifier and generator (for materiel or non-materiel alternatives or concepts), a series of assessments on common constraints, and, APM-A desired characteristics. The actual list of alternatives, both material and non-material, was the result of this process, national contributions on current system developments and national studies on future concepts. The US War Fighters Conference on Non Material Alternatives was also a valuable tool. All reasonable proposals are categorized by the time frames created by the study group: near term – by 2003; mid term 2004- 2008; and long term beyond 2008. The material alternatives are further classified by:

a. which APM functions it embraces (sense, communications means etc);
b. which APM missions it is suited for (of the 5 top mission scenarios);
c. which APM effect it achieves (block, turn etc.);
d. what technical characteristics are possessed or incorporated in the alternative;
e. when the alternative will be available; and
f. an initial assessment based on the common constraints list.

Chapter 3 provides more details on the process to define and assess APM alternatives.

Initially, it was thought that a short list of materiel and/or non-materiel alternatives would eventually emerge from either the unconstrained, generic list or the actual systems and concepts list. This was not the case. The Study Group determined it to be unduly restrictive to eliminate any of the so many promising variations and alternative themes.

1.4.5 Areas for Study or Research

As the study progressed, several areas were identified by the group as requiring further work (see Chapter 4, Section 4 Recommendations for details). It is recommended that the NATO NSA be made aware of these areas so that various NATO Working Groups or other forums can be assigned to investigate.

1.5 SCHEDULE

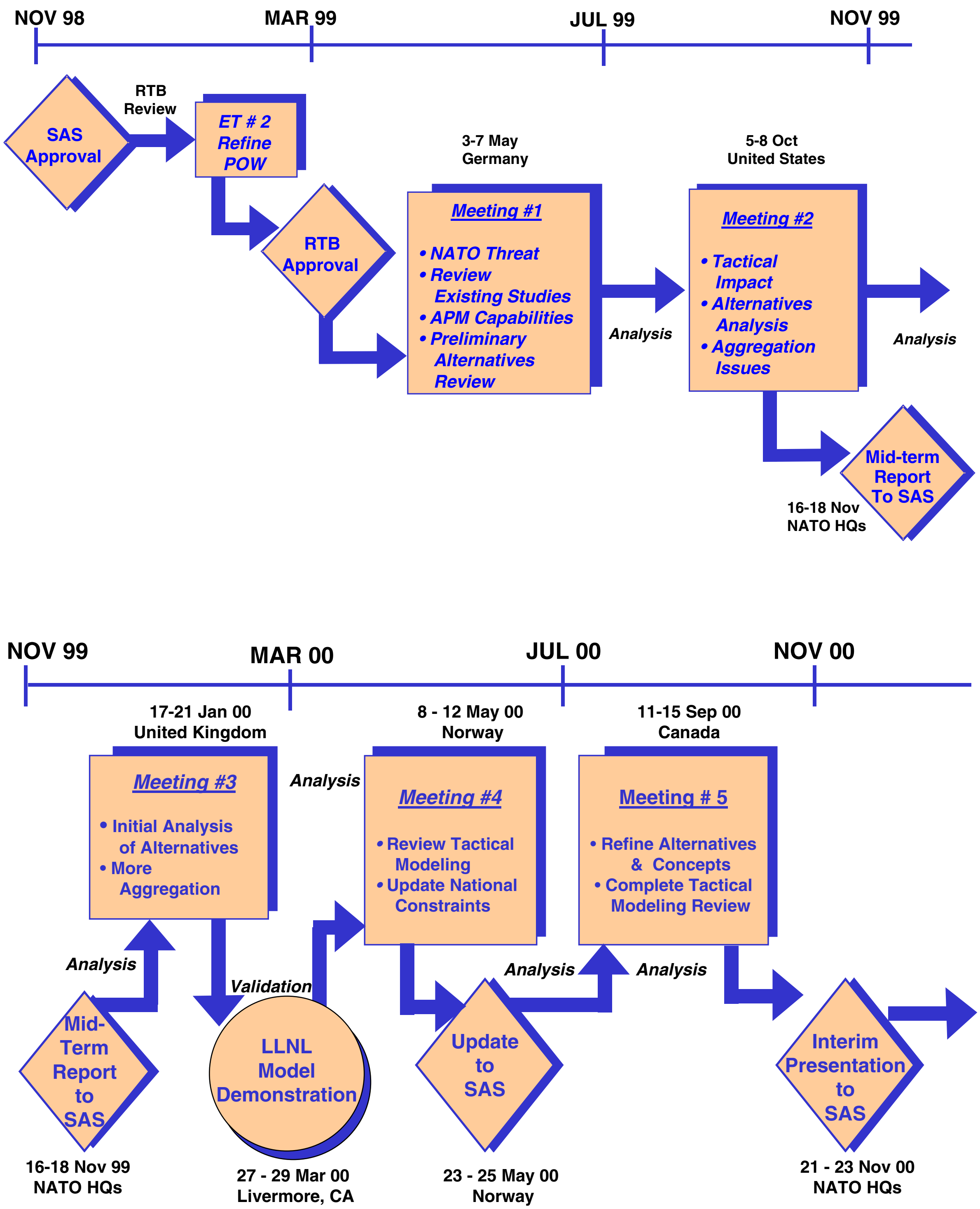
The Military Application Study on Alternatives to APMs was approved for a 12-month duration. After the interim SAS Panel review of May 2000, the co-chair of the working group requested the SAS Panel chair to approve an extension of the study until May 2001. The extension was to allow the Study Group to finalize additional analysis of the impact due to the loss of APMs and further address the characteristics and implications of non-materiel APMs alternative concepts. The study methodology and tasks were based around the originally scheduled six meetings that occurred during the first 12 months of the effort. Subsequent study meetings were scheduled to specifically address non-materiel alternative issues as well as the development of the final report. Each meeting built upon the preceding one and refined the established goals and objectives for the forthcoming meetings. The first meeting established the baseline objectives for the study effort and presented the SAS Panel approved Terms of Reference (TOR) for the study (see Annex E).

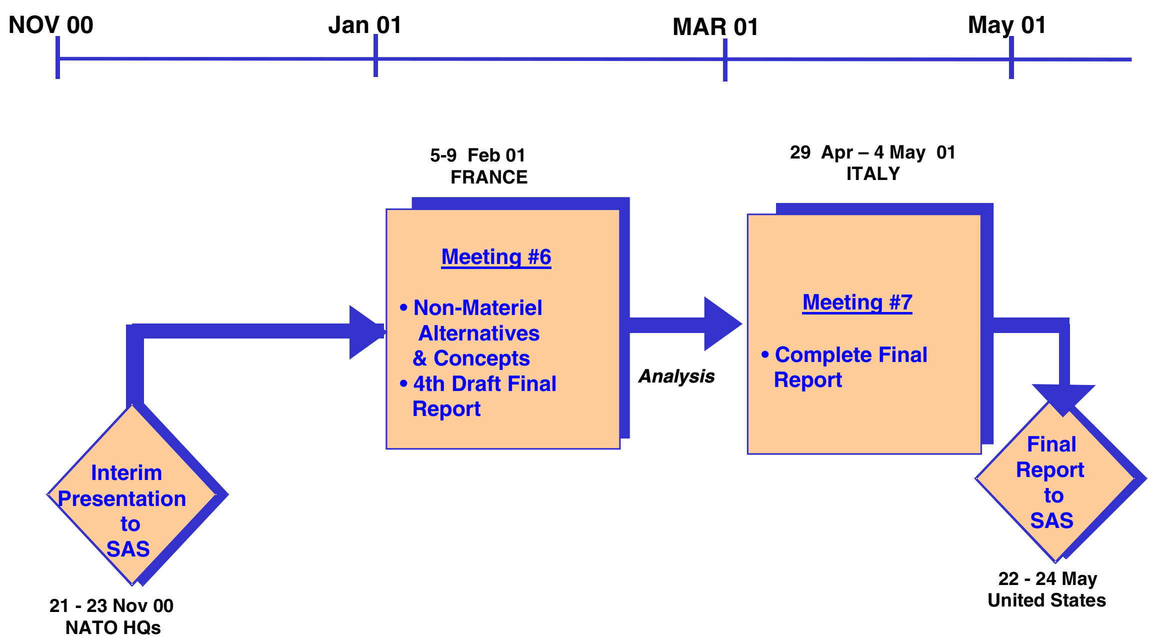
The first meeting took place in Germany during 3-7 May 1999. The study was completed 24-25 May 2001 with a final brief. The final report document was submitted to the SAS Panel on 22 February 2002 after review by the SAS-023 members. A total of seven study group meetings were held during the course of the study. The locations and timeframes of the working group meetings were:

Meeting #1	Germany	3-7 May 1999
Meeting #2	United States	5-8 October 1999
Meeting #3	United Kingdom	18-21 January 2000
Meeting #4	Norway	9-12 May 2000
Meeting #5	Canada	11-15 September 2000
Meeting #6	France	5-9 February 2001
Meeting #7	Italy	30 April -4 May 2001

Two special interest meeting were also held during the study period. In March 2000, a modeling and analysis meeting was held in the United States at the Department of Energy Lawrence Livermore National Lab (LLNL). A NATO scenario and the modeling capability of LLNL was discussed and approved by the study group for inclusion in the group's efforts. A second special interest meeting concentrating on non-materiel APM alternatives was held November 2000, again in the United States. The results of the examination of non-materiel APM alternatives from the US hosted conference are also incorporated in this report. The study group co-chairs presented three interim status reports to the SAS Panel on the following dates: 16-18 November 1999, 22-24 May and 23-25 November 2000. The study meeting schedule and objectives for each meeting held is provided in figure 1.

Figure 1. APM-A Study Schedule




NOV 00
Jan 01
MAR 01
May 01
5-9 Feb 01
FRANCE
Meeting #6
• Non-Materiel Alternatives & Concepts
• 4th Draft Final Report
Analysis
29 Apr – 4 May 01
ITALY
Meeting #7
• Complete Final Report
Interim Presentation to SAS
21 - 23 Nov 00
NATO HQs
Final Report to SAS
22 - 24 May
United States

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CHAPTER 2

ANTI-PERSONNEL MINE (APM) CAPABILITY

2.1 THREAT

The study to identify potential APM-A is related to the role of APM with regard to the combat functions of counter mobility and survivability and whether these functions are still important for warfighters in the foreseeable future. A NATO threat assessment was deemed the best directive to ensure the long-term viability to counter-mobility and survivability. The SHAPE threat assessment was reviewed and it is the opinion of the study group that Article V (warfighting) and Crisis Response operations remain the primary requirement for having NATO ground forces. In addition, it was determined that counter-mobility and survivability remain key combat functions for these operations. Therefore, weapon systems that contribute to the success of counter-mobility and survivability plans are still legitimate. In the past APM were considered to be important in support of the above mentioned two operations; alternatives to APM could very well fulfill this requirement in the future.

Given the continued existence of significant mounted and dismounted threats, NATO forces will continue to be placed in situations where they are initially outnumbered. Additionally they will be forced to conduct operations against asymmetric opponents in environments that attempt to exploit NATO force vulnerabilities. Operations will expose NATO forces to the spectrum of threats ranging from organized, conventional forces to loosely structured groups who fight symmetrically and asymmetrically. Enemy forces will continue to equip themselves with increasingly advanced weapons and sophisticated countermine equipment making them more capable of initiating complex operations with increasing tempo of operations and momentum. In such an operational environment, the ability to provide force protection, economy of force assets, and enable the shaping of the battlespace will remain a necessity. Such functions are currently performed by APM making the need for an alternative a continued requirement of NATO forces.

2.2 THE APM ROLE, EFFECT, CHARACTERISTICS AND IMPORTANCE

2.2.1. APM Role as an Element of a Military Obstacle

Obstacles and barriers are planned and employed as part of many military operations. Obstacles on the battlefield are divided into a number of categories and types, the first distinction being either existing or reinforcing obstacles. Existing obstacles are those barriers present on the battlefield as inherent aspects of the terrain or from previous operations. Existing obstacles include natural obstacles such as rivers, forests, or mountains, and manmade obstacles such as bridges, canals, or railroad embankments. Existing obstacles also include areas that have been enhanced by military construction, emplaced or detonated by military forces during previous operations that are no longer integrated with fires for the current operations.

In most cases, mines are employed in re-enforcing obstacles. Such obstacles are covered by fires and are intended to prevent the enemy from traversing an area without suffering a decrease in their forward momentum. The decrease in enemy momentum is measured in terms of casualties, loss of equipment, and/or expenditure in time and logistic burden to overcome the obstacle. Reinforcing obstacles are specifically constructed, emplaced, or detonated by military forces and are assumed to be integrated with fires. Reinforcing obstacles require breaching or reduction type-operations to overcome. Reinforcing obstacles are categorized as tactical or protective in function. APM are integrated into both tactical and protective obstacles to complicate breaching attempts and decrease the enemy's momentum associated with traversing the area. Anti-personnel (AP) mines in mixed minefields increase the complexity of the breaching decisions and operations of the hostile force. Employed deep, a mixed minefield with AP elements provides a form of field-self protection to the AT elements complicating the breach and potentially delaying the hostile force until other weapon systems can be brought to bear on the hostile elements.

The decision to emplace obstacles containing landmines resides at the Division or Corps (two or three star) level command authority. Detailed procedures, doctrine, regulations, and controls contained in numerous NATO field manuals ensure responsible and accountable use.

2.2.2. APM Battlefield Effects

APM are employed on the battlefield to accomplish certain functions and provide specific battlefield tactical effects. They assist in fixing, turning, blocking and disrupting the progress of the attacking force. The uses of APMs in tactical and protective minefields help influence and obstruct the direction of enemy movement. APM as elements of tactical obstacles inflict direct damage on the enemy and reinforce natural barriers and obstacles for defensive positions. APM protect defending forces and guard flanks during attacks. APM assist on the operational level by enabling economy of force operations, providing force protection and shaping of the battlefield.

2.2.3. APM Characteristics

APM provide specific contributions on the battlefield due to their unique system and operational characteristics. APM provide friendly force alert of a dismounted threat presence, disrupt the advancing attacking force, and produce psychological effects. APMs target dismounted threats, produce casualties, and protect obstacles against dismounted personnel actions (including ATM obstacle elements). APM provide harassment to, and, generate surprise against attacking dismounted threat personnel.

As with all systems or devices, APM have a number of positive and negative characteristics associated with the design of these military assets.

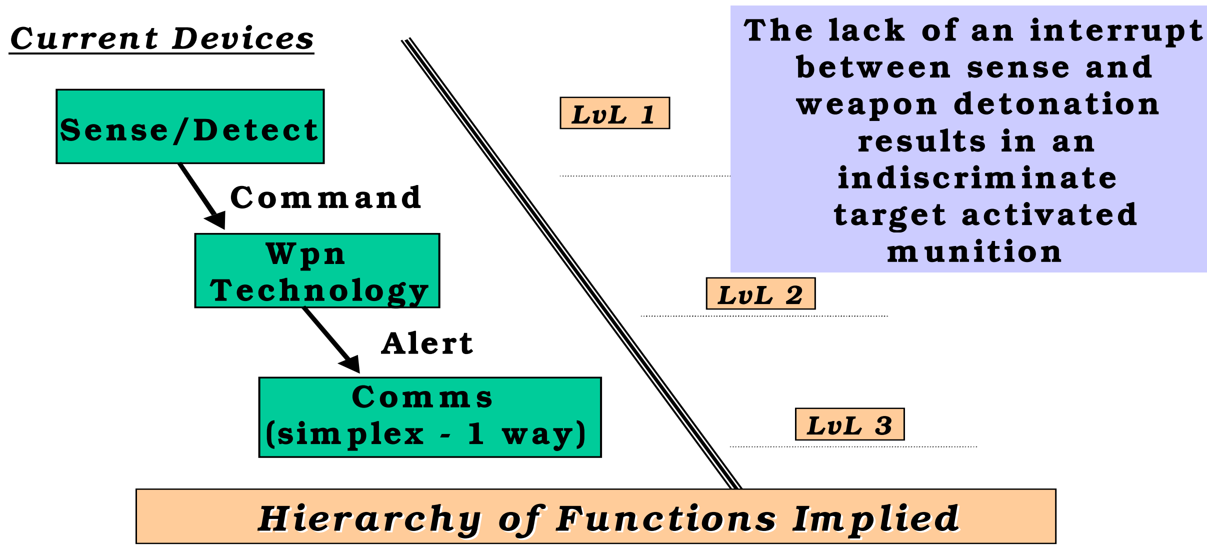
Typical positive APM system characteristics include their ability to be produced cheaply, operate in all weather conditions, require minimal training to employ, light weight and small volume, and, logistically non-burdensome. APMs' operational characteristics enable them to provide continuous area coverage, economy of force, and force multiplier effects. APM are hard to detect and counter, as well as being highly reliable in all terrain types over what is usually a well defined area.

Typical negative characteristics associated with APM systems or devices are their indiscriminant targeting (i.e. their immediate lethal response once tripped). The fact that APM can potentially be an obstacle to friendly mobility (dismounted infantry) as much as they inhibit hostile forces is a negative characteristic[2]. Most APM are "single shot" devices with inflexible active life and are not tactically amenable to easy or efficient attempts to reuse elements of an APM field. Current long-duration APM present a potential residual hazard after hostilities have ended. Finally, the potential for imprecise location and registration of entire fields of APM is a negative characteristic despite current employment procedures.

In summary, current APM possess a hierarchy of functions initiating with sense/detect followed by an immediate command for a weapon response with the sound of the blast providing the final alert to friendly forces of the intrusion. This functional hierarchy prevents target discrimination to occur between sense and detonation of a lethal response. This is illustrated in Figure 2.

[2] Obstacles to own force implies it would consume nearly as much time and resources by friendly forces to breach or clear as those expended by the threat.

Figure 2. General (Functional) Decomposition of Current APM Devices



2.2.4. APM Tactical Employment Situations

There are many military missions for APM and even more scenarios by which the working group could have examined the capabilities associated with the spectrum of employment of APM or APM alternatives. To prevent an inefficient expenditure of the working group's energy on enumerating APM military missions, the group agreed during the first meeting to an abbreviated list of key representative APM tactical employment situations (see Table 1). From the list of sixteen situations, five were identified as top priority and subject to analysis before the rest.

Table 1 - APM Tactical Employment Situations

REAR AREA	CLOSE AREA	DEEP AREA
Key Point Protection*	**Defend Against Mass Infantry Assault***	**Protect AT Mines***
Counter Desant (Counter Air Assault)	**Protect Obstacles***	Area Denial
Counter Beach/River Assaults (coup de main)	**Dismounted Infiltration***	Protect Obstacles
Dismounted Infiltration	Key Point Protection	Route Denial
	Counter Desant	
	Strong Point Protection	
	Cover Withdrawal	
	Ambush	

Key: * - Indicates the 5 top priority Tactical Situations to analyse

These five key tactical situations chosen for analysis are discussed below with regard to the mission of APM to perform successfully in each tactical situation.

Key Point Protection (rear)

Key points such as logistic supply areas, infrastructure, base camps, command and control installations, and lines of communications require protection against sabotage, early capture, or espionage. APM provide an all weather 24 hr capability that will give early warning of offensive action and provide an economy of force to combat such attacks. The threat could consist of forward enemy elements such as Special Forces, Air Maneuver elements, infiltrators, saboteurs, or thieves. The use of APM in this mission provides time to enable friendly forces to organize themselves to deal with the threat and frees forces for use elsewhere. APM therefore provide cost-effective force multiplier, and an all-round protective early warning system that enables a limited number of troops to concentrate on their primary duties.

Protect Obstacles (Close)

The reasons for tactical obstacles are: to delay or canalize enemy movement, to enable friendly maneuver, to fix the enemy in an area where direct and indirect fires can be optimized against them, all with the goal of disrupting and delaying the attacking hostile force. The use of APM to increase the complexity of breaching and clearing obstacles or protecting anti-vehicle obstacles increases the vulnerabilities of the enemy and dilutes his firepower. APM force the enemy to make critical decisions regarding their breaching technique, trading the cost in resources and time to conduct dismounted breaching or “bull-throughs” versus bringing forward mounted counter-mine assets to breach the obstacle.

Dismounted Infiltration (Close)

The use of APMs provide continuous, all terrain and all weather protection of defensive positions against infiltration of dismounted enemy. APM in this mission provides early warning, delay and attrition of enemy forces enabling friendly forces to react in timely and appropriate manners. APM often provide the only means of coverage in difficult terrain (dense forest, vegetation or dead space) resulting in a force multiplier to the defending force.

Mass Infantry Assault (Close)
APM provide an all weather continuous capability and is manpower efficient in protecting a prepared position against overwhelming odds. APM cause significant early casualties in combination with other integral assets before the enemy is able to overrun the position. This provides friendly forces with an effective force multiplier that would otherwise have required significant extra friendly forces or fires.

Protect Anti-Tank minefields (Deep)
APM are used to protect tactical, nuisance and remotely delivered or pre-emplaced Anti-tank minefields to the deep battle. They are used against enemy maneuver assets by forcing them to bring forward and use dismounted engineers or dedicated breaching vehicles to breach the obstacle. Such actions thereby delay the enemy movement and enable friendly forces to maneuver into a position of advantage.

2.3 SUMMARY OF MODELING AND ANALYSIS RESULTS

The panel examined summary descriptions of 15 national studies related to the impact of APM and alternatives. Five of these studies (numbers in bold) were carried out specifically to support the work of SAS-023. The national inputs are covered in more detail in Annex F. Table 2 gives an overview of the national studies.

Table 2 - Overview of NATO Studies Related to APM

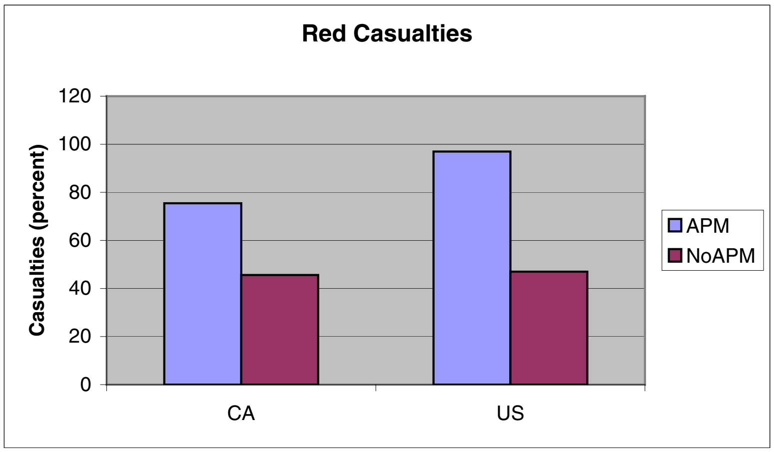
Country	Study no.	Name of Study	Subject/Description	Year	PPT-file*
Canada	**1.1**	**Exercise Duffer's Drift 1&2**	**JANUS Wargame Simulation of close combat**	**2000**	**Yes Vol II, CA**
France	2.1	Prospective Study on the Evolution of Counter Mobility	Technical and operational aspects of future counter mobility	2000	No
	2.2	ETO Architecture of Remote Area Control Systems	Control of remote areas	2002	No
	2.3	ETO Protection of Land Deployments	Force Protection	2002	No
Germany	3.1	Future Capability for Counter Mobility	Mech Div in Defence & in attack. No APM	2000 – 2002	No
Hungary	4.1	Barrier Situation after the Ottawa Treaty	Tactical and operational impact on the Ban on APM	2000	Yes Vol II, HU
Netherlands	5.1	Stocktaking of Area Denial Means (ADM)	Stocktaking of ADM	Ongoing	N/P
Norway	6.1	Operational Impact of Ban on APM	Operational and Economic Impact for National Defence	1998	Yes Vol II, NO
	6.2	**Tactical Impact of Ottawa Treaty**	**Map Exercise. Tactical Impact for National Defence**	**1999**	**Yes Vol II, NO**
	6.3	Norwegian Landmine Study	ATM in new Force Structure. Impact of no APM.	2000 – 2001	Yes Vol II, NO
United Kingdom	7.1	Alternatives to APM	Simulations	N/P	N/P
	7.2	**Tactical Impact of no APM**	**Map exercise plus SIMBAT simulations**	**2000**	**Yes Vol II, UK**
	7.3	Anti-Handling Device	ACE Simulations	N/P	N/P
United States	**8.1**	**Battlefield Utility of APM for NATO**	**Tactical Modelling and Simulations (Joint SAS-023)**	**2000**	**Yes Vol II, US**
	8.2	**Battlefield Utility of APM – Alternatives for NATO**	**Tactical Modelling and Simulations (Carlisle Conf.)**	**2000 – 2001**	**Yes Vol II, US**
	8.3	Utility of Shelf Healing Minefield Concepts	Korean (TRADOC) scenario APM to protect AT mines	1999 – 2000	No
	8.4	Battlefield Utility of APM and Alternatives, Track 3	Tactical Modelling and Simulations (various scenarios)	1999 – 2001	No

Bold numbers indicate studies that are/were performed for SAS-023, N/P: Information Not Provided, * - See Volume II Annex for powerpoint presentation

Three nations (Canada, United Kingdom, and United States) employed computer-based combat simulations as tools in their analysis. All three looked at many scenarios as discussed in Annex F. As a part of their analysis, all three looked in detail at the protective obstacle employment of APM against massed infantry assault, and analyzed remarkably similar scenarios. In these, the force ratios were in favor of the attacker, facilitating isolation of specific APM contributions. The similarities between these scenarios, provided as an illustration, permits comparison.

Canada used the Janus combat simulation and a scenario where APM and other obstacles protected a defending platoon of 42. The attacker was an infantry force of 189 attacking across a space of about 400 meters. The United States used the JCATS combat simulation and a scenario where APM and other obstacles protected a defending platoon of 30. The attacker was an infantry force of 190 attacking across a space of about 400 meters. This similarity is not unexpected – the scenario is the common infantry platoon defensive problem. In both cases, the force ratios are such that the issue is in doubt. Results for the "No APM" cases, as shown in figure 3, are virtually identical.

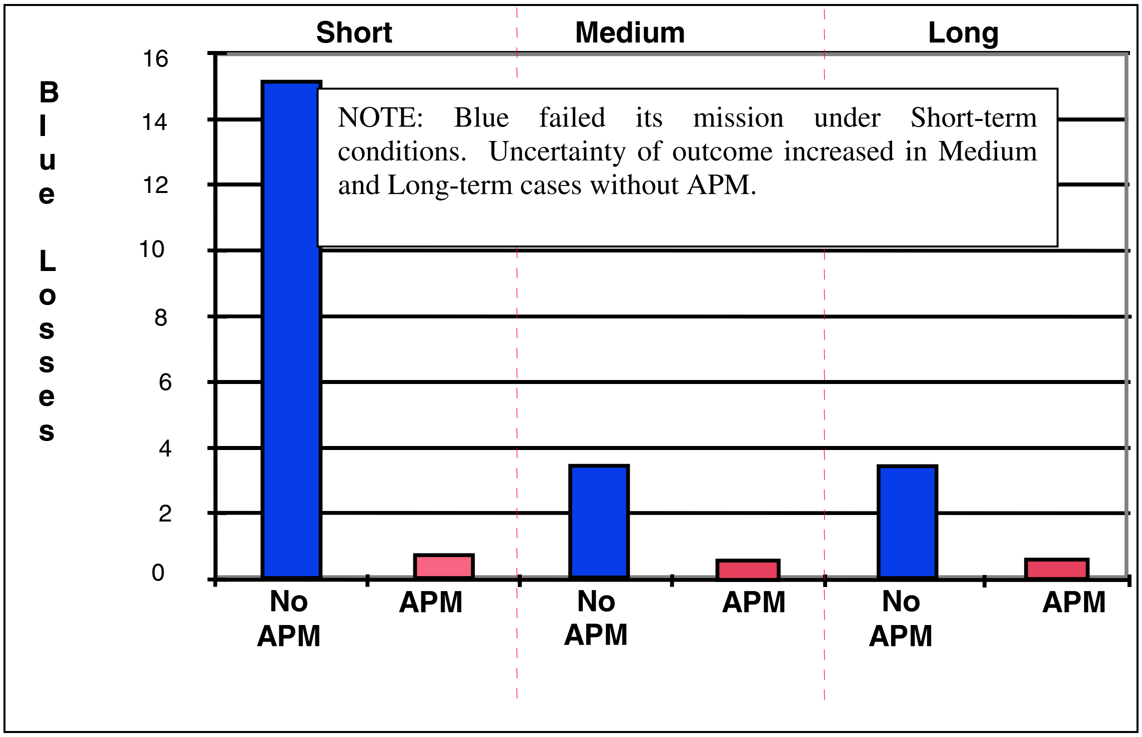
Figure 3. Analyses of Infantry Platoon Defensive Problem



Under the "APM" cases more Red became casualties in the US analysis because the US employed a much denser APM minefield. When APM were removed, the outcome was exactly the same in both US and Canadian scenarios, the majority of the Blue force became casualties.

The UK modeled a similar scenario using the CAEn model, with a scenario where a reinforced company attacked a platoon on an airfield perimeter. The lower force ratio than the Canadian or US scenarios (4:1 rather than ~ 10:1) meant that the Red force almost always lost. Blue casualties were used to differentiate between alternatives. Results as contained in Figure 4 illustrate the criticality of APM in this scenario. With current equipment and no APM, Blue failed to hold the airfield perimeter and failed in its mission.

Figure 4. Casualty Impact on Blue Platoon without APM



The categories short, medium, and long reflect weapons available to the force in those timeframes. The mid- and long-term analyses reflect the possible inclusion and availability of future weapon systems. Specifically, in the mid-term the replacement of conventional sustained fire medium machineguns with automatic grenade launchers with fragmenting rounds is the major change. The long-term analysis includes improved 81mm mortar accuracy. [Note: the employment of any weapon improvements in the mid- or long-term analyses does not necessarily imply guaranteed development or fielding of such systems.]

The results from all three studies reinforced each other and showed similar reductions in force effectiveness when APM were not employed.

Based on the results of the modeling and analyses, the group agreed that without APM or adequate replacement the following challenges occur on the battlefield.

1. In the defence:
   - It is harder to shape the battlefield
   - The attacker is harder to target (he's moving)
   - There is less time to target the attacker (he's moving faster)
   - There are more attackers firing at defenders (they are not busy with complex obstacles)
2. As an economy of force:
   - It is harder to mass forces to decisively overpower the enemy
   - Forces are more vulnerable (exposed flanks)
   - It is necessary to keep more forces on the flanks and in reserve
   - Battle tempo is higher, reducing decision time for the defender (must plan, organize, position and commit resources earlier).

3. In the area of force protection:
   - Forces are placed at greater risk
   - Forces have less stopping power (early entry and support units have fewer defence options)
   - Forces have a more difficult task when asked to disrupt or deter an attack (commit more to defend our lodgement).

Study results demonstrated it is possible to compensate for only some of the lost APM capabilities by employing different mixes of weapons at the small unit level. Further, employment of different weapons and alternatives at the small unit level in many cases results in increased uncertainty and risk on the mission outcome.

2.4 TACTICAL AND OPERATIONAL IMPACT STATEMENTS

The study group attempted to devise a method to measure the effects of fighting without APM at the tactical and operational levels of war. Members of the group were able to perform modeling and analyses that measured, at the tactical level, the impact on the battlefield. Assessing the impact at the operational level was not readily attainable due to the lack of resolution of theater level models to address the contributions of individual weapon systems. Despite the lack of an operational modeling capability, the study group aggregated tactical results over time and space to provide an initial assessment of the loss of APM that could be expected at higher combat levels. The resulting tactical and operational impact statements developed by the group from the modeling and analysis performed are stated below.

Tactical Impact Statement: Tactical level modeling and analysis was performed by study group members from: Canada, Norway, United Kingdom, and United States. Their efforts addressed all five of the key tactical situations for APM identified in Table 1. As a result of their analyses and the study groups review of those results the study group developed the following tactical impact statement:

The SAS-023 agrees that NATO forces fighting without Anti-Personnel Mines (or adequate replacements) provide the enemy with significant military advantages in most operations. In particular, without NATO employment of APM (or a replacement), adversaries are unencumbered and provided more freedom of movement; a potential for increased tempo of operations, and the removal of significant levels of fear among dismounted units.

Operational Impact Statement: After development of the tactical level impact statement and the review of the NATO scenario employed in the US LLNL modeling effort, the study group was able to draw the following implications appropriate to higher combat levels of command. The tactical level battlefield results would impact NATO force reserves, timelines and contingency plans. Such complications to planning and the positioning of forces would result in an impact at higher levels of command. As a result of this qualitative analyses on the tactical results and their aggregation to higher command level implications, the study group developed the following operational impact statement:

The SAS-023 Study group agrees that the loss of APM from the NATO inventory with no replacement provides the enemy with significant advantages in all areas of the theater.

In the rear area, or COMM Z, vital installations such as critical nodes in the logistic and C2 systems would be easier for the enemy to disrupt or destroy using covert or deep infiltration forces. This interference would affect NATO's ability to command, sustain and/or regenerate forces.

In the main defensive area, the results of the tactical level modeling conclude that APM are very useful to restrict the enemy's freedom of movement and operational tempo. In addition, NATO forces will sustain more casualties without APM (or an adequate replacement).

In the deep battle area, the NATO operational commander's ability to interdict the enemy's avenues of approach is reduced again without APM or adequate replacements. Therefore, the enemy's tempo of operations remain unscathed.

In addition, all study group members provided their qualitative assessment of the impact of APM on the selected five APM missions. Naturally, the scores vary from nations-to-nations in accordance with the importance that their respective nation's doctrine places on the use of mines in a specific situation. Nevertheless, this subjective weighting of the missions provided additional indication and justification that all members of the group considered at least one tactical situation (of the five) would be severely impacted due to the loss of APM. Table 3 provides the results of the qualitative assessment.

Table 3 - Qualitative Assessment of Loss of APM vs Situation/Mission

Battlespace Situation/Nation		**BE**	**CA**	**DK**	**FR**	**GE**	**HU**	**IT**	**NL**	**NO**	**UK**	**US**	**SHAPE**
REAR	Key Point	5	5	3	5	5	5	5	3	3	5	1	5
CLOSE	Mass Assault	1	5	3	1	1	3	3	1	1	5	5	5
	Protect Obstacle	3	3	3	3	5	3	3	3	3	3	3	5
	Dismounted Infiltration	5	3	5	5	5	5	3	5	3	3	3	5
DEEP	Protect ATM	1	3	1	1	3	3	1	5	5	5/1*	5	5/1*

Key: 5 = Major, 3 = Medium, 1 = Minor indicates qualitative assessment of the loss of APM for each APM mission. * - Indicates a difference between importance of mission and Nations APM use in the mission.

Therefore, from both the quantitative and qualitative analyses and at both the tactical and operational levels of conflict, the removal of APM from the NATO fighting forces inventories were viewed as presenting increased mission risk to the allies. The risks were measured in increased casualties, increased loss of military equipment, increased probability of loss of key battlefield terrain, and increased time to regain the initiative and accomplish mission objectives. Because of these initial results, the working group determined that a search for alternatives to APM was a necessary endeavor.

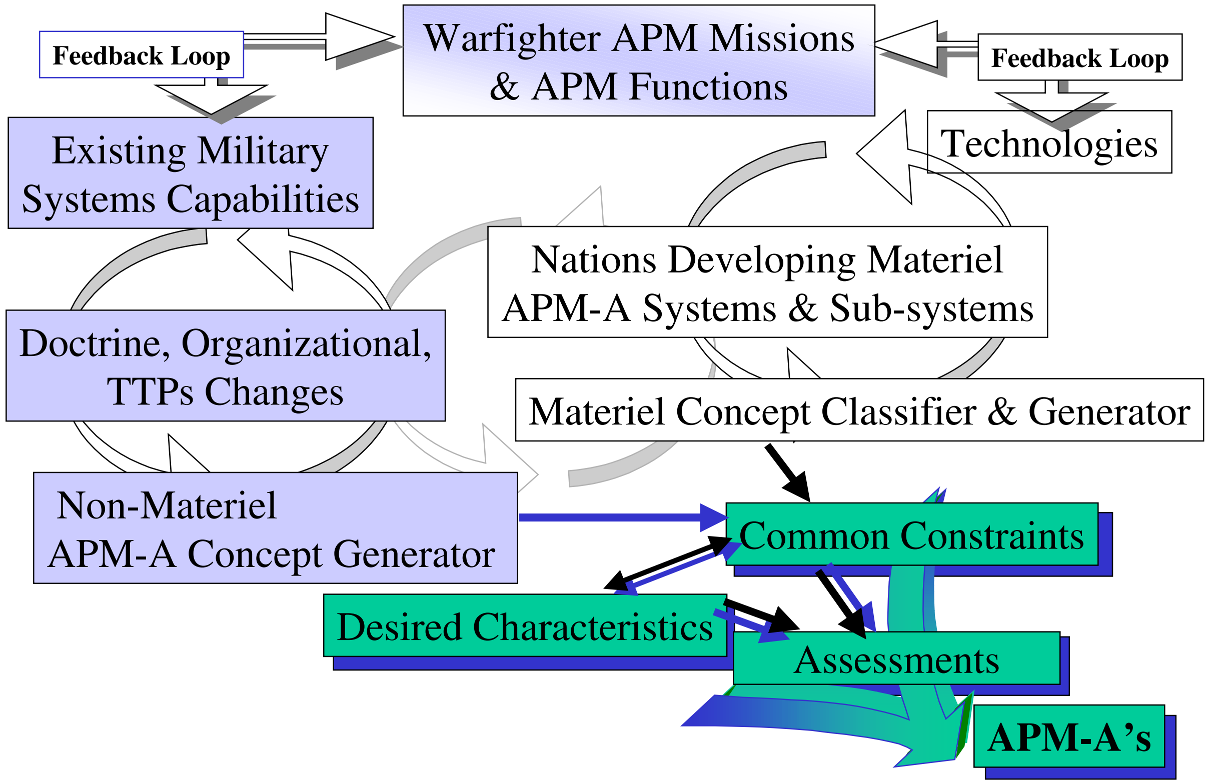
CHAPTER 3

THE ALTERNATIVES

3.1 GENERAL

Having determined that the loss of APM had serious enough consequences for the NATO warfighter to warrant an investigation into possible alternatives, the study group designed a process by which it could gather proposals and classify them. The process to explore alternatives employed the warfighter APM missions and APM functions previously presented. Since the study was started as a result of the nations having to eliminate their current APM inventories, some of the nations had already identified materiel and/or non-materiel APM alternative systems/devices/concepts or programs. The review of these alternatives was incorporated in the study's process. The group developed lists of both common constraints for any APM-A (materiel or non-materiel in nature), and desired APM-A characteristics. The group segmented the alternatives by timeframes by which alternatives could be implemented, and finally developed a general functional architecture for any (materiel or non-materiel) APM-A. The technologies involved in materiel-based alternatives were segmented and classified in general terms. Non-materiel-based alternatives of doctrine, tactics or organizational changes were similarly segmented and classified with regard to the APM-A functions they satisfy. Finally, a general concept classifier and generator was developed that enabled the characteristics, functionality and technologies of any alternative to be mapped against the APM-A functional architecture developed. Alternatives were then subjected to the common constraints, desired characteristics and assessed by the group. Any alternative to successfully complete this process was deemed a viable APM alternative by the group. Comparative assessments among the alternatives were not performed. This process of identifying, generating and assessing APM alternatives is summarized in Figure 5.

Figure 5. The Process of Identifying, Generating and Assessing APM Alternatives



The lists of possible material and non-material alternatives compiled as part of the SAS-023 study (see Annexes H and I) are by no means exhaustive. The alternatives represent contributions made by the nations participating in the study. Several other NATO nations and partner nations may well have instituted programs of which the SAS-023 Study Group has no knowledge. The study group believes that any alternative and its associated technologies or doctrine/tactical concepts can be described, classified, and assessed within the process employed by the study group. During the evaluation process of the alternatives, several areas for further technical study were revealed. One such technology left for further evaluation was that of non-lethal weapons. Advances in all technologies and doctrinal areas may well lead to other alternatives. Naturally, the search for alternatives should not end with this report. This report should be considered as the springboard from which nations can choose short-term solutions and hopefully, be the catalyst for inspiring nations to develop more refined long-term alternatives in either case aware of the associated costs and military risks.

3.1.1 APM Types of Alternatives

It was necessary to break the potential family of alternatives into two basic categories, material and non-material. Of course, a combination of material and non-material systems or concepts may very well prove to be the best solution for any particular nation, but the study group did not have the time to evaluate the many possible combinations. In fact, combined materiel and non-materiel concepts postulated by the study group were found to be an important family of alternatives that warrant further investigation and evaluation.

a. **Materiel Alternative**. A materiel alternative involves the specific design, technical development and procurement of new military systems to replace APM capabilities (See Annex C. Definitions). Materiel alternatives also include specific enhancements to systems that are currently undergoing development to better address lost APM capabilities, such as improved directed fragmentation devices.

b. Non-Materiel Alternative. A non-materiel solution was interpreted as not involving new hardware development, but rather changes to doctrine, tactics and innovative employment or increases in the number of other existing systems to fill the void created by the APM ban. (See Annex C. Definitions)

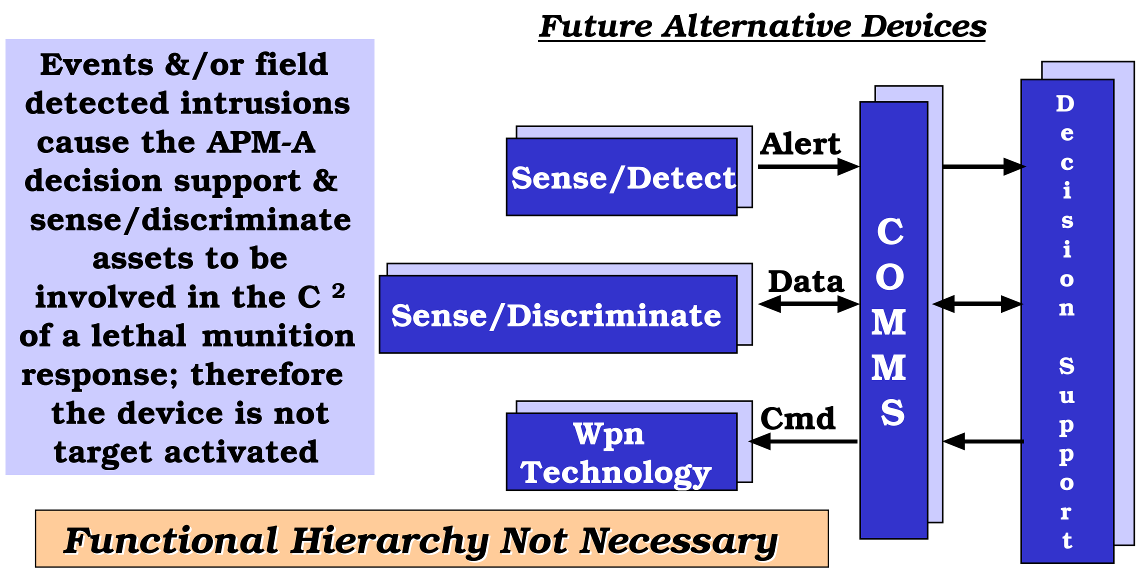
3.1.2 Desired Characteristics and the General (Functional) Description of an APM-A

To guide the collection and assessment of potential materiel and non-materiel alternatives, a list of desired APM-A characteristics was created. Although it was used in the first level analysis of each candidate solution, the list was not intended for use as a means of assigning a priority ordering to the alternatives. The list may also prove useful to nations developing APM-A concepts:

a. reliable discrimination,
b. multi-roled (effectively fills as many APM roles as possible),
c. inexpensive,
d. simple to train and employ,
e. lightweight,
f. minimum latency (sensor to activation time),
g. flexible employment (terrain and weather),
h. compatible with other systems,
i. difficult to detect,
j. difficult to counter, and
k. achievable (time and technology).

In addition to these desired characteristics, a functional description of APM alternatives was also developed by the group. Five functions of sense/detect, communications, decision support, sense/discriminate, and weapons technology were defined. These functions distribute alerting data, mission data, and device/munition commands across an architecture that provides for devices to vary their response to events and sensed intrusions. This architecture is illustrated in Figure 6. The functional architecture illustrated in Figure 6 allows for a flexibility of control and response heretofore not provided by APM. Initial intrusion detection to the controlled area can come from either the “sense/detect” or “sense/discriminate” functions as well as from sources outside the APM-A directly to the “decision support” node. Additionally, the architecture allows for immediate non-lethal responses to “sense/detect” intrusions without interruption from the “decision support” function.

Figure 6. General (Functional) Description of APM-A



3.1.3 General APM-A Concept Classifier and Generator

The working group contends that any materiel or non-materiel APM-A should address most if not all the functions of Figure 6. The identification of the technologies involved in materiel concepts or tactics/organizational postulated changes of non-materiel concepts should span the entire set of functions of figure 6 if the concept is to be a self-contained APM alternative. Therefore, a general APM-A concept classifier and generator was developed that allowed such an assignment of concept components to APM-A characteristics, architecture and functionality. The classifier/generator that resulted from the groups' effort is illustrated in Figure 7.

Figure 7. General APM-A Concept Classifier/Generator

APM-A Concept	Sense (Detect)	Comms (alert)	Discriminate	Decision Support	Comms (data/com-mands)	Weapons Effects	APM Mission
Non-Materiel or Materiel Alternatives	**None** **Contact sensors** *Tripwire, pressure…* **Line of sight (LOS) sensors** proximity (10 m) mid. range (100 m) long range (1000 m) *Human, optical sensors (passive or active IR, laserbeam, CCD, intelligent retinas), radars…* **Non line of sight (NLOS) sensors** proximity (10 m) mid. range (100 m) long range (1000 m) *Magnetic, seismic, acoustic, radars odours…*	**None** **Basic information** *Noise, light…* **Basic or smart information on physical support** *Wire, optical fibre, mechanical…* **Basic or smart information on non physical support** *RF, electromagnetic …*	**None** **Human** **Human with artificial mind classification system assistance** *Data base, sensors data fusion…* **Friend/Foe Identification (IFF)** **Autonomous**	**None** **Human (MITL)** **Human with expert system assistance** *Smart tech, data base, network management…* **Autonomous**	**Information on physical support** *Cable, optical fibre, electromechanical, electropyro-technical…* **Information on non physical support** *RF, acoustic, laser…*	**Lethal in-field** **Non lethal in-field** **Lethal remote** **Non lethal remote**	**List primary and secondary missions addressed**

APM-A concepts are generated by selecting an implementation for each APM-A function

The group employed figure 7 to enable the generation of equivalent descriptions of all materiel alternatives submitted by the members and to identify technologies that could, (if matured and applied) address key functional areas of any APM-A. The figure was also employed to discuss non-materiel alternatives and how the concepts based on doctrine, tactics or organization could also address the desired functions and characteristics of APM-A. The spectrum of alternatives is defined by listing technologies, characteristics, methods or military devices for each of the six functions listed across the top of figure 7 (Sense (detect), Comms (alert), Discriminate, Decision Support, Comms (data/commands), and Weapon Effects). Equivalently, an alternative concept is generated by selecting (from each column) a technology or method that can be used to accomplish a function and provide characteristics associated with APM-A. Alternatives that did not within their own system (or concept) boundaries, address all six functions of figure 7 would have to rely on external methods or devices to complete the required function set.

As an example of the utility of Figure 7, the following hypothetical materiel and non-materiel alternatives are described by identifying how each of the six APM-A functions are satisfied. A materiel alternative providing:

- Detection accomplished by a tripwire sensor;
- Communication of the detection accomplished by a hardwired electronic signal to alert an operator or observer
- Discrimination performed by a human aided with binoculars;
- Decision support by the same or different operator or observer, and finally,
- A command for a lethal response issued (as required by the decision support element) over hardwired means.

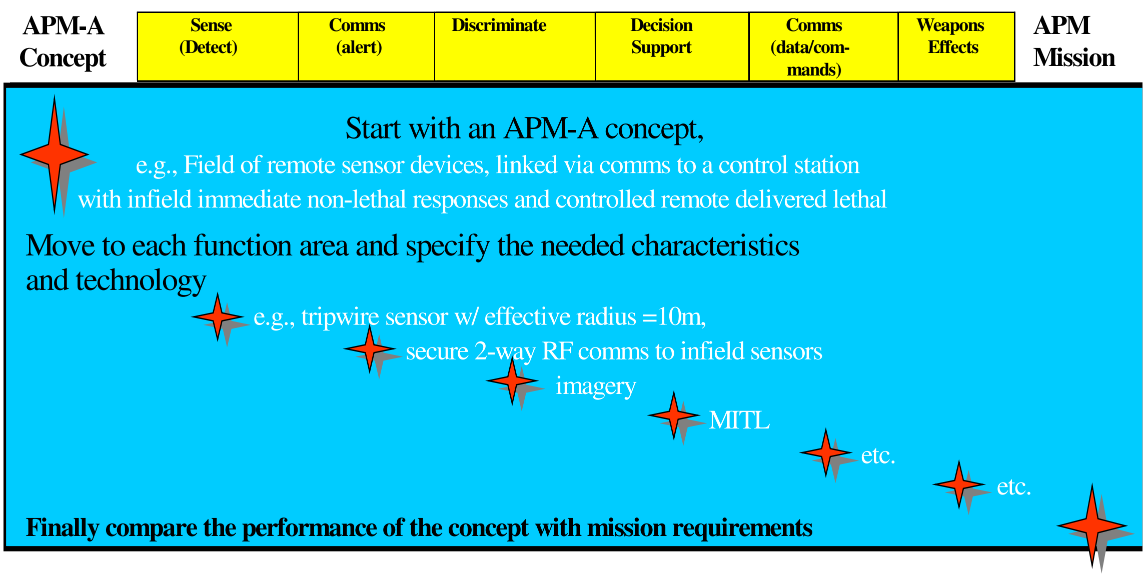
A non-materiel alternative providing:

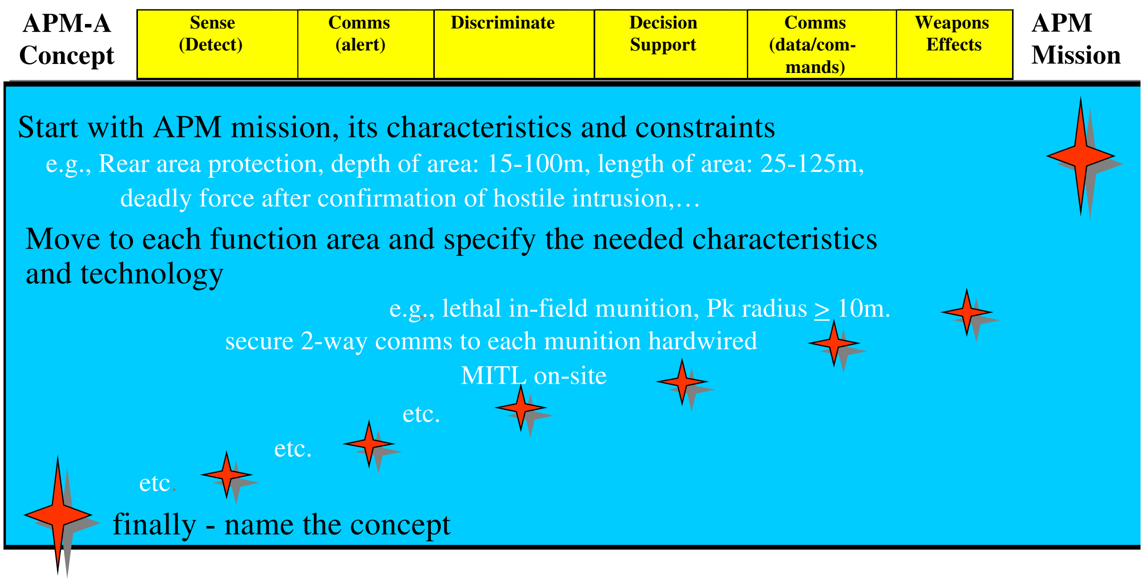
- Detection through the use of deep reconnaissance patrols;
- Alert to a controller by voice/data RF means;
- Discrimination by the reconn patrol members;
- Decision support by a remote commander; and finally,
- A command by radio to the fire support coordinator to fire an artillery barrage.

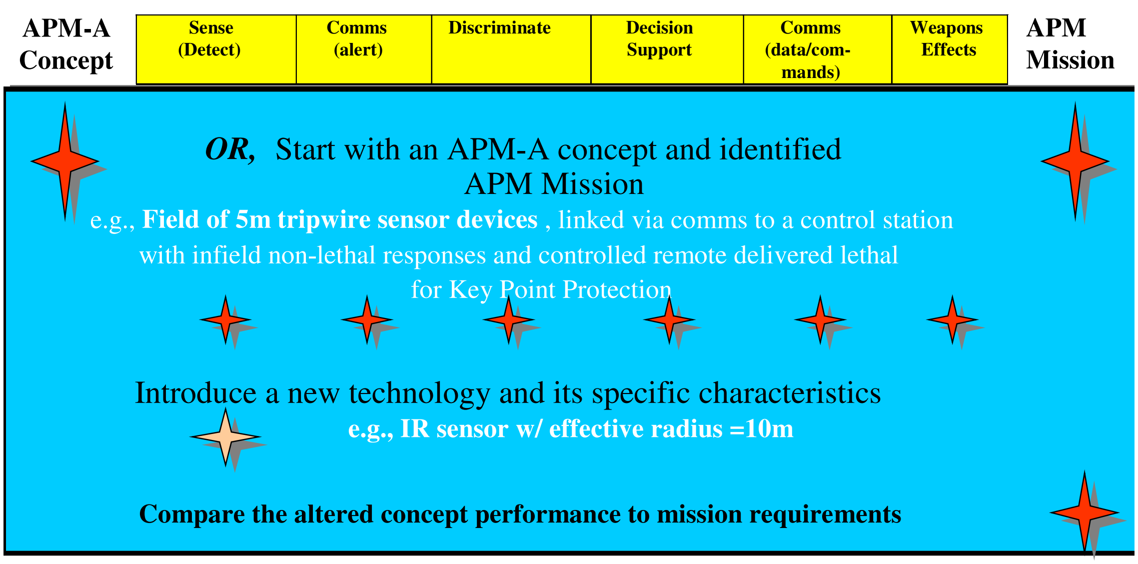
Hybrid materiel/non-materiel alternatives can also employ Figure 7 by identifying which functions are performed by materiel devices and those addressed by doctrinal, tactics or organizational methods.

Additionally, figure 7 can be employed if the parameters of the APM mission can be quantified or parametrically stated in the APM Mission column of Figure 7. Under such conditions, the parameters of the mission can be compared to the capabilities and effectiveness of the technologies (or non-materiel elements) comprising the alternative. Trade-offs can then be conducted based on the ability of any alternative concept to effectively address the military need as expressed by the mission parameters captured in the description of the "APM Mission". Figure 8 illustrates a series of views of the figure 7 matrix highlighting these various applications mentioned.

Figure 8. Example Applications of the General APM-A Concept Classifier/Generator







3.1.4. Timeframe

The study group decided that it as useful to group the family of potential alternatives by timeframe (of availability). To do this, it was necessary to define these timeframes:

a. near-term – by 2003,
b. mid-term – between 2004 and 2008, and
c. long-term – post 2008.

3.2 CONSTRAINTS AND LIMITATIONS

3.2.1. The Common Constraint List

The ban on APM is a very sensitive, politically charged topic. Each participating nation was tasked to submit their list of national constraints and limitations. These submissions are available for review in Annex G. The national submissions were condensed by the group to create a Common Constraint List (Table 4) that was used in the evaluation of the acceptability of alternatives.

Table 4 - Common Constraint List

Mandatory

Comply with all applicable international treaties – in particular: CCW Amended Mines Protocol II and the Ottawa Convention

Effective in at least one of the top five APM missions (Table 1).

Supplementary

Minimal environmental hazard
Interoperability (barrier handover, communication, etc)
Simple to emplace, safe, secure, robust, redundant C3
Reasonable impact on training and logistics
Compatible with doctrine and other weapon systems
Public acceptance

It is no surprise that this constraint list shares many of the same items found on the desirable characteristics list. However, because it represents common national concerns, it was felt that it was a more useful first-level evaluation tool than the desired characteristics list.

3.2.2. Additional National Concerns

Naturally enough, individual study group members did not want to see issues, peculiar to their nation, omitted from study. Most of these additional concerns are listed in Annex G, but several others appear as footnotes.

3.3 APM ALTERNATIVES AND THEIR ASSESSMENTS

3.3.1. Methodology

The material alternatives were submitted by nations. Most non-material solutions were generated as part of a special US-sponsored Warfighters' conference and during SAS-023 working group meetings. In both cases, it was necessary to categorize and evaluate each alternative using the Common Constraints, the Desirable Characteristics Lists, and the Concept Classifier/Generator. This provided a sufficient first level screening function to ensure that submissions were reasonable. The process employed was presented earlier in Section 1 of this Chapter (Figure 5). There was no second level evaluation made to try and rate alternatives relative to one another. Nor was there any attempt to quantify the APM mission characteristics and constraints to enable an assessment of alternatives' military effectiveness versus APM missions. (This quantification of APM mission characteristics is a SAS-023 group recommendation to the SAS Panel).

3.3.2. Nations Submissions of Materiel APM Alternatives

The submissions of alternative systems and concepts are available, alphabetically by nation, in Annex H. The submissions have been standardized under the headings APM (military) function, system/concept descriptor, APM Mission, and program status. The working group assembled thirty materiel alternatives/concepts. Most of the concepts/alternatives involve a human operator/observer to perform decision support and/or discrimination functions. A number of the alternatives expect technology to mature to levels where concepts can implement autonomous modes or significantly assist in the decision support and/or discrimination functions.

3.3.3. APM-A Materiel Assessment Results

The results of the first level evaluation, addressing the desired characteristics and common constraints lists are also attached to the national submission sheets in Annex H. The assessment states the evaluation criteria that were satisfied, which were not and any other limitations of the system/concept. Some of the alternatives were determined to be too early in their development/definition to be meaningfully assessed. Of the remaining materiel alternatives, all met the common constraint list criteria but one. None of the alternatives could address as a primary mission all five studied APM tactical situations, each had strong points of their designs that optimized their military utility for some situations at the expense of effectiveness in all. An initial assessment on the availability of materiel alternatives indicated that the submitted collection was almost evenly distributed across all three timeframes. Materiel alternatives found to satisfy the above first level evaluation are as follows:

Near-term (<2003) – MITL lethal systems, directional fragmentation devices (DFD), area denial weapon systems (ADWS), and non-lethal nets or caltrops

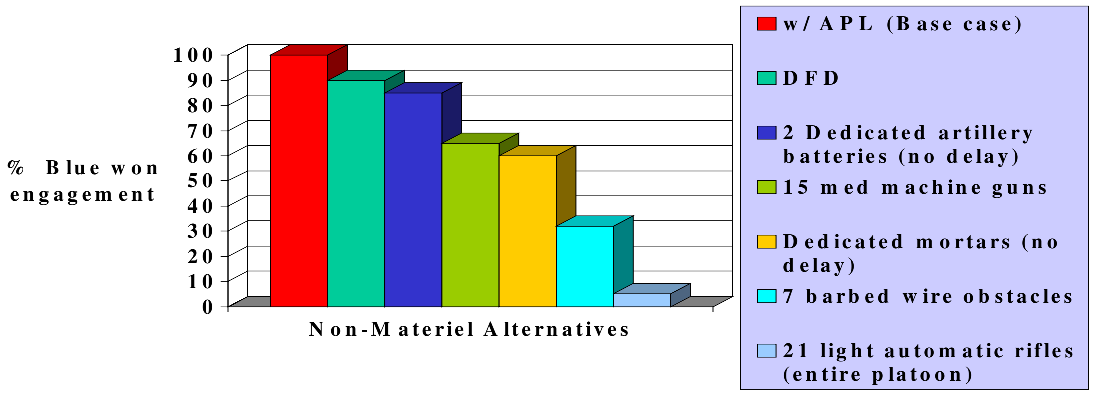
Mid-term (2004-2008) – Remotely controlled DFD or ADWS, improved MITL-based sensor and weapon systems, and improved non-lethal materials

Long-term (>2008) – Advanced area/maneouver denial systems, incorporation of advanced discrimination technologies.

3.3.4. Non-Materiel APM Alternatives

The working group conducted a number of discussions related to non-materiel alternatives to APM. The APM-A general functional description and the concept generator/classifier of an APM-A (Figures 6 and 7 respectively) were still valid to describe elements and functionality of any non-materiel concept presented by the group. Of special interest to the SAS-023 effort were the following aspects of the non-materiel conference and its results. The non-materiel conference specifically examined a potential NATO area of operations by using vignettes/scenario pertaining to the Balkans. The conference addressed the progression of military involvement, from peacekeeping to full engagement of military forces to enable examination of non-lethal barrier as well as lethal alternatives. Force structure of both friendly and threat forces for the Balkan scenarios were representative of the NATO forecasts. Modeling performed by LLNL was conducted after the conference to examine further the alternatives proposed. The results were presented to the SAS-023 members and generalized further to provide additional reference material for their own analyses (see US Annex of Volume II). An example of the scope LLNL modeling of non-materiel alternatives that embodied employing more force against the threat (more and dedicated artillery or mortars, more machine guns per platoon, more barbed wire obstacles,…) is provided in Figure 9 below.

Figure 9. Example Non-Materiel Alternatives Analysis



- Base cases taken from the APM .vs. No APM analyses:
  - Red lost 94% of his force w/ APM .vs. 25% w/o APM
  - W/o APM: battle outcome uncertainty increased, and/or the non-materiel alternatives were operationally unrealistic to implement
- Red never overran the defenders when APM were present, but always did when they were absent
- Red's use of smoke negates the increased defensive direct and indirect fires of the alternatives examined

3.3.5. APM-A Non-Materiel Assessment Results

The following statements summarize the non-materiel concepts, issues and insights of the study group.

Suggested concepts and non-materiel alternatives:

a. Doctrine-

(1) Review force protection doctrine.
(2) Review NATO fires (direct and indirect) doctrine.
(3) Review NATO fires tactics, techniques, and procedures.
(4) Decrease the latency in sensor-to-trigger decision cycles by having C4 fully linked to sensors.
(5) Synchronize intelligence, surveillance, and reconnaissance assets and provide rapid dissemination of useful intelligence to commanders.
(6) Reduce the "footprint of the force" and move the force more often.
(7) Update base camp security doctrine, and layer the defence.
(8) Review NATO Tactical Air Support for Land Operations (TASLO) tactics, techniques, and procedures.
(9) Reconsider the use of reserve forces (size and entry point.)
(10) Review employment of naval fire support (location and use.)

b. Organization-

(1) Reconsider task organization of intelligence, surveillance, and reconnaissance personnel.
(2) Streamline the flow of information across the battlefield.
(3) Allocate sensors and early warning systems to tactical units.
(4) Use more efficient smaller footprint command posts.
(5) Provide dedicated batteries as indirect fires for faster response.
(6) Reorganize engineer assets in task, purpose, and allocation to obtain more efficiency.
(7) Reconsider the organization and employment of snipers.

(8) Increase the close-in lethality of tactical units (automatic rifles, machineguns, automatic grenade launchers, thermal sights.)
(9) Re-allocate material which becomes available due to force downsizing.

c. Training-
(1)Train for the complexity of digitization.
(2) Increase the focus on patrolling, deception, and force protection.
(3) Increase joint and combined training.
(4) Train in the use of fires to protect anti-tank minefields and physical barriers including non-lethal barriers.
(5) Train in the use of directional fragmentation munitions.
(6) Train to employ increased information operations at all levels.
(7) Increase cross-training in engineer skills of all soldiers.

d. Leadership-
(1) De-centralize decision authority to ensure timely reactions and to reduce the latency in sensor-to-trigger decision cycles.
(2) Challenge leadership at all levels to train at all basic skill levels to compensate for the event of technology degradation.

e. Personnel-
(1) Develop a separate military occupational specialty for "sensor monitor/operator."

Issues and insights related to non-materiel concepts and alternatives:

1. The difficulty in developing non-materiel alternatives to anti-personnel landmines is that when using APM there is an automatic response and when using any lethal alternative a decision is required prior to activating a response. This decision requirement leads to the potential for significant delay. Replacing APM with an alerting function only, requires friendly forces to respond with either their own direct fire weapons (thereby revealing their location and force size) or request fire support such as artillery, attack helicopters, or TASLO. Either action (direct or indirect fire) has associated with it a delayed response and increased latency between sense and engagement of the target. The potential for delay (latency) causing ineffective fire is the critical issue with many of the non-material alternatives.
2. Non-lethal systems as APM alternatives may provide some capability but most likely will not be appropriate for all threat/situations.
3. Employment and greater reliance on many of the high-tech and operationally complex alternatives postulated present problems when contrasted by recommendations to reduce consumption levels, reduce the force, and, reduce the logistic footprint of a deployed force. The operational techniques and technology requirements to support alternatives discussed during the conference introduce potential vulnerabilities that could be exploited by hostile forces.
4. There were doctrinal issues that, if resolved, could potentially mitigate the absence of anti-personnel landmines. Generally though, the ideas surfaced involved doing things better, faster, or bypassing echelons of command.
5. Anti-personnel landmines have the most immediate and significant impact on the forward deployed dismounted infantry forces of platoons and companies. Removing the timely effects of anti-personnel landmines places soldiers at a disadvantage and increased risk.

Additional assessments are provided in Volume I, Annex I of the logistic and operational implications of the non-materiel alternatives and in the LLNL report provided in Volume II, US Annex.

3.3.6. Combined Materiel and Non-Materiel APM Alternatives

As a result of the study group's evaluation of materiel and non-materiel alternatives, numerous concepts were postulated that combined elements of, or entire materiel and non-materiel systems. These combined alternatives were not subjected to any evaluation by the study group. Combinations of materiel elements (e.g., devices that provide in-field sensor capability) with lethal response non-materiel weapons (e.g., dedicated indirect fires) are an example of the combined materiel and non-materiel alternatives within this family of concepts. The combining of AGL or DFD with sensor fields, the adaptation of remote control devices with DFD, and remotely piloted vehicles providing sensor input to dedicated indirect fire assets are alternatives that represent the operational, technical and analytical complexities associated with this class of alternatives.

3.3.7. Conclusion

A number of conclusions on the utility of APM, the complexity of defining materiel, non-materiel, and/or, combinations of alternatives (materiel and non-materiel) can be stated as a result of the assessments performed by the SAS-023 working group.

The analysis of APM, their materiel, and non-materiel alternatives illustrate that APM delay the forward progress of the enemy toward their objective. APM assist in the fixing of the enemy and protect own force positions. APM provide these delay, fixing, and protection capabilities with little-to-no increased vulnerability to the friendly force. Understanding the complex interrelationships between APM, range of engagement, attacker-to-defender force ratios, effective weapons ranges, effects of combined fires, and, posture and probability of hit are key in developing compensating (materiel or non-materiel) APM alternatives. Materiel alternatives with other-than MITL-based decision support should be investigated further (this class of alternatives would include NLW-based technologies). Technology to aid the decision support and discrimination processes should be further explored and monitored (for application to the APM-A issue) as they mature.

Own force structure increases (other than in discrete tactical situations) are not reasonable alternatives on a nation-wide scale and will most likely cause adversary changes in weapons employment and their own force structure. Increasing own force structure will also lead to countermeasures and doctrine changes by the threat in an effort to negate any benefits of such alternatives. Own force increases in lethality, awareness and engagement ranges increases result in less clear counters by potential adversaries.

Materiel, non-materiel or alternative concept combinations that increase small unit lethality, (small unit) situational awareness, or (small unit) operational range without appreciable force structure increases should be examined in further detail. Further details of this complex issue are provided in the Volume II, US Annex.

CHAPTER 4

CONCLUDING MATERIAL

4.1 SUMMARY

4.1.1 General

The SAS-023 study group consisting of scientists, warfighters and analysts was well supported by eleven NATO nations. Also participating were representatives from Supreme Headquarters Allied Powers Europe (SHAPE), NATO Consultation, Command and Control Agency (NC3A), and Joint Headquarters Center (JHQ CENT). The contributions made by each country and organization proved to be invaluable in accomplishing the study group's objectives.

4.1.2 Traditional Role of APMs

Anti-Personnel Mines (APMs) have been an important warfighting asset for many NATO members. They have played key roles in both defensive and offensive operations. In the protective minefield role, APMs have been used to keep the enemy "outside the wire" where defenders could better engage the enemy with other weapon systems. In the tactical minefield role, APMs have been used to assist in shaping the battlefield to allow more effective friendly fire and maneuver. NATO doctrine and standards identify five tactical effects that landmines provide to shape the battlefield; block, turn, fix, disrupt, and deny. To dominate maneuver on the battlefield, the enemy's mobility must be countered by enhancing natural obstacles or by installing man-made obstacles. The inclusion of APMs in these obstacles and their cover by fire provided capabilities that assisted warfighters in accomplishing the objective of dominant maneuver. APMs have had application in the deep battle as well, providing protection to anti-tank minefields, interfering with ground activities, and aiding in economy of force and force multiplier roles.

4.1.3 The Ottawa Convention

As of today, seventeen of the nineteen NATO countries have signed the Ottawa Convention on the Prohibition of the Use, Stockpiling, Production and Transfer of Anti-Personnel Mines and on Their Destruction. As of September 1998, 40 nations worldwide had ratified the Convention thus enabling it to enter into force in March 1999. As a result, many of the NATO nations are now actively seeking alternatives to replace the capabilities that APMs provide the warfighter. Alternatives can be materiel, non-materiel, or a combination of both.

4.1.4 The SAS-023 Study Group

In response to the APM ban, NATO found it prudent to examine the impact of the loss of APMs on NATO operations. Consequently, the SAS-023 Study Group, was established. The objectives of the Study Group were to investigate, at the tactical and operational levels, the impact of no longer having APMs available to NATO forces and to consider alternative systems/concepts for replacing any capability shortfalls.

4.1.5 Study Results

The study results identified the military characteristics and capabilities that are lost when APMs can no longer be employed on the battlefield. The study also provides a general functional description of potential alternatives. Preliminary evaluations and assessments of materiel and non-materiel systems and concepts being considered by various nations were performed using a common constraint list developed by the Study. The study leaves the final analysis to the individual nations and to NATO to weigh these options against their respective and collective constraints in order to determine which are most relevant to them and worthy of further pursuit. The study also provides a very important opportunity to examine the interoperability benefits gained by having NATO members work collectively on acceptable materiel and non-materiel alternatives.

4.2 SAS-023 STUDY GROUP ACCOMPLISHMENTS

The study group:
a. Developed a general methodology to describe anti-personnel mine alternative (APM-A) characteristics for both materiel and non-materiel concepts (see Figure 7).

b. Developed a common constraint list from national inputs (see Table 4).

c. Measured the tactical impact of military operations with and without APM for five key tactical employment situations. Key tactical employment situations studied were: key point protection in the rear area; defence against mass infantry assault, protection of obstacles, protection against dismounted infiltration in the close area; and protection of anti-tank minefields in the deep area (see Volume I, Annex F and Volume II Annexes).

d. Developed a tactical level impact statement supported by modelling and analyses performed for the SAS-023 Study (see Section 2.4).

e. Formulated an operational level impact statement on military operations without APM-A. The operational level statement is supported by sound military judgement and is an extrapolation of the tactical analyses (see Section 2.4).

f. Compiled a list of materiel and non-materiel alternative solutions that partially replicate the capabilities of APMs (Volume I, Annexes H and I).

g. Determined that additional tactical and operational analyses might prove beneficial in addressing the military effectiveness and resource implications associated with the reported alternatives (see Section 4.3).

h. Recommended additional analyses and investigations that could result in improved alternatives (see Section 4.3).

4.3 CONCLUSIONS

4.3.1 Tactical Level Impact Statement

The study found that, at the tactical level, the loss of APMs to NATO forces, without an adequate alternative, provides significant military benefits to the enemy in most operations. When APMs are not available: the tempo of enemy operations is unencumbered; the enemy is provided more freedom of action; the enemy enjoys reduced psychological stress; and friendly forces sustain more casualties. (See Section 2.4).

4.3.2 Operational Level Impact Statement

At the operational level, the study found that the loss of APMs from NATO's inventory with no comparable replacement provides the enemy with significant advantages in all areas (rear, close, and deep) of the battlefield. (See Section 2.4).

4.3.3 Overriding Criteria for Alternatives

An undesirable characteristic of APMs is that they are indiscriminately target-activated ("exploded by the presence, proximity, or contact of a person.") APM alternatives with injurious or lethal warheads that are not target-activated are considered acceptable alternatives. These alternatives replace target activation with a man-in-the-loop (MITL) engagement sequence. Many of these alternatives possess sensors to detect intrusions, communication and control systems to query sensors for discrimination, and communications to control the response of mechanisms that deliver lethal effects. Unfortunately, the introduction of an MITL increases latency in the sensor-to-shooter response and adds complexity and vulnerability to the system. Non-lethal alternatives do not require an MITL and can be target-activated. However, the non-lethal alternatives thus far identified do not satisfy the broad range of mission requirements. Decision support techniques that provide adequate discrimination to allow alternatives to be target activated was considered worthy of further investigation as a result of the group's discussion of APM-A characteristics, MITL technologies, enabling APM-A technology maturity, and warfighter requirements. If such operational APM-A modes (target activated subsequent to discrimination) were possible the group recognised that it would be employed most likely only under severe hostile scenarios.

4.3.4 Materiel Alternatives

Today not all the contributions of APMs can be replicated in a single system, nor does the capability to do so appear to be obtainable in the foreseeable future. Nonetheless, the study was able to identify several alternatives that can replace *some* of the capabilities provided by APMs. The alternatives were divided into near-term (<2003), mid-term (2004-2008), and long-term (>2008) solutions. Near-term alternatives may include the French MODER and MODER Plus, various nations' man-in-the-loop directional fragmentation munitions, the Norwegian Area Denial Weapon System (ADWS), and the Canadian Auto Grenade Launcher (AGL). Possible non-lethal alternatives for the near-term include nets and caltrops (a ground placed spike deterrent device.) Mid-term alternatives may include the French SUZON 1 and SPECTRE, the Norwegian OPAK plus ADWS, the Canadian remotely-controlled Directional Fragmentation Device, the U.S. Non-Self Destruct Alternative (NSD-A), and the U.S. Track III systems/concepts. Non-lethal mid-term alternatives include better wire, or glue-like materials as examples. Long-term alternatives may include the French SUZON 2, the U.S. Self-Healing Minefield and the U.S. Tags/Minimally Guided Munitions. (See Annex H for additional information on country submitted materiel concepts).

4.3.5 Non-Materiel Alternatives.

Non-materiel alternatives included changes in doctrine, organization, training, leadership, and personnel. Non-materiel alternatives can also include changes in the use and/or quantities of existing equipment and/or systems, such as employment of more (existing) ground surveillance sensors, or dedicated assignment of artillery or mortar assets (as examples). The Study Group concluded that increases in force structure are not feasible given the fiscal constraints on the nations. However, other non-materiel alternative recommendations were viewed as promising (see US Annex, Volume II). In addition, there are some doctrinal issues that, if resolved, could potentially mitigate the absence of APMs, but the ideas that surfaced generally involved doing things better and faster, such as bypassing and/or streamlining echelons of command. (See Annex I for additional information on non-materiel concepts).

4.3.6 Combination of Materiel and Non-Materiel Alternatives

The Study Group identified the possibility that suitable APM alternatives could be developed using a combination of materiel and non-materiel alternatives. An example of a combined solution might be the introduction of new intrusion sensors (or complete surveillance systems) with dedicated indirect fire assets or remotely controlled DFD munition. Given the limited scope and time constraints of the study, the Study Group did not fully explore the "gray area" of a combination of materiel and non-materiel alternatives. For this reason, recommendation 4.4.1.a is deemed to be of highest priority.

4.4 RECOMMENDATIONS

4.4.1 SAS Panel.

The SAS Panel should:

a. Recommend a follow-on study to examine the effectiveness and complexities associated with the union of both materiel and non-materiel alternatives which could prove extremely beneficial militarily. This study would employ modelling, operations research analyses, and military wargaming to determine the limits of materiel and non-materiel alternative effectiveness. A quantification of APM mission characteristics is also recommended as part of this follow-on study to further enable a level examination and assessment of any and all APM-A concepts to APM missions.

b. Determine the availability and capability of higher fidelity operational level modelling programs (eg. JCATS) to further analyse the loss of APMs at the operational level (particularly the Deep Battle).

c. Address the use of NLW as alternatives for APMs. The SAS Panel Study Group on Non-lethal Weapons (NLW) (SAS 035) should specifically address the use of NLW as alternatives to APMs. NLW will become an important replacement, as they do not require man-in-the-loop or confirmation of combatant or non-combatant.

d. Share the findings of the Study Group with other international groups that are also addressing aspects of this important topic. (e.g., the SAS Panel Study Group on Human Factors and Medicines should address and try to quantify the psychological effects of APMs in order to assist in the assessments of concepts as adequate replacements).

4.4.2 NATO HQ

NATO HQ should:

a. Designate a lead organisation (possibly the NATO Army Armaments Group (NAAG)) to develop an Outline NATO Staff Target (ONST) for materiel alternatives for APMs. These alternatives will effect not only the mission areas of Engineers, but also many of the missions of other land forces on the battlefield. Therefore, the development of the ONST may involve a collaboration between Land Group 9 (LG9) and other LGs.

b. Designate a lead organisation (possibly the Systems Concepts and Integration (SCI) Panel) to continue the science and technology work started by the SAS-023 study group. Specifically, the lead organisation should review, complete and address the technological areas explicitly or implicitly identified in Figure 7. General APM-A Concept Classifier/Generator Matrix of this report.

c. Request the NATO Industrial Advisory Group (NIAG) to perform a pre-feasibility study to determine if the requirements of materiel APM-A can be met.

d. Request the NATO Standardisation Agency (NSA) to continue the work started by the SAS-023 study group with a primary focus on maintaining the operational flexibility for commanders on the battlefield by developing critical interoperability procedures for:

(1) Taking over, or participating in, area responsibilities or missions which may include obstacles containing APMs or other systems prohibited to the relieving force by their national law.

(2) Fighting adjacent to, and being supported by, a force employing APMs or other systems prohibited by one or more of the forces' national law.

(3) Operating with other national forces employing non-materiel alternatives that change previously agreed to NATO doctrine.

e. Request the nations to provide comprehensive information about current and future national APM-A using the Defence Planning Questionnaires (DPQ) to incorporate the impact of these alternatives in the NATO Force Requirement Analysis Process and the Defence Requirements Review (DRR).

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Annex A - SAS-023 Country Participation & Representatives

OFFICE	LAST	FIRST	3-7 May 99	5-8 Oct 99	17-21 Jan 00	8-12 May 00	11-15 Sep 00	6-9 Feb 01	Apr/May 01
BELGIUM	Ferooz, MAJ	Serge	NO	YES	NO	NO	YES	YES	YES
BELGIUM	Van Mulders, LtCol	Karel	YES	YES	YES	YES	NO	YES	NO
CANADA	Markewitz, LTC	Alan	NO	NO	NO	YES	NO	NO	NO
CANADA	Roy, Mr.	Roger	NO	YES	YES	YES	YES	YES	YES
CANADA	Dickinson	Robert	YES	NO	NO	NO	NO	NO	NO
DENMARK	Garhoj	Per	YES	YES	YES	YES	YES	NO	YES
FRANCE - DGA	Munoz, Mme	Dominique	YES	YES	YES	NO	YES	YES	YES
FRANCE - DGA	Lendrin, GEN	Gerard	YES	YES	YES	YES	YES	YES	YES
GERMANY	Deutschman, MAJ	Bernd	YES	YES	YES	NO	YES	YES	YES
GERMANY	Funke, MAJ	Ulrich	YES	YES	YES	YES	YES	YES	YES
GERMANY	Schindler, LTC		NO	NO	NO	YES	NO	NO	NO
GERMANY	Wolf, BDir	Franz	YES	YES	YES	YES	NO	YES	YES
GERMANY	May, Mr.	Dirk	NO	NO	NO	NO	YES	NO	NO
HUNGARY	Olah, MAJ	Attila	NO	YES	NO	NO	NO	NO	NO
HUNGARY	Lukaca, LTC	Laszlo	NO	NO	NO	YES	YES	YES	YES
ITALY	Checchi, CPT	Antonio	YES	YES	NO	NO	NO	NO	NO
ITALY	Giannatiempo, LTC	Francesco	YES	YES	YES	YES	YES	YES	YES
JHQ CENT	Bieleny, MAJ	Robert	NO	NO	NO	NO	YES	NO	YES
JHQ CENT	Kennedy, Maj	Donald	NO	YES	YES	YES	YES	YES	YES
NC3A	Friedrich, Mr.	Gernot	NO	NO	NO	YES	YES	YES	YES
NC3A	Eberhard, Mr	Manfred	YES	YES	YES	NO	NO	NO	NO
NETHERLANDS	deGroot, MAJ	Ben	YES	YES	YES	YES	YES	YES	YES
NORWAY-EN RGT	Aspelund, MAJ	Victor	YES	YES	YES	YES	YES	YES	YES
NORWAY-FFI	Østevold, Mr.	Einar	YES	YES	YES	YES	YES	YES	NO
SHAPE	Holtzwart, LTC	Ralf	YES	NO	YES	YES	YES	NO	NO
SHAPE	Wright,LTC	Thomas	NO	YES	YES	YES	NO	NO	NO

OFFICE	LAST	FIRST	3-7 May 99	5-8 Oct 99	17-21 Jan 00	8-12 May 00	11-15 Sep 00	6-9 Feb 01	Apr/May 01
UK	Bedford, CPT	Paul	NO	NO	NO	NO	YES	YES	YES
UK	Fairrie, CPT	Adam	YES	YES	NO	NO	NO	NO	NO
UK	Cave, Dr.	Richard	YES	YES	NO	NO	NO	NO	NO
UK	Dunlop, Dr.	Alistair	YES	YES	NO	YES	YES	No	
UK-DERA	Hood, Mr.	Fred	YES	YES	YES	YES	YES	YES	YES
US-JCS, DDJWCA	Metz MG or Batiste BG	Tom John	NO	YES	NO	NO	YES	NO	NO
US-JCS	Gibbs, LTC	Ricky	YES	YES	YES	NO	NO	NO	NO
US-JCS	Page, Col	John	NO	YES	YES	YES	YES	YES	YES
US-JCS	Brown, LTC	Bob	NO	NO	NO	NO	YES	YES	YES
US-JCS	Cunningham, Mr.	Jay	YES	YES	YES	YES	YES	YES	YES
US-JCS	Carbone, Mr.	Ernest	YES	YES	YES	YES	YES	YES	YES
US-OUSD(AT&L)	Butler, Mr.	Patrick	NO	NO	YES	YES	NO	NO	NO
US-OSD	Stafford, Mr.	Scott	YES	YES	NO	NO	NO	NO	NO
US-USAES	Semple, LTC	Andy	NO	YES	NO	NO	NO	NO	NO
US-LLNL/DOE	Greenwalt, Mr.	Bob	NO	YES	YES	YES	YES	YES	YES
US-LLNL/DOE	Magnoli, Dr.	Doug	NO	NO	NO	YES	YES	YES	YES
US-Picatinny Arsenal	Wong, Mr.	Kevin	YES	YES	YES	NO	YES	YES	YES
US-Picatinny Arsenal	Pearcy, Mr.	Stephen	YES	YES	YES	YES	YES	NO	YES
US-DARPA/ATO	Altshuler, Dr.	Thomas	NO	YES	NO	YES	YES	YES	YES

Annex B

Impacts of SAS-023 activities on Defence Requirements Review

Defence Requirements Review

NATO Defence Planning includes seven principal planning disciplines: Force Planning, Armaments Planning, Resources Planning, Logistics Planning, C2 Planning, Nuclear Planning and Civil Emergency Planning. Defence Planning provides a framework within which national defence policies and planning can be harmonised. A key element in NATO Force Planning is the Biannual-Strategic Commanders' (SC) Defence Requirements Review (DRR) as this has a major influence on the development of the SCs' Force Proposals. The DRR is a joint military scientific study, involving military staff at Supreme Headquarters Allied Powers Europe (SHAPE) and Supreme Allied Commander Atlantic (SACLANT), and, operational analysts from SACLANT and the NC3A. Its purpose is to derive, for the next 5 – 7 years ahead, the Strategic Commander's force requirements specified by military force levels, readiness structure and capabilities that the SCs require to execute their missions.
Figure 1 depicts the major events in the two-year Force Goal cycle and places the DRR in context.

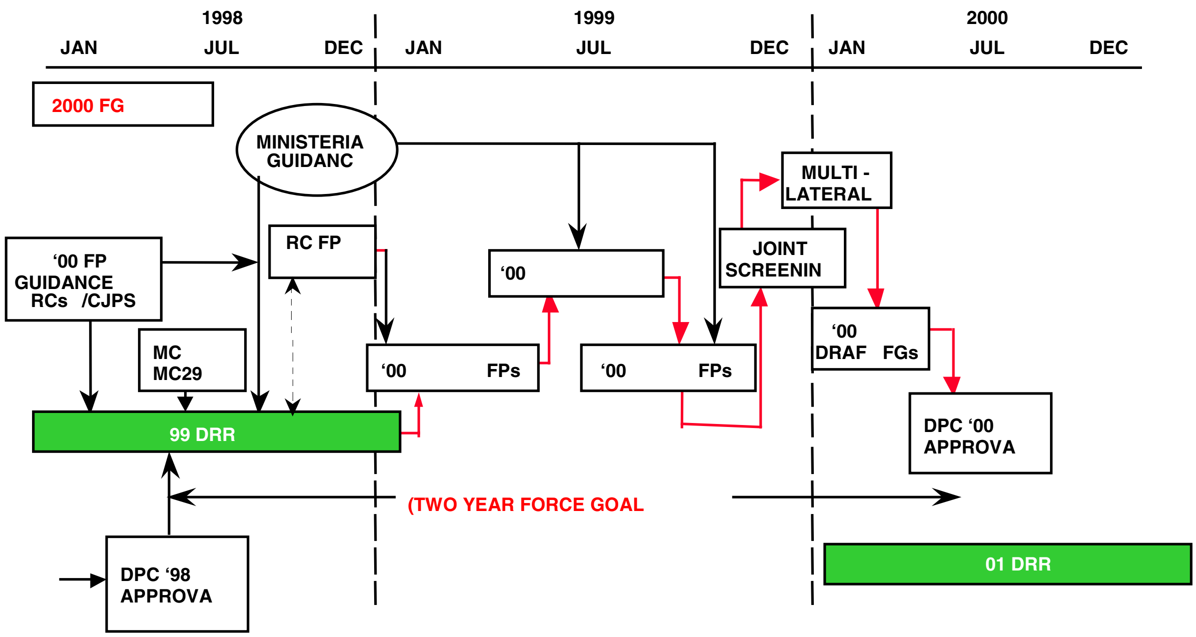

Figure 1 Force Goal Cycle

Force Proposals (FPs) are proposals to the individual NATO nations concerning the forces and capabilities that NATO would like them to provide. Force Proposals are submitted to member nations every two years and are the primary means by which NATO influences the quantity and capability of forces committed to the Alliance by the member nations. After several iterations the "final" FPs are refined into the draft Force Goals (FGs). Force Goals

are issued every two years, in even numbered years, and represent an agreement on the part of the nations to achieve certain force targets.
The nations report yearly, via their replies to the Defence Planning Questionnaire (DPQ)[1], the degree of achievement of the goals applicable for that year and they also make a force commitment for the following year, together with their force intentions for a further four years. The commitment and four-year intentions is known as the NATO Five Year Force Plan.

GENERAL APPROACH

Figure 2 shows the main elements considered in the review. The task is to determine military requirements from an analysis of the SCs' missions, taking into account Ministerial Guidance for Defence Planning, the predicted security environment and lessons learned from ongoing operations. The requirements are expressed in terms of force levels, force structures, force capabilities, force readiness and general military capabilities.

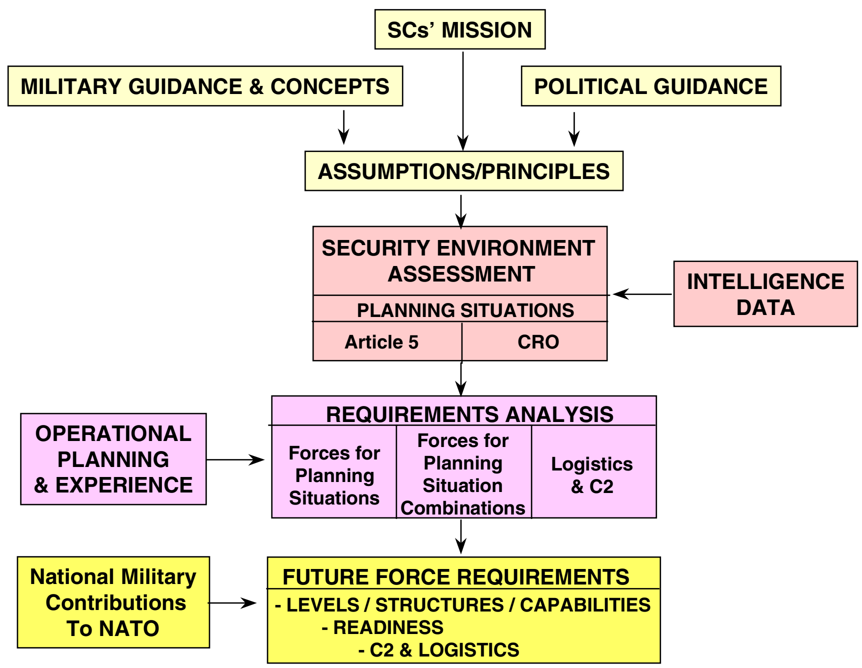

Figure 2 Main Elements of the DRR

The final stage of the DRR determines the NATO force pool required to be able to execute the type and number of concurrent missions specified in Ministerial Guidance. This includes an assessment of whether predicted national force contributions (derived from DPQ data) would enable the Strategic Commander's to execute their missions, and also identifies any shortfalls and/or excesses.
The projected national forces required to fulfil the SCs' mission requirements, together with identified shortfalls and/or excesses, provide the basis for the preparation and prioritization of Force Proposals by the SC Force Planners.

Impact of Loss of APM and possible APM-Alternatives to the DRR

For air forces, the ban on Anti-Personnel Mines (APM) has denied the use of some air-delivered weapons that incorporated such munitions. The loss of these weapons has been factored into the aerospace requirements analysis by revising the effectiveness data for

[1] Land forces are typically reported by the Nations on brigade level for combat units.

forces previously equipped with such munitions or by replacing these weapons by existing/planned alternatives.

The remainder of this paper concentrates on the land force analysis. For land forces, a quantitative operational assessment requires a complete assessment of the loss of APMs on the operational level and the effects of APM-A onto the operational level. Alternatives to APM can include changes in tactics, such as different use of time and space, doctrine, such as using different ways of employing forces or technology, such as new weapon systems or the modification of existing weapon systems.

The SAS-023 study shows, that in the near-, mid-term and future there are potentially promising concepts and systems available, especially for close battle situations or rear area security tasks. From the perspective of the DRR analysis there seems to be a deficiency in alternatives for Deep Battle missions like protection of Anti-Tank minefields.

The *Operational Impact Statement* provided by the SAS-023 Study Group highlights the complexity of such an evaluation. This is a subject beyond the resources allocated to the conduct of the DRR. Therefore, it is seen as necessary to continue the analysis of the impact of Alternatives to APM to the operational level.

To represent the impact of current or future national alternatives to APM in the requirement analysis process as well as to the inputs to the Force Proposal process, the analysts require comprehensive information about these alternatives. Therefore, the nations are asked to provide such information using the existing DPQ reporting system.

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Annex C

Definitions

Active
In surveillance, an adjective applied to actions or equipments which emit energy capable of being detected 1/11/75 (Ref. AAP 6).

Actuate
To operate a firing mechanism by an influence or a series of influences (23 Engr WP) (Ref. AAP 19).

Alert: to forewarn; a warning signal of a real or threatened danger, such as an air attack. (Ref AAP 6)

Ammunition
Ammunition is anything that contains an active ingredient such as explosives, or a chemical, smoke, pyrotechnical or an incendiary composition. (Jane's Mines and Mine Clearance 1998-99)

Anti-countermining device
A device fitted to a mine, designed to prevent its actuation by a countermeasure. (*See also anti-disturbance device; anti-lift device.* (23 Engr WP) (Ref. AAP 19).

Anti-disturbance device
An internal or external device on a mine arranged to actuate the mine in case of outside disturbance. *(See also anti-countermining device; anti-lift device)* (Ref. AAP 19).

Anti-disturbance
A fuze or booby trap designed to operate when moved. (Jane's Mines and Mine Clearance 1998-99)

Anti-handling
Another term for anti-disturbance (see above). (Jane's Mines and Mine Clearance 1998-99)

Anti-Handling Device (AHD)/ Dispositif Anti-Manipulation: A device intended to protect a mine and which is part of, linked to, attached to or placed under the mine and which activates when an attempt is made to tamper with or otherwise intentionally disturb the mine (synonymous with Anti-disturbance device and Anti-lift device. ESDC June 1999). See Anti-Lift Device.

Anti-handling device
A device fitted to, added on, placed under, attached to or near that acts as part of a mine or munitions mechanism, which can be electrically or mechanically operated when the mine or munition is disturbed. (Jane's Mines and Mine Clearance 1998-99)

Anti-Lift Device/ Dispositif Anti-Relevage: A device designed to activate a mine, if the mine is moved. (NAL No.71). See Anti-Handling Device.

Anti-magnetic
A term sometimes used to describe an object with a minimal magnetic signature, meaning that it is difficult or impossible to detect using a magnetometer. Anti-magnetic does not mean the same as magnetic influence (see following). (Jane's Mines and Mine Clearance 1998-99)

Anti-Personnel Mine (or Anti-Personnel Landmine) APM or APL:
According to CCW Landmine AMENDED MINES PROTOCOL II :
"Anti-personnel mine: means a mine primarily designed to be exploded by the presence, proximity or contact of a person that will incapacitate, injure or kill one or more persons." The CCW is a Law of War Treaty that governs the use and design characteristics of APL.

According to OTTAWA CONVENTION :
"Anti-Personnel mine: Means a mine designed to be exploded by the presence, proximity or contact of a person and that will incapacitate, injure, or kill one or more persons. Mines designed to be detonated by the presence, proximity or contact of a vehicle as opposed to a person, that are equipped with anti-handling devices, are NOT considered anti-personnel mines as a result of being so equipped".

According to Jane's Mines and Mine Clearance (1998-99)
An explosive or material, normally encased, designed to wound, kill or otherwise incapacitate personnel. It may be detonated by the action of its victim, by the passage of time or by controlled means.

Anti-tank mine
A mine which is designed to disable or destroy vehicles and tanks. The explosive can be activated by many types of fuze mechanism normally by pressure, tilt rod, influence or command detonated. (Jane's Mines and Mine Clearance 1998-99)

Area reduction
The act of defining and marking the extent of a mined area, usually undertaken as a part of a Level Two survey (see survey). (Jane's Mines and Mine Clearance 1998-99)

Armed period
The period in which a mine or munition is electronically and/or mechanical armed and active. (Jane's Mines and Mine Clearance 1998-99)

Arming
The process required to ready the mine for initiation. This usually includes completing the explosive train and removing all mechanical safety devices. (Jane's Mines and Mine Clearance 1998-99)

Assembly
A component containing several constituent parts. (Jane's Mines and Mine Clearance 1998-99)

Ballistic protection
Protection from projectiles, often referred to for protection against sniper or small arms ammunition but in demining terms is used for protection against fragmentation and blast. See body armour. (Jane's Mines and Mine Clearance 1998-99)

Barrier minefield
A minefield which aims to block a direction. (Jane's Mines and Mine Clearance 1998-99)

Base line
The line which is used to initiate all demining operations and is the point from which all clearance lanes start. Also known as the start line. (Jane's Mines and Mine Clearance 1998-99)

Battle area clearance
The term used for the clearance of all mines and UXO from an area of land. (Jane's Mines and Mine Clearance 1998-99)

Belleville Spring
A metal or plastic disc shaped diaphragm, with a metal striker on the concave side, which inverts when pressure has been exerted to one side. This causes the metal striker to come into contact with a detonator causing an explosion. (Jane's Mines and Mine Clearance 1998-99)

Benchmark
A fixed point of reference outside the minefield. This point has known co-ordinates that have been either ascertained by survey, resection or use of DGPS. (Jane's Mines and Mine Clearance 1998-99)

Black powder
A type of gunpowder, often used in clearing charges for shaped charge mines and as a propellant in bounding mines. (Jane's Mines and Mine Clearance 1998-99)

Black widow
A name given to the Russian PMN mine so called because of its effectiveness and colour of the pressure plate. (Jane's Mines and Mine Clearance 1998-99)

Blasting cap
See detonator (Jane's Mines and Mine Clearance 1998-99)

Block: To stop the enemy on a specific avenue of approach in order to break up his attack, destroy his forces and prevent him from accomplishing his objectives. (ref STANAG 2036)

Blind
Any ammunition that has been thrown, projected at or placed upon a target and which fails to function completely at the point of delivery or placement. (Jane's Mines and Mine Clearance 1998-99)

Blow in situ
The destruction of any item of ordnance by explosives without moving the item from where it was found, normally by placing an explosive charge alongside. Sometimes referred to as Blow in Place (BIP). (Jane's Mines and Mine Clearance 1998-99)

Body armour
In demining, the term protective armour normally refers to the flak jacket, but for EOD work this refers to the full body 'Bomb Suit'. (Jane's Mines and Mine Clearance 1998-99)

Bomb disposal
The act of disposing of UXO and IED. (NATO definition) (Jane's Mines and Mine Clearance 1998-99)

Booby trap
Any device or material which is designed, constructed or adapted to kill or injure and which functions unexpectedly when a person or object (vehicle) disturbs or approaches an apparently harmless object or performs an apparently safe act. (Jane's Mines and Mine Clearance 1998-99)

Booby-Trap / Piege: A booby-trap is defined, as a device which functions unexpectedly when a person disturbs or approaches something perceived to be harmless. It is characterized by containing an element of improvisation. (source UK delegation)

Booster
A small charge of sensitive secondary high explosive such as Tetryl, placed next to the detonator in order to propagate the detonation into the main charge. (Jane's Mines and Mine Clearance 1998-99)

Booster charge
The addition of explosives in order to increase the detonation capability of the detonator in order to detonate the main charge. Sometimes used in order to increase the explosive content. This can be done by stacking mines and/or adding explosives. (Jane's Mines and Mine Clearance 1998-99)

Bounding mine
An Anti Personnel mine which is activated by either a trip wire or pressure. The activation of the fuze causes a primary charge to be initiated which ejects the mine to a predetermined height before the main fragmentation charge is initiated. (Jane's Mines and Mine Clearance 1998-99)

Box mine
A mine normally manufactured from plastic or timber, containing the explosive charge and the activating mechanism. Mainly used for AP mines but has also been used for some AT mine models. (Jane's Mines and Mine Clearance 1998-99)

Breaching
A term generally referring to the military practice of creating a safe lane through a minefield, rather than clearing an entire area. Military breaching, especially when in contact with the enemy, often tolerates a risk level that would be unacceptable in a demining operation. (Jane's Mines and Mine Clearance 1998-99)

Breakwire
A thin electrical conductor, normally insulated, which passes sufficient current to keep a collapsing circuit open. When the wire is broken the circuit collapses, closing a relay

or electronic equivalent, to initiate a fuze. (Jane's Mines and Mine Clearance 1998-99)

Caltrops
A device with four metal points, so arranged that when any three are on the ground the fourth projects upward as a hazard (Webster's dictionary)

CASEVAC (Casualty Evacuation)
The process of moving a casualty from the site of the accident to medical facilities. (Jane's Mines and Mine Clearance 1998-99)

Casualty: In relation to personnel, any person who is lost to his organization by reason of having been declared dead, wounded, diseased, detained, captured or missing. (ref AAP 6)

Claymore mine
A directional AP mine, the claymore consists of a curved outer case containing a huge number of fragments. Behind the fragments is a layer of explosive. The mine can be initiated by either pull or command detonation. (Jane's Mines and Mine Clearance 1998-99)

Clear lane
A lane that has been cleared of all mines and UXO. (Jane's Mines and Mine Clearance 1998-99)

Clearance
Clearing an area of all mines, UXO and IED to a predefined standard. (Jane's Mines and Mine Clearance 1998-99)

Clearance site
The site where demining activities (the removal of mines and/or UXO) are being conducted. (Jane's Mines and Mine Clearance 1998-99)

Clearance standards
The standards that are to be applied to clearance operations. Normally specified in the contract document or clearance plan. In the UN it is normally achieved to a clearance standard of 100 per cent with a tolerance error of not more than 0.4 per cent. (Jane's Mines and Mine Clearance 1998-99)

Cluster munition
A number of submunitions in one container that is aerially delivered. (Jane's Mines and Mine Clearance 1998-99)

Countermine
The activities, equipment or process, used to counter mines. (Jane's Mines and Mine Clearance 1998-99)

Crimp
The act of fixing (crimping) the open end of a non-electric detonator to a length of safety fuse. (Jane's Mines and Mine Clearance 1998-99)

Crimper
The tool used to crimp. (Jane's Mines and Mine Clearance 1998-99)

Datum point
A point on the perimeter of a minefield that has been surveyed in from the benchmark. It has known co-ordinates and it can also be the start point of the first lane. Turning points and intermediate points are also datum points as they have known co-ordinates. (Jane's Mines and Mine Clearance 1998-99)

Deflagration
An explosion caused by extremely rapid combustion, but without detonation taking place. . (Jane's Mines and Mine Clearance 1998-99)

Demining
A recent, but widely adopted term referring to humanitarian mine clearance in countries where the civilian population is at risk. It implies clearance of complete minefields to a very high level of confidence. . (Jane's Mines and Mine Clearance 1998-99)

Demolition pit
A hole in which mines and UXO are placed for destruction. . (Jane's Mines and Mine Clearance 1998-99)

Density
The amount of mines in the minefield divided by the minefield length. This is normally referred to as mines per metre of minefield frontage. . (Jane's Mines and Mine Clearance 1998-99)

Deny: to hinder or deny the enemy the use of space, personnel, or facilities. It may include destruction, removal, contamination, or erection of obstructions. (ref AAP6)

Destruction in situ
Destruction of the mine or UXO normally by explosives, without moving the item. See also Blow in Situ. . (Jane's Mines and Mine Clearance 1998-99)

Detectability
In this context, the relative ease with which a given mine can be detected by a modern, high-quality metal detector. Often directly proportional to the metallic content of the mine, though other factors such as metal type are also significant. . (Jane's Mines and Mine Clearance 1998-99)

Detonation
The powerful explosive effect caused by the propagation of a high-speed shockwave through a high-explosive compound or mixture. During the process of detonation, the high explosive is largely decomposed into hot, rapidly expanding gas. . (Jane's Mines and Mine Clearance 1998-99)

Detonation wave
A shockwave which passes through high explosive as a uniform front, from the point of ignition, breaking the chemical bindings at molecular level (<3,000 m/s). . (Jane's Mines and Mine Clearance 1998-99)

Detonator
A sensitive explosive item that can be initiated by either electrical or non-electrical means. The first item in the explosive chain, used to initiate the main or booster charge. (NATO definition)

Detonator assembly
A section of a mine, often removable, usually comprising the detonator and an initiating composition or cap in a suitable housing. . (Jane's Mines and Mine Clearance 1998-99)

Differential GPS
A GPS which can provide readings to an accuracy of 5 cm. . (Jane's Mines and Mine Clearance 1998-99)

Disarming
The physical separating of components in the explosive train in order to render the mine incapable of functioning. See also neutralisation. (Jane's Mines and Mine Clearance 1998-99)

Disposal work
EOD work. (Jane's Mines and Mine Clearance 1998-99)

Disrupt: To cause the enemy to break his formation and tempo, interrupt his timetable, cause him to commit breaching assets prematurely and piecemeal his attack in order to unhinge his plan, and to delay and constrain his freedom of maneuver. (ref STANAG 2036)

Double impulse mine
A mine, normally an Anti-Tank, that is fitted with a Double Impulse fuze which requires two separate pressures on the fuze in order to initiate the detonation chain. (Jane's Mines and Mine Clearance 1998-99)

Drill
An unambiguous procedure, or series of procedures, taught to operators for use in the field. Drills ensure that safe, consistent practices are used throughout an organisation. (Jane's Mines and Mine Clearance 1998-99)

Electrical initiation
Initiation of an electrical detonator. (Jane's Mines and Mine Clearance 1998-99)

Exploder
A device used to produce an electrical current safely through electrical cable in order to initiate electric detonators or safety fuse ignitors. Also known as a blasting machine or firing device. (Jane's Mines and Mine Clearance 1998-99)

Exploratory breach
A method of breaching the suspect mined area in order to identify the actual location of the mine strips or rows and obtain mines information. (Jane's Mines and Mine Clearance 1998-99)

Explosive
A substance or mixture of substances which under external influences, is capable of rapidly releasing energy in the form of gases and heat. (NATO definition)

Explosive detector dogs (or explosive sensing dogs)
Dogs that are specially trained to detect the vapours emitted by explosives contained in IEDs, mines and munitions. Some dogs can also be trained to detect tripwires and non-explosive booby traps. The dogs are normally referred to as explosive or mine detection dogs. (Jane's Mines and Mine Clearance 1998-99)

Explosive ordnance
Munitions that contain explosives, nuclear fission or fusion material, biological and chemical agents. This includes bombs and warheads, guided and ballistic missiles, artillery, mortar, small arms ammunition, mines, torpedoes, depth charges, demolition stores, pyrotechnics, cluster munitions and dispensers, cartridges and propelled actuated devices, electric explosive devices and similar items that are explosive in nature. (Jane's Mines and Mine Clearance 1998-99)

Explosive Ordnance Disposal (EOD)
The detection, identification, field evaluation, render safe, recovery and disposal of Unexploded Ordnance (UXO). (Jane's Mines and Mine Clearance 1998-99)

Explosively Formed Projectile/Penetrator (EFP)
The fragment formed by a Misznay Schardin plate when subjected to detonation. See Misznay Schardin. (Jane's Mines and Mine Clearance 1998-99)

Extraction drill
The immediate action undertaken in response to an uncontrolled detonation which has caused injury to personnel. It involves team members in the recovery of injured personnel and the provision of first aid. Also known as man down drill. (Jane's Mines and Mine Clearance 1998-99)

Firing device
A device such as an exploder, used to produce an electrical current in order to initiate an electrical detonator. See exploder. (Jane's Mines and Mine Clearance 1998-99)

Fix: To slow the enemy within a specific area in order to acquire, target, and destroy with fire. May be used to generate the time necessary for friendly force counter moves or to break contact and disengage from the enemy. (ref STANG 2036)

Fragmentation zone
The area that fragmentation will cover from the point of detonation. There are several factors which require to be reviewed when determining this zone; the amount of explosive, body construction, type of material, ground conditions and so on. See also secondary fragmentation. (Jane's Mines and Mine Clearance 1998-99)

Free From Explosive (FFE)
The state of a particular manufactured munition which has had all the explosive removed. All mines or munitions being used for training and demonstrative aids should have the explosives removed and be marked ‘FFE’. (Jane's Mines and Mine Clearance 1998-99)

Fuel Air Explosive (FAE)
A technique in which a fuel (which may be gaseous, finely divided solid or atomised liquid) is dispersed in air and initiated to cause an explosion. FAE generally has a substantially greater effect than the equivalent weight of conventional explosive, mainly because the oxygen needed for combustion is drawn from the atmosphere and not carried within the explosive. The relatively long duration of the FAE pressure pulse has lead to its use in mine clearance charges. (Jane's Mines and Mine Clearance 1998-99)

Full-Width Attack Mine (FWAM)
An AT mine designed to be initiated when a vehicle passes over it, whether or not it is subjected to direct pressure. Older types of FWAM tend to use tilt-rods while modern ones generally have magnetic influence fuzes. (Jane's Mines and Mine Clearance 1998-99)

Full-width clearance
Clearance of a lane to the total vehicle width. This normally includes a small margin at each side. Associated with mechanical mine clearance equipment such as flails, rollers in tandem, sifters and full-width ploughs. (Jane's Mines and Mine Clearance 1998-99)

Fuse
A slow burning pyrotechnic normally used to delay the initiation of a detonator. (Jane's Mines and Mine Clearance 1998-99)

Fuze
A designed and manufactured mechanism to activate a mine or munition. It can be designed for use by electrical, chemical or mechanical systems; by push, pull, pressure, release and time activation, singly or in combination. Usually consists of an igniter and detonator. (Jane's Mines and Mine Clearance 1998-99)

Fuze well
A recess or cavity in the mine body, often threaded, that accepts all or part of the fuze. (Jane's Mines and Mine Clearance 1998-99)

Gunpowder
An explosive that must be confined in order to create a low-order explosion. It decomposes through a combustion reaction at a very fast rate. This reaction takes place on the surface of the composition and burns layer by layer. (Jane's Mines and Mine Clearance 1998-99)

Hand clearance
The act of clearing hazardous areas manually. Normally refers to clearance teams using mine detectors and probes. (Jane's Mines and Mine Clearance 1998-99)

HEAT (High explosive anti-tank)
A warhead which uses the Munroe Effect (see following) to defeat armour. (Jane's Mines and Mine Clearance 1998-99)

High Explosive (HE)
A compound or mixture which, when initiated, is capable of sustaining a detonation shockwave to produce a powerful blast effect. (Jane's Mines and Mine Clearance 1998-99)

Hollow charge
See shaped charge. (Jane's Mines and Mine Clearance 1998-99)

Horizontal action mine
An Anti-Tank/Vehicle mine placed at the side of the track or road which will normally be activated by a vehicle. The Horizontal Action Mine will propel a shaped charge warhead into the side of the vehicle or tank. See also Off Route Mine. (Jane's Mines and Mine Clearance 1998-99)

Humanitarian mine clearance
The removal of mines and UXO under the auspices of a humanitarian organisation in order to allow the land to be returned to the local community. (Jane's Mines and Mine Clearance 1998-99)

Improvised Explosive Device (IED)
An improvised explosive device is normally of local manufacture and is often associated with booby traps. It has all the elements of a mass manufactured mine or booby trap. (Jane's Mines and Mine Clearance 1998-99)

Inert
A mine or munition without explosives, made from the actual parts of the real explosive item. It is identical to the actual live object but has no explosive content. Used for training and should be marked ‘inert’. (NATO definition). See also FFE. (Jane's Mines and Mine Clearance 1998-99)

Influence fuze mine
A mine with a fuze which has been designed to be activated by the actual magnetic or other influences such as IR, radar, seismic or combinations thereof. (Jane's Mines and Mine Clearance 1998-99)

Intermediate lane
A lane forward of the start or base line where all cleared lanes finish and successive lanes commence. Intermediate lanes are numbered successively forward of the start line. (Jane's Mines and Mine Clearance 1998-99)

Intermediate marker
A marker used between the start and finish markers or between turning points on the perimeter of a minefield to indicate an intermediate point. There can be several such markers. (Jane's Mines and Mine Clearance 1998-99)

Interoperability
The ability of Alliance forces and, when appropriate, forces of Partner and other nations to train, exercise and operate effectively together in the execution of assigned missions and tasks. 15/7/2000 (AAP – 6 (V), 07 August 2000)

Irregular outer edge
Short mine strips laid in an irregular manner or pattern in front of minefields, facing the enemy, to deceive them as to the shape and density of the main minefield. It can consist of both AT and AP mines. (Jane's Mines and Mine Clearance 1998-99)

Landmark
A permanent feature or object that has known co-ordinates and is easy to identify on the ground. Used in conjunction with a benchmark to locate the start point of a minefield perimeter. Also called a reference point. (Jane's Mines and Mine Clearance 1998-99)

Levels of Standardization

1. **commonality**
   The state achieved when the same doctrine, procedures or equipment are used. 15/7/2000 (AAP – 6 (V), 07 August 2000)
2. **compatibility**
   The suitability of products, processes or services for use together under specific conditions to fulfil relevant requirements without causing unacceptable interactions. (ISO-IEC) 15/7/2000 (AAP – 6 (V), 07 August 2000)
3. **interchangeability**
   The ability of one product, process or service to be used in place of another to fulfil the same requirements. 15/7/2000 (AAP – 6 (V), 07 August 2000)

Levels of War (Land Force Tactical Doctrine, ATP-35b): - The conduct of modern joint warfare may be viewed in the context of three levels: strategic, operational and tactical. There are no distinct boundaries between the three levels of joint operations and they are not associated with any particular level of command, size of unit, piece of equipment or type of force or component. Actions are defined as strategic, operational or tactical based on their effect or contribution to achieving strategic, operational or tactical objectives. This concept applies not only to conflict but also operations other than conflict. (See also Strategic, Operational and Tactical Levels of War)

Locator
Generally used as another name for a metal detector. (Jane's Mines and Mine Clearance 1998-99)

Low-order technique
A specific EOD technique which uses a small explosive charge to disrupt a UXO without initiating the main charge. (Jane's Mines and Mine Clearance 1998-99)

Magnetic Influence
A fuzing principle in which the device is initiated by the change in magnetic field caused by the magnetic signature of its target. (Jane's Mines and Mine Clearance 1998-99)

Main charge
The main and normally the largest explosive charge of a mine or munition. Normally initiated by either the detonator or a booster charge. (Jane's Mines and Mine Clearance 1998-99)

Materiel Alternative: Materiel alternatives to APM systems or devices are defined as involving the specific designing of and procurement of systems or devices either new or significantly modified to compensate for the removal of APM from the battlefield. Examples of materiel alternatives are: the design, development and procurement of an APM system with MITL radio control link. Materiel alternatives will also precipitate changes or new doctrine and tactics to be developed to employ the new system or device. (See Non-Materiel Alternative)

Mine: In land mine warfare, an explosive or material, normally encased, designed to destroy or damage ground vehicles, boats, or aircraft, or designed to wound, kill or otherwise incapacitate personnel. It may be detonated by the action of its victim, by the passage of time, or by controlled means. (AAP-6 – First definition only).

Mine: means a munition designed to be placed under, on or near the ground or other surface areaand to be exploded by the presence, proximity or contact of a person or a vehicle. (OTTAWA Convention)

Mine action
All aspects at a national programme to address the mine problem in a country. (Jane's Mines and Mine Clearance 1998-99)

Mine Action Centre (MAC): Mine Action Centre (MAC) usually refers to a facility, containing personnel who co-ordinate and assist the national mine action activities in a country. (Jane's Mines and Mine Clearance 1998-99)

Mine awareness
A method of informing, teaching and relaying messages about land mines to the public, normally through a mine awareness programme. Mine awareness encompasses mine risk education, mine awareness training (MAT) for peacekeepers, multimedia presentations, and what action to take when a mine or UXO is found. It is intended to modify behaviour patterns to reduce casualties. A result of Mine Awareness is the flow of information back to a MAC about mine and ordnance locations. (Jane's Mines and Mine Clearance 1998-99)

Mine clearance
The clearance of mines and UXO from a specified area to a predefined standard. (Jane's Mines and Mine Clearance 1998-99)

Mine cluster
Anti-Tank or Anti-Personnel mines are often laid in groups or clusters. They can consist of one or several mines of one or various types. (Jane's Mines and Mine Clearance 1998-99)

Mine database
A collection of information on land mines and UXO, used for determining national plan priorities, collating and analysing the mine information, surveys, performance and other mine clearance related details. Most MACs also contain a limited map producing capability. (Jane's Mines and Mine Clearance 1998-99)

Mine protected vehicles
Vehicles that have been specially designed or have additional protection from land mines in order to deflect the shockwaves past the vehicle. (Jane's Mines and Mine Clearance 1998-99)

Mine verification
The act of verifying that an area or road is clear of mines and munitions. Normally undertaken when roads have been frequently used but actual mine clearance operations have not taken place. (Jane's Mines and Mine Clearance 1998-99)

Mined area
An area declared dangerous due to the presence or suspected presence of mines. (NATO definition)

Minefield
In land warfare, an area of ground containing mines laid with or without a pattern. (NATO definition)

Minefield survey
One of three disciplines in demining which involves the gathering of intelligence in order to identify suspect or known minefield areas. It also involves the reduction and marking of the areas prior to demining activities. There are three levels of survey. (See Survey) (Jane's Mines and Mine Clearance 1998-99)

Minimum-metal
The correct term for a mine in which the metal content has been kept to a minimum. Almost all fuzed mines contain some metal, therefore terms such as non-metallic, undetectable and anti-magnetic are misleading. (Jane's Mines and Mine Clearance 1998-99)

Minimum metal content
A term given to both AT and AP mines, but more commonly to AP mines with a limited metal content. Minimum metal content mines normally have a few very small components of metal, for example a spring, ball bearing/s and the striker pin. In addition these metal components may have been manufactured from specialised material such as stainless steel which can be difficult to detect. It has been recommended that protocol II of the Geneva Convention be amended to specify a metal content of at least 8 g. (Jane's Mines and Mine Clearance 1998-99)

Misfire
The failure of a munition or explosive charge to fire or explode as intended. (Jane's Mines and Mine Clearance 1998-99)

Misznay Schardin
Named after its inventors, an effect used for the penetration of armour. A shallow dished metal plate (normally copper or steel) is forged into a projectile by the detonation of a charge. The fragment, sometimes called a self-forging fragment or Explosively Formed Projectile/Penetrator (EFP) has sufficient density and velocity to

penetrate armour at ranges of several metres. The range makes the Misznay Schardin Plate ideal for use in off-route mines while the low weight and compact profile have lead to its widespread use in modern scatterable AT mines. (Jane's Mines and Mine Clearance 1998-99)

Monitoring
The authorised observation, by qualified personnel, in order to report on a clearance or demining activity, without taking responsibility for the quality or effectiveness. (Jane's Mines and Mine Clearance 1998-99)

Munroe effect
Named after its inventor, a principle used to focus the power of detonation, normally to defeat armour. A metal cone, generally copper, is surrounded by high explosive and detonated from behind the apex of the cone. As the detonation wave propagates through the explosive, the cone is focused into a high-velocity molten jet. For optimum penetration, the cone must be at the correct distance or ‘standoff’ from the target. (Jane's Mines and Mine Clearance 1998-99)

Neutralisation
The act of replacing safety devices, such as pins or rods into an explosive item to prevent the fuze or ignitor from functioning. It does not make the item completely safe as removal of the pins or rods will immediately make the item active again. It should not be confused with Disarming. (Jane's Mines and Mine Clearance 1998-99)

NG-based explosives
Nitro-Glycerine-based explosives. (Jane's Mines and Mine Clearance 1998-99)

Non-Materiel Alternative: Non-Materiel Alternatives include changes in Doctrine, Organization, Training, Leadership, and Personnel (DOTLP). Non-materiel alternatives can also result in the addition of equipment or systems to the field, however the additional equipment is assumed to already be in existence within the military or planned for development to address other mission needs and will possess capabilities and mission responsibilities other than those identified for APM and therefore be employed in military applications/operations/missions other than just those identified as APM.

Non-metallic
Indicating the total absence of metal, this term is often loosely and incorrectly applied to plastic mines, most of which are actually minimum-metal (see NG-based explosives). (Jane's Mines and Mine Clearance 1998-99)

Nuisance minefield
The term used for a few mines placed randomly around locations that will disorganise or demoralise an enemy. (Jane's Mines and Mine Clearance 1998-99)

Off-route mine
A mine that fires a projectile into the side of a tank or vehicle, the mine sensor or fuze normally being activated by the vehicle. Sometimes referred to as a Horizontal Action Mine. (Jane's Mines and Mine Clearance 1998-99)

Operational level of war / Niveau operationnel de la guerre – niveau operatif: The level of war at which campaigns and major operations are planned, conducted and sustained to accomplish strategic objectives within theaters or areas of operations. (NATO Glossary of Terms and Definitions (AAP-6(V))) …..(FM100-5) (See also Levels of War)

Patterned minefield
An Anti-Tank, Anti-Personnel or mixed minefield where the mines are laid out in known mine clusters, rows or mine strips. Can be laid by hand or mechanical means. (Jane's Mines and Mine Clearance 1998-99)

Percussion cap
An initiation assembly (normally just a few millimetres wide) containing a small amount of a sensitive explosive composition sandwiched between a thin metal cap and an anvil. In a mine, the percussion cap is normally initiated by a striker with a rounded tip; this acts like the firing pin in a firearm. (Jane's Mines and Mine Clearance 1998-99)

Perimeter marking
The outer visible marking of a minefield, consisting normally of wire, tape and/or minefield warning signs. (Jane's Mines and Mine Clearance 1998-99)

Phoney minefield
An area of ground prepared using fences, mine boxes and other minefield identification material to give the impression of a live minefield without it containing any land mines. Used to deceive. (Jane's Mines and Mine Clearance 1998-99)

Plastic explosive
A moldable form of high explosive. (Jane's Mines and Mine Clearance 1998-99)

Pressure plate
The top surface of the mine to which the target applies load, often containing or bearing upon the fuze. (Jane's Mines and Mine Clearance 1998-99)

Probe
A tool, consisting of one or more pointed rods or tines that is used to probe the subsurface of the ground at a predetermined angle in order to locate buried ordnance. Also known as a prodder. (Jane's Mines and Mine Clearance 1998-99)

Prodder
See Probe (Jane's Mines and Mine Clearance 1998-99)

Propellant
A fast burning explosive compound or mixture. On ignition, considerable force is generated by the rapidly expanding hot gases. Unlike high explosives, propellants do not detonate. (Jane's Mines and Mine Clearance 1998-99)

Protect: to achieve and maintain security by an organized system of defensive measures instituted and maintained at all levels of command.

Protective minefield
A minefield laid by a unit in order to assist its locality and provide close in protection. Normally consists of only Anti-Personnel mines. (ref AAP 6)

Pulling: The act of attaching a wire or cable to a mine or munition in order to move the item in case an anti-lift or anti-disturbance device has been attached. (Jane's Mines and Mine Clearance 1998-99)

Quality assurance
These processes and procedures, management oriented, which if followed would result in a quality product or outcome. (Jane's Mines and Mine Clearance 1998-99)

Quality control
Activities focused on determining through measurement, the level of compliance with technical standard. (Jane's Mines and Mine Clearance 1998-99)

Quality Management System (QMS)
The combination of an organisation's quality philosophy, quality assurance and quality control measures. (Jane's Mines and Mine Clearance 1998-99)

Reference point
A fixed point of reference outside the minefield. This point has known co-ordinates that have been either ascertained by survey, resection or use of GPS. Also called a benchmark. (NATO definition)

Render Safe Procedures (RSPs)
Render Safe Procedures are the procedures that enable the neutralisation and/or disarming of mines and munitions to occur in a recognised and safe manner. (NATO definition)

Ribbon charge
Specific technique for emplacing explosives. (Jane's Mines and Mine Clearance 1998-99)

Safe lane
A lane that is clear of all mines and UXO. (Jane's Mines and Mine Clearance 1998-99)

Safety pin
A simple safety device used to prevent actuation of a fuze mechanism. The safety pin is generally removed to arm the fuze, and replaced to neutralise it. (Jane's Mines and Mine Clearance 1998-99)

Secondary fragmentation
The material not belonging to the mine resulting from the detonation such as rocks, branches and dirt. Depending on the material, secondary fragmentation can travel long distances. (Jane's Mines and Mine Clearance 1998-99)

Self-forging fragment
The projectile formed by a Misznay Schardin plate when subjected to detonation. See Misznay Schardin. (Jane's Mines and Mine Clearance 1998-99)

Shaped charge
A warhead in which the explosive is specially shaped to achieve a directional effect. Examples include HEAT and Misznay Schardin warheads (see HEAT and Misznay Schardin). (Jane's Mines and Mine Clearance 1998-99)

Single impulse mine
A mine activated by pressure which is designed to activate after a single actuation on the pressure mechanism. (Jane's Mines and Mine Clearance 1998-99)

Site mapping
A diagram which details the organisation of a working site. (Jane's Mines and Mine Clearance 1998-99)

Squib
A squib is a small electrically initiated pyrotechnic charge similar to a match head, though faster burning. In mines, squibs are normally used to ignite propellant charges or generate gas to drive a mechanical component. (Jane's Mines and Mine Clearance 1998-99)

Stab-sensitive
Designed to be initiated by the penetration of a striker tip. Stab-sensitive initiators contain an extremely friction-sensitive explosive composition covered by a thin waterproof membrane. The striker used to initiate a stab-sensitive composition is normally sharply pointed. Unlike percussion caps, they require very little mechanical energy for initiation, and are therefore extremely dangerous. (Jane's Mines and Mine Clearance 1998-99)

Standardization
The development and implementation of concepts, doctrines, procedures and designs to achieve and maintain the required levels of compatibility, interchangeability or commonality in the operational, procedural, materiel, technical and administrative fields to attain interoperability.. *See also Levels of Standardization: commonality; compatibility; interchangeability; or interoperability.* 15/7/2000 (AAP – 6 (V), 07 August 2000)

Start line
A line related to the benchmark or reference point forward of which all demining occurs. The line does not have to be straight. See also base line. (Jane's Mines and Mine Clearance 1998-99)

Start point
A point where demining commences within an allotted clearance area. Normally the start point is the location where the first clearance lane intersects the start line. (Jane's Mines and Mine Clearance 1998-99)

Striker
The moving part of a mechanical fuze, normally spring-loaded, which initiates the explosive train. Strikers are normally used with percussion caps or stab-sensitive compositions. See percussion cap and stab-sensitive. (Jane's Mines and Mine Clearance 1998-99)

Submunitions
A submunition is a minelet or bomblet that forms part of a cluster bomb or artillery shell payload. (Jane's Mines and Mine Clearance 1998-99)

Survey
The method of determining the location of suspect or verified mined areas and further determining through survey methods the perimeters of the actual mined area. This is undertaken by use of three levels of survey:
Level one : General Survey
Level two : Technical Survey
Level three : Completion Survey.
Sympathetic detonation
The propagation of a detonation wave between two physically separated charges. (Jane's Mines and Mine Clearance 1998-99)

Sensor: an equipment which detects, and may indicate, and/or record objects and activities by means of energy or particles emitted, reflected, or modified by objects. (ref AAP 6)

Strategic level of war / Niveau strategique de la guerre : The level of war at which a nation or group of nations determines national or multinational security objectives and deploys national, including military resources to achieve them. (NATO Glossary of Terms and Definitions (AAP-6(V))) …..(FM100-5) (See also Levels of War)

Tactical level of war / Niveau tactique de la guerre: The level of war at which battles and engagements are planned and executed to accomplish military objectives assigned to tactical formations and units. (NATO Glossary of Terms and Definitions (AAP-6(V))) …..(FM100-5) (See also Levels of War)

Turn: To divert the enemy from one avenue of approach to another or into an engagement area. (ref STANG 2036)

Tethering wire
A wire connecting the internal body to the outer container of a central portion of the bounding mine, which determines the height at which the main charge will detonate.
(Jane's Mines and Mine Clearance 1998-99)

Tilt-rod
A post or pole normally attached to a fuze mechanism on top of a mine. Pressure against the tilt-rod activates by breaking or releasing mechanical retaining devices, thereby starting the activation chain of the fuzing mechanism. (Jane's Mines and Mine Clearance 1998-99)

Track width clearance
Normally associated with mechanical clearance devices that clear the width of the vehicle tracks only, such as rollers and ploughs. See also full-width clearance. (Jane's Mines and Mine Clearance 1998-99)

Tripwire
A wire, arranged across the path of an intended victim, used to initiate a mine. In most applications the tripwire is simply used to pull out the pin retaining a spring-loaded striker. Tripwires can be taut or slack and are normally laid on, or close to the ground. One end is normally anchored to vegetation or a stake, but tripwires can have both ends attached to mines. A taut tripwire can also be used to initiate a mine when it is cut, though this is dangerous to set up and therefore rare. (Jane's Mines and Mine Clearance 1998-99)

Turning point
A surveyed point on the perimeter of a minefield where there is a change in direction. This point has known co-ordinates and is related by bearing (azimuth) and distance to either an earlier turning point or intermediate point. (Jane's Mines and Mine Clearance 1998-99)

Unexploded ordnance
Explosive ordnance which has been primed, fuzed, armed or otherwise prepared for use or used. It could have been fired, dropped, launched, projected yet remains unexploded either through malfunction or design or for any other cause. (Jane's Mines and Mine Clearance 1998-99)

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Annex D

Acronyms & Abbreviations

A
AHD – Anti-Handling Device
AP – Anti-Personnel
APL – Anti-Personnel Landmine (see also APM)
APM – Anti-Personnel Mine (see also APL)
AT – Anti-Tank
ATL – Anti-Tank Landmine (see also ATM)
ATM – Anti-Tank Mine (see also ATL)
AVL – Anti-Vehicle Landmine (see also AVM)
AVM – Anti-Vehicle Mine (see also AVL)

B
BE – Belgium

C
CA - Canada
CAA – Center for Army Analysis (US)
CAS – Close Air Support (see TASLO)
CCW – Convention on Conventional Weapons
CEM – Cluster Effects Munitions
CMS – Comprehensive Mine Simulation (US)

D
DERA – Defence Evaluation & Research Agency
DFD – Directional Fragmentation Device (MITL Claymore-like device)
DK – Denmark
DPQ – Defence Planning Questionarie
DRR – Defense Requirements Review
DSTL – Defence Science & Technology Laboratories (UK)

E
ET – Exploratory Team
EUCOM – European Command (US)

F
FR – France

G
GE – Germany

H
HU - Hungary

I
IED – Improvised Explosive Device
IMS – International Military Staff
IT – Italy

J
JCATS – Joint Conflict and Tactical Simulation (US)
JCS – Joint Chiefs of Staff (US)

K

L
LLNL – Lawrence Livermore National Laboratory, Livermore CA (US)

M
MAS - MITL – Man-in-the-Loop
M&S – Modeling & Simulation

N
NAAG – NATO Army Armaments Group
NATO – North Atlantic Treaty Organization
NBC – Nuclear, Biological and Chemical
NC3A – NATO Consultation, Command & Control Agency
NO – Norway
NL - Netherlands
NLW – Non-Lethal Weapon
NSD – Non-Self Destruct
NSD-A – NSD Alternative

R
RDEC – Research & Development Engineering Centers (US)
RTB – Research & Technology Board
RTO - Research & Technology Organization

S
SCI – Systems Concepts and Integration
SHAPE – Supreme Headquarters Allied Powers Europe
SAS – Studies, Analysis & Simulation

T
TASLO – Tactical Air Support (for) Land Operations (see CAS)
TRAC-WSMR – TRADOC Analysis Center – White Sands Missile Range NM (US)
TTPs – Tactics, Training and Procedures

U
UK- United Kingdom
US – United States
USAES – US Army Engineers School, Ft Leonard Wood MO
USAMSAA – US Army Materiel Systems Analysis Activity

Annex E

Terms of Reference

Military Application Study on Alternatives to Anti-Personnel Mines
SAS-023

I. ORIGIN

A) Background – Anti-Personnel Mines (APM) have been an important asset to most NATO nations for many years. They currently play a key role in many aspects of land operations planning, providing force protection and the capability to shape the battlespace.

In September '97, fourteen of the sixteen NATO nations and the three Accession nations signed the Ottawa Treaty (Convention on the Prohibition of the Use, Stockpiling, Production and Transfer of Anti-Personnel Mines and on Their Destruction). As of 16 September '98, 40 nations worldwide had ratified the convention, and thus it enters into force on 1 March '99. Therefore, the signatory nations have a little more than ten years to completely phase out the use of APM, though most have policies with more ambitious schedules. As a result, most of the NATO nations are actively considering alternative means of providing the capabilities that APM give to the warfighter. These alternatives could be technological or doctrinal, or a combination of the two.

In one of their regular briefings to the Research and Technology Board (RTB), SHAPE identified the loss of APM as one of their current challenges and requested the Research and Technology Organization's (RTO's) support with this problem. In parallel, the System Concepts and Integration (SCI) Panel's Exploratory Team on Combat Engineering Technology was developing a proposed Level 3 Technical Team on this same subject. This Terms of Reference (TOR) resulted from a joint meeting of the Studies, Analysis and Simulation (SAS) and SCI groups. The SCI Panel will be invited to participate in this Study and will be kept abreast of progress.

B) Military Benefit – The outcome of this study will have obvious military benefit, as it will supply NATO with a thorough identification of military characteristics and capabilities that will be lost when APM can no longer be used. The study will also generate a list of potential alternative concepts and a preliminary evaluation of the primary options. It will be up to the nations and the Alliance as a whole to weigh these options against their respective constraints to determine which are most relevant to them and worthy of further pursuit. There is also an opportunity to have an interoperability benefit by having the Alliance work on alternatives together. If the study is successful in identifying truly viable alternatives, or facilitating progress within the participating nations, there will also be significant political benefit.

II. OBJECTIVES

<u>A. Assumptions</u> – Although the Study Group will consider the use of APM in different scenarios covering the entire range of potential NATO missions (Article V and non-Article V), including their utilization to protect Anti-Tank mines, the group will consider alternative concepts for APM only. Alternative concepts will be consistent with applicable obligations following from International Treaties and customary International Law, including the Laws of Armed Conflict.

B. Specific Goals

1. Generate a list of capabilities that APM provide and identify those capabilities that should be replicated to compensate for their loss. Consider specific NATO threat scenarios.
2. Investigate the impact that the lack of APM has at the Tactical, Operational and Strategic Levels. Consider impact on forcepower requirements in context of SHAPE's Defence Requirement Review (DRR) process. Review existing data. Consider ways to accurately aggregate impacts in NATO models.
3. Identify potential alternative concepts and associated research efforts. Consider ongoing national activities and conduct additional brainstorming. Look at short and long-term concepts. Include materiel (hardware systems, including both current systems and research areas into future concepts) and non-materiel (doctrine and procedures) solutions.
4. Identify constraints (policy, budget, "acceptable casualty" level, national interpretations of Ottawa Convention, …). Apply most common constraints and produce short list.
5. Analyze the effectiveness of those concepts on short list, taking account where possible their estimated costs.
6. Report the outcome of the study and provide recommendations for possible further analysis and study.

C. Deliverables

1. Final Report

<u>D. Duration</u> – 18 months

III. RESOURCES

<u>A) Membership</u> – To successfully achieve the objectives a broad base of experience is necessary. Each interested nation should contribute appropriate permanent representatives. Specific subject matter experts will be called upon as required (from NATO and the Nations). The integrated expertise should cover the following areas:

- Warfighters
- Doctrine
- Threat
- Acquisition
- Research and development
- Analysis, modeling and simulation
- Policy

<u>B) Special Needs</u> – None

IV. SECURITY LEVEL – NATO Restricted

V. LIAISON

In addition to RTO SAS and SCI participants the following other NATO bodies should be involved in this study:

- SHAPE (both Policy/Requirements and Operations/Logistics)
- NC3A
- NAAG / Land Group 9 (Battlefield Engineering)
- MAS / Combat Engineering Working Group
- NATO Policy Group on Non-Lethal Weapons (NLW)
- Future NATO WGs on Non-Lethal Weapons (NLW)

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Annex F

Summaries of National APM and APM Alternative Studies & Reports

F.1 Canada

No of studies: 1

Study no 1

Study Name: Exercise Duffer's Drift 1 & 2 (Janus Wargame)

Study performed at (Establishment): LFDTS, Kingston, Canada

Point of Contact: OR Advisor, Mr. Roger Roy, (613) 541-5010 x 8725

Start and End Dates for Study: March – September 2000

Description of Analysis Tool: Janus Wargame, is a computer based deterministic model that computes probabilities of weapon systems hit on a target and target kill given a hit. The tool produces variable outcomes for similar events due to its random value assignment to operational factors. Factors such as smoke, line of sight, weapon engagement zones and suppression can affect results from run to run.

Description of Scenario: A dismounted Battalion, breaking through a clearing out of a forest, attacking a light Infantry Platoon in a prepared defensive position. Two gaps in forested areas were used to evaluate mid (400m) and close (200m) range defensive options. For each option, ten runs were executed with no obstacles, with allowed obstacles including wire and remote-detonated Directional Fragmentation Devices (DFD), and with full obstacles which allowed M16A1 AP mines. Short and long preparation time evaluated different densities of obstacles. Excursions used fields of sensors, longer-range DFDs and/or Automatic Grenade Launchers (AGL). Mortars and Artillery were used as Prep fire and for smoke screens in all scenarios.

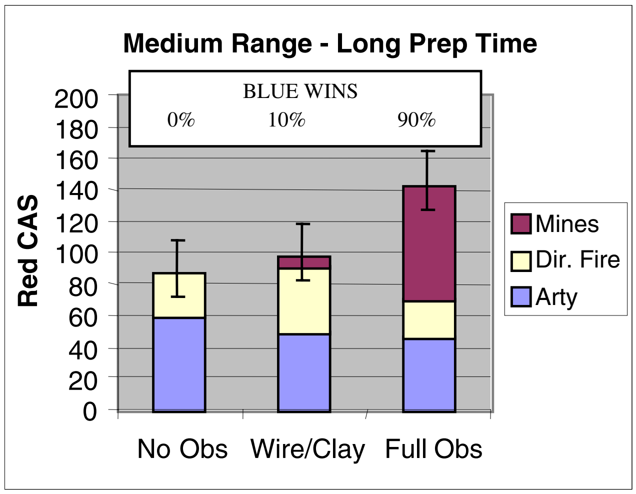
Description of Own Forces: Light Platoon in defense with a supporting Section consisting of 42 weapons stations.

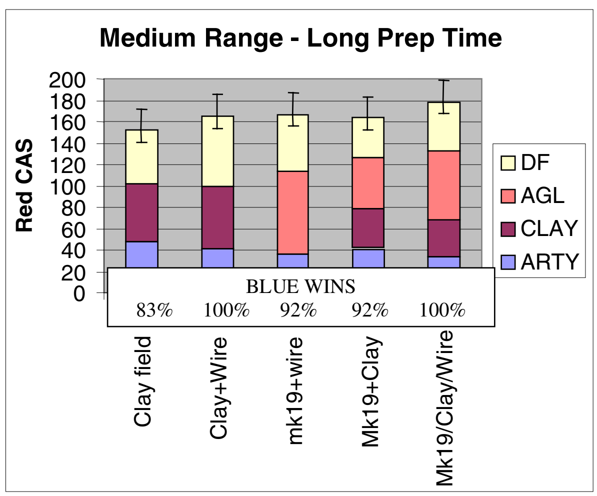
Description of Threat Forces: Dismounted Infantry Battalion consisting of 189 dismounts attacking through a forest three Companies abreast, and a firebase with supporting Mortars and artillery.

Mission/Function of APM: APM contribution toward providing close-in force protection against a mass assault. The role of APM was part of an obstacle/barrier to enemy infiltration. Close range (200m with 3-4 hour preparation time and no overhead protection) and mid-range (400m with sufficient preparation time, dug in with overhead protection) obstacles were examined. Two obstacle types were modeled: full obstacles (wire, DFDs and APM), and obstacles with allowed barrier devices but without APM. Both cases included close-in DFDs, direct fire and indirect fire (Mortars and Artillery) weapons. Situations with no obstacles were also included in the analysis.

Summary of Results: APM have a significant effect (compared to wire and close-in DFDs) against Mass Infantry attacks in the mid-range gap (400m) which allows Red to have an effective smoke screen but not as significant in a close range gap (<200m). Employment of automatic grenade launchers (40mm) and DFDs with extended range wire/RF detonation were alternatives that could compensate for lost APM capabilities. Conclusions included requiring more sensor systems and devices to warn and identify area infiltration. The optimization of weapons and sense equipment suggestions include: replacing 60mm mortars with 40mm AGL and employing more DFDs with extended control links (RF/IR command links).

Power point presentation: See Volume II, Annex Canada.





F.2 France

No of studies: 3

As announced at the SAS-023 meeting in October 1999, France has not conducted any formal simulations or quantitative analysis of the impact due to the loss of APM in combat brigade defenses versus attacking division operations. This is because APM were already used only to block dismounted infantry infiltration. In this case, it is difficult to quantify the rate of casualties and delays gained. Just a qualitative evaluation by military experts is possible.

It is also very difficult to quantify the operational impact of AT obstacles wether reinforced or not by APM in the success of a manoeuver. Even training systems like JANUS or BBS do not succeed in this matter. In mix minefields (AT + APM) it is even more difficult to determine the ratio of the operational efficiency only due to APM. All the more, since most of the armies own very efficient mechanical demining means against APM.

Therefore, it is not worth now, for France, to perform simulations on the effects of munitions strictly forbidden.

However, after the APM ban, France recognizes that even if it is not possible to quantify precisely the importance of the loss of the operational capability especially at tactical level, there is a requirement to cover the loss in operational efficiency very quickly.

That's why French efforts consist of searching for systems that are able to protect Land Deployments and to reinforce obstacles out of range of direct and indirect fires.

France has done a study (no 1) on the evolution of Counter Mobility including the role of obstacles in crisis response operations as well as combat operations. Furthermore, France is now working on two studies (no 2 & 3) in relation with APM-Alternatives, even if the aim of these studies widely exceed the objective to find APM-Alternatives.

The summaries of these 3 studies, which objectives overstep widely operational APM alternatives, are described below:

Study no 1

Study Name: Prospective Study on the Evolution of Counter Mobility

Study performed at: DGA, France

Point of Contact: GB Lendrin, ICT Amichaud

Start and End Dates for Study: September 1999 – September 2000

Description of Analysis Tool: multi-criteria analysis tools

Description of Scenarios: use of macroscopic scenarios: from riot control to full combat in symmetrical, unsymmetrical, and asymmetrical conflicts

Description of Own Forces: All types and volumes of Land Forces

Description of Threat Forces: Symmetrical and asymmetrical Forces, uncontrolled crowds

Mission/Function of APM :

Summary of Results:

The classical approach of counter-mobility is based on the creation of obstacles (TTA 106). With all kind of changes (geo-strategic, technological, ethical, legal…) the question of the durability and the evolution in the long run e.g. 2030 of this operational activity arises. Possible answers should be found in that context. This is why the study focused on researches concerning what doesn't change or doesn't change very much with time.
As any commitment of forces is linked to a confrontation of various players which may involve a great number of usual or unusual actions, the approach used identified the fields in which forces will perform counter-mobility operations, the durable ends to be achieved and the effects making them possible.
These fields may be conventional, such as the physical environment like ground, urban areas, space or less conventional such as the morale of the player targeted, population, players in the media world, information and information techniques. In other words, counter-mobility more and more concern operations especially related to the numerous « new » fields rather than to physical environment.

Thirty-one durable ends were identified either to improve the global performance of friendly forces (increase of freedom of action, economy of forces) or to damage the global performance of external players (weakening of their manoeuvring and surviving capacity). The principles of any confrontation and the durable significance of the function of counter-mobility are the point here.

These ends can be reached using relevant effects – forty-seven have been identified concerning:

° the psycho-sociological environment, for example « the external players do not moving any more »,

° the management of movements, for example « the de-synchronizing of external players' movements,

° the ground, for example the creation of obstacles,

° the mobility means, for example « the destruction of means of transport ».

The employment concepts of countermobility methods are determined by identifying effects intended to attaining a given end in a given field. The following were highlighted :

° Five concepts pertaining to the morale of the external player targeted : the point is, for example, to « trigger a loss of confidence in leaders, by pointing out their errors, and thus reducing any capacity to execute movements ».

° Four concepts dealing with players involved with the media : for example, « orienting the movement of crowds by getting some news circulated and broadcasted by various players in the media world ».

° Four concepts dealing with the local population. For example « generating distrust towards various itineraries, to saturate others ».

° Eight concepts regarding information. For example, « cutting off enemy transmissions, and thus preventing the enemy from obtaining information on its moves ».

° Seven concepts on information technologies. For example « attacking what enables the external player to navigate ».

° Fourteen concepts regarding the physical environment. They are rather traditional, but remain useful. For example « disturbing signalling, to trigger delays or traffic jams » or « create obstacles by using mines ».

These various concepts show that counter-mobility is much more than the mere creation of obstacles.

Nearly 270 technical solutions are able to meet the 16 main concepts covering almost all the ends concerned. Once they are brought together according to the techniques used, 40 counter-mobility entities or « modules »* are identified. After assessing them according to the following criteria : technical and operational feasibility, cost-effectiveness, ethical and legal compatibility, 25 modules ranked according two priorities are selected. As an example modules generating « polluted » information or modules intended to fight against geographical database should be mentioned, etc…It is noted that these modules call for various technologies (electromagnetism, explosives), for social sciences and non lethal means.

These modules were studied according to six main criteria, such as efficiency, technical realism. This study led to identifying 70 possible research trends, such as non lethal weapons, electromagnetic methods, networked area defence weapons, charges, IT warfare, psychological action, power source, remote control, unmanned vehicles, etc…It is noted that this work is also of great interest to many other subjects than "countermobility".

The employment domain of counter-mobility methods is in strong development at the moment, especially because « traditional » methods to counter-mobility, such as creating obstacles, are being strongly restricted in the case of violence containment operations for example. This development also comes from the increasing number of actions now made possible on various fields, and from the extension of the range of techniques now available. Obviously, in the long run, « traditional » systems need to be maintained at a sufficient level to allow for their implementation, but new avenues presenting themselves also need to be explored.

This « system » oriented vision, which involves fields of action, operational ends and technical systems, clearly depends on the operating level. The Staffs must now further investigate the subject, and deduct what methods and actions need to be selected. Some modules are more specific, such as the ones devoted to creating obstacles, whereas other are unspecific, such as the ones dealing with electronic warfare or with IT warfare : the effects expected here are targeted, their co-ordination in time and space is extremely fine, and they must be tracked very closely. Forces must get ready to these new developments during peacetime.

Counter-mobility seems to be in strong development because of the rapidity of its evolution and the enhancement of its capacity, some points being thus given a greater importance. Counter-mobility in the future could have a greater part to play.

As a conclusion, land-based counter-mobility in the future will increasingly be directed towards neutralizing and stopping mobiles, rather than towards destruction and obstruction, which are often irreversible once implemented in the field. Counter-mobility will not only operate on armoured or wheeled vehicles but will help bringing under control uncontained crowds often involved in conflicts in urban areas.
When using obstacles, their effect should be reversible in order to protect the environment, maintain the infrastructure and make the return to normal life possible.

Mines and explosives should be progressively replaced by physico-chemical means, measures taken against vetronics, navigation and location systems of mobile vehicles.

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* *a module consists of the following : the means, staff, equipment and methods devoting to create the effects, produced within the framework of the operational function of « countermobility ».*

Land-based counter-mobility should go through a conceptual transformation and have a greater part to play aiming at maintaining the freedom of action and the economy of forces of airmobile units in any type of conflicts and in the case of violence containment operations.

Studies should be launched to develop new methods. Several points for investigation in the short term are proposed:
- secured networked area defense weapons
- IT intrusion in regulation systems
- sensors designed for target designation
- defensive measures taken against C3R
- spreading of a sticky or slippery substance
- defensive measures taken against geographical database
- electromagnetic munitions
- decoying to confuse electromagnetic information

Power Point Presentation: Is not provided

Study no 2

Study Name: ETO Architecture of remote area control systems

Study performed at: DGA, France

Point of Contact: GB Lendrin, IPA C Jurczak, ICT C Amichaud

Start and End Dates for Study: January 2001 to June 2002

Description of Analysis Tool: multi-criteria analysis tools and specific models to assess effectiveness of "system of systems"

Description of Scenarios: missions of our forces will be from coercition of forces to violence control, environmental characteristics from urban areas to desert areas , the study will take in account if the area is occupied or not , if the survey function will be done continuously, sometimes , after an alert, if the action must be done immediately, after a delay …

Description of Own Forces: All type and volumes of Land Forces

Description of Threat Forces: All kind of threat from dismounted infantry to tank , if possible in the long term hostile crowd or person.

Mission/Function of APM (would have been): the system will have to ensure alert, protect & deny functions against dismounted infantry and hostile crowds (no armored threat).

Summary of Results: Ongoing study, at present the scenarios are being built

Power Point Presentation: Is not provided

Study no 3

Study Name: ETO Protection of land deployments

Study performed at: DGA, France

Point of Contact: GB Lendrin, IPA C Jurczak , ICT Amichaud

Start and End Dates for Study: June 2001 to December 2002

Description of Analysis Tool: multi-criteria analysis tools and specific models to assess effectiveness of this kind of system.

Description of Scenarios: Protection of bivouac area, key areas or points, improvement of strong points, implantation of logistic area

Description of Own Forces: All types of Land Forces deployed on the ground (all armes issue)

Description of Threat Forces: Dismounted infantry with variable size (15 max for each unitary device)

Mission/Function of APM (would have been) : protection against infiltration of dismounted infantry. The system will have to ensure alert, protect & deny functions

Summary of Results: Ongoing study, at present several concepts are being built

Power Point Presentation: Is not provided

F.3 Germany

Due to different national circumstances, Germany is not able to conduct a simulation or analysis regarding the impact on loss of APM for the defending brigade scenario. The staff study of German Armed Forces Engineer School, introduced to the SAS 023 group during the first meeting at Oberjettenberg states that there is a major impact on loss of APM in particular tactical situations. The study does not provide quantitative analysis. Therefore we are still very interested in discussing the results of simulations and analysis presented by the other nations of the SAS 023 working group. We shall support those results of simulation and analysis that are close to our tactical/operational position. Furthermore Germany intends to concentrate all efforts in finding alternative means concerning the Ottawa convention which are able to fill the gap caused by the ban of APM. Of course, Germany will provide information on its current research and technology efforts to the working group.

No of studies: 1

Study no 1

Study Name: Future Capability for Counter Mobility (Künftige Fähigkeiten zum Hemmen von Bewegungen)

Study performed at: Army Office, Germany

Point of Contact: LTC Radlmeier

Start and End Dates for Study: 6. Dec 2000 – 31. March 2002

Description of Analysis Tool:

Description of Scenarios: South East area of NATO. Defending NATO area against attack from outside

Description of Own Forces: MechDiv in defence and MechDiv in attack (using the new structure of a German division). No APM in scenario, but attempt to integrate APM Alternatives (NLW or others)

Description of Threat Forces:

Mission/Function of APM (would have been):

Summary of Results: Ongoing study, at present the scenarios are being built

Power Point Presentation: Is not provided

F.4 Hungary

No of studies: 1

Study no 1

Study Name: The Barrier Situation in Hungary after the Ottawa Threaty

Study performed at: Hungary, Miklos Zrinyi National Defence University

Point of Contact: LTC Laszlo LUKACS, PhD

Start and End Dates for Study: First half of 2000

Description of Analysis Tool: Study examined tactical and operational consequences ban of the antipersonnel landmines for the barrier situation.

Description of Scenarios: The following situations were analysed: Common barrier (required materials and barrier ammunitions) of battalion defense area and barrier of brigade

- in the covering force area of division,
- in the 1st echelon of division, in the area of main effort
- in the 1st echelon of division, in the other towards of enemies assault
- in the 2nd echelon (reserve operation) of division.

Description of Own Forces: Mechanized rifle battalion and brigade

Description of Threat Forces:

Mission/Function of APM: Mission/function of APM were examined as an element of tactical/operational barrier with all its tasks

Summary of Results: After the examination we can establish that needed development of alternatives for the producing of tasks the next length of AP minefields:

- in the barrier of battalion defense area: 1.6 – 2.0 km
- in the covering force area of division: 1.6 – 2.0 km
- in the 1st echelon of division, in the area of main effort: 6.0 – 9.0 km
- in the 1st echelon of division, in the other towards of enemies assault: 3.5 – 6.0 km
- in the 2nd echelon (reserve operation) of division: 2.5 – 4.0 km

Power Point Presentation: See Volume II, Annex Hungary.

F.5 Netherlands

No of studies: 1

Study no 1

Study Name: Stocktaking of Area Denial Means, Past and Future.
Report: PML 2000-B53, Feb 2001

Study performed at: TNO

Point of Contact: M Sc R.J.M. van Amelsfort (Tel.: +31 15 284 2842)

Start and End Dates for Study: 1999 - 2003

Phase 1: 1999 – 2000, Phase 2: 2000-2001 Phase 3: 2001-2002, Phase 4: 2002-2003

Description of Analysis Tool: Qualitative Analysis in Phase 1 and 2, development of evaluation tools in Phase 3

Description of Scenarios: Art. 5 Operations and Military Operations other than War

Description of Own Forces:

Description of Threat Forces:

Mission/Function of APM: all

Summary of Results:

Phase 1: Summary of inventory of current area denial means, future possibilities and operational roles (reported in TNO Report PML2000-B53 *Stocktaking of area denial means, past and future*)

Phase 2: Structuring and identifying the elements of means and needs (will be reported as a TNO Report PML2001-… *Review of alternatives to anti-personnel landmines for evaluation purposes*)

Power Point Presentation: Is not provided

F.6 Norway

No of studies: 3

Study no 1

Study Name: Operational Impact of Ban on APM

Study performed at: Norwegian Defence Research Establishment (FFI)

Point of Contact: Principal Scientist Tor Langsæter

Start and End Dates for Study: Feb – Apr 1998

Description of Analysis Tool: The study employed best warfighter judgment and operations research analyses techniques on various tactical situations related to the national defence. Time did not allow for extensive simulations. Selected tactical situations with and without APM were analyzed in order to develop Norwegian force structure implications. Operational and economic consequences were examined, with focus on army troops equipped for a mobile war concept.

Description of Scenario: Various scenarios used for development of the future structure of the Norwegian Armed forces (focus on the National defence)

Description of Own Forces: Planned future Norwegian force structure

Description of Threat Forces: National threat context 10-15 years ahead

Mission/Function of APM: Tactical situations examined were: (1) protecting ATM, (2) protect defensive position, (3) protect against air/sea landing operations, (4) cover retreat of troops, (5) disturb enemy operations in (our) forward area, and (6) securing/protection of key objects.

Summary of Results: APM play no major role in the Norwegian defence concept. In most tactical situations APM can be replaced by other means. Alternatives proposed included: (1) higher density employment of ATMs, (2) increased employment of direct fire, (3) increased use of sensors and claymore-like sector charges, (4) increased use of indirect fire and (5) development and use of "intelligent" off-route ATM systems and devices. Preliminary consequences of the study are: (1) lack of APM reduces flexibility in solving defensive tasks, (2) significant costs are associated with replacing APM, (3) remotely delivered mixed mine alternatives remain unsolved. (4) In most roles APMs can be replaced by a combination of surveillance and weapon systems (sector charges). One important exception is protection of objects (e.g. AT mines) in the deep battle area, where we cannot deliver direct fire. (5) Attempting to compensate for the loss of APMs by adjusting tactics/procedures without adding other force structure or military materiel is not recommended. The study has not addressed the assessment of increases in casualties due to the lack of APM on the battlefield.

Power point presentation: See Volume II, Annex Norway.

Study no 2

Study Name: Tactical Impact of the Ottawa Convention (Study carried out for SAS-023)

Study performed at: Norwegian Defence Research Establishment (FFI)

Point of Contact: Principal Scientist Einar Østevold, FFI

Start and End Dates for Study: July – September 1999

Description of Analysis Tool: Map exercise, technical and military judgment. Several cases related to each of the 5 prioritized (by SAS-023) missions were examined according to the following procedure: **a)** Given APM available, assess the situation, optimal use of APM, and outcome of (local) combat, **b)** Remove APM and judge what is now best Blue course of action, **c)** Assess cost (broadly speaking) and military consequences for Blue of having to use another course of action, **d)** Judge outcome of combat now (without APM), **e)** Assess consequences for the overall battle.

Description of Scenarios: National defence context, Northern Norway, primarily Troms County. Canalizing terrain, high mountains, sparsely populated, few roads. Forest in lower regions.

Description of Own Forces: Planned future Norwegian force structure

Description of Threat Forces: One Enemy Corps (Two Mech Inf Divisions)

Mission/Function of APM: All APM functions defined by SHAPE or SAS-023 (Disrupt, Turn, Fix, Block, Deny, Protect, Alert) and all 5 prioritized (by SAS-023) missions.

Summary of Results: APM can play an important role in many tactical situations, but can in most of them be replaced by other means (with some penalty in form of poorer performance, extra cost, requirement for manpower, logistics, etc). Two major exceptions where APM are not easily replaced are: i) Close defence of vital installations and units against dismounted personnel and ii) Protection of remotely delivered or pre-emplaced Anti-tank mines in the deep battle area.

We were not able to make a meaningful assessment of the consequences for the overall battle (i.e. at the operational level).

Power Point Presentation: See Volume II, Annex Norway.

Study no 3

Study Name: Norwegian Land Mine Study

Study performed for: HQ Defence Command Norway, Joint Staff

Point of Contact: Principal Scientist Einar Østevold, FFI

Start and End Dates for Study: Feb 2000 through August 2001.

Description of Analysis Tool: The study concentrated on combat effectiveness, firepower, anti-mobility and protection by use of landmines in a maneuver oriented operational concept. The Fighting Services' and Home Guard's need for landmines (anti-vehicle mines) in the new maneuver oriented operational concept were mapped, and advice on the tactical use of them were given. The study also made assessments on the operational impact of losing APM. Use of land mines in international operations was studied by simulations on the Norwegian Army Staff & Commander Trainer (A German product, SIRA GSI, run on Unix computers). For simulations of mine use in the national defence, the JCATS model at Lawrence Livermore National Laboratory was applied.

The overall study also comprises several sub-studies for specific problems related to the use of land mines in the national defence; e.g. protection of air fields and prevention of enemy air and sea landing. Simulations were not run for these sub-studies. The results are based on calculations and military judgment.

Description of Scenarios: Scenarios related to both international operations and the national defence was used. For international operations simulations were carried out for forested and hilly terrain with lot of roads and villages. Blue's mission was to prevent enemy forces of breaking through Blue lines to conquer the town of Hammelburg, Germany. For the national defence simulations have been conducted for terrain typical of Northern Norway, i.e. very much canalizing, sparsely populated and with few roads, forested in the lower regions, and with a lot of marshes inhibiting mobility in the summer season. Two national scenarios were simulated, one in which regular Blue (Norwegian) forces are not used, but where enemy advance is inhibited by extensive use of various mine capabilities. The other one was the active defence of an area by a Battalion task force supported by various mine capabilities and artillery.

Description of Own Forces: Battalion task force (reinforced with Engineer elements) supported by Brigade artillery

Description of Threat Forces: Mechanized Infantry Brigade (in both cases)

Mission/Function of APM: The study includes all present missions of APM (taken care of mainly through SAS-023) and present and possible future missions of anti-vehicle land mines.

Summary of Results: The study focuses basically on anti-vehicle mines, as it makes use of the results from the work of SAS-023 and other Norwegian APM studies. The study shows that extensive use of land mines is a very powerful force multiplier, which can compensate for an overwhelming Red-to-Blue force ratio. A prerequisite for this is that the mines can be effectively protected against manual (dismounted) or mechanical breaching/mine clearance. Without APM the best countermeasure against manual mine clearance seems to be sector charges (DFDs) operated remotely by observation posts (OP). Adverse weather and generally pour sight conditions may inhibit this protection unless the sector charges and OPs have some sort of camera support. In addition to being an effective vehicle killer, modern horizontal effect (off-route) mines seem to provide an effective protection against mechanical breaching (provided they can themselves be protected against manual (dismounted) clearance). On wider terrain axes, remotely delivered mines, like the AT2, seems to be an agile tool for reinforcement of "standard" minefields, as well as a potent and flexible "stand-alone" weapon. For full effect it should be protected against dismounted clearance by artillery or sector charges. AT2 should not be used on road axes. The study reveals a need for remote control (for instance by OPs), on-off as a minimum, of modern mines and minefields, e.g. off-road mines. This will prevent our minefields from inhibiting own manoeuvre, and it will ensure a mine reserve being effective against the enemy's follow-up forces. It also enables us to pick out specific high value targets.

Power point presentation: See Volume II, Annex Norway.

F.7 United Kingdom

No of studies: 3

Study no 1

Study Name: Tactical Impact of no APM (carried out for SAS-023)

Study performed at: United Kingdom, Fort Halstead

Point of Contact: Mr. Fred Hood, DSTL Analysis

Start and End Dates for Study: November 1999 to August 2000

Description of Analysis Tools: Map exercise and stochastic simulation. The map exercise was used to determine the Blue and Red deployments, obstacle plans and approach routes. Wargaming was used to determine the interactions of forces. These were then input into the SIMBAT (battlegroup simulation) model. SIMBAT is a fast running arc and node battlegroup level probabilistic with 20 replications run per case).

Description of Scenarios: The battlefield is broken by rivers and marshes and becomes more heavily wooded from west to east. Scenario segmented into four vignettes. Blue's mission was to block the passage of the Red division for (a planned) 24 hours. The Red division attempted to bypass if at all possible to maximize rate of advance.

Description of Own Forces: Brigade deploying two armoured (US mech.) infantry battalions and one tank regiment (US Bn) .

Description of Threat Forces: Motor rifle division.

Mission/Function of APM: Protect AT mines/obstacles, area denial, counter desant.

Summary of Results: APM caused significant delays in enemy progress toward objective and/or increased in enemy casualties depending upon the route and forces deployed. Overall the mission time and Red losses increased by 11%.

Power Point Presentation: See Volume II, Annex United Kingdom.

Study no 2

Study Name: Alternatives to APM

Study performed at: United Kingdom, Fort Halstead

Point of Contact: Mr. Fred Hood, DSTL Analysis

Start and End Dates for Study: April 1998 to April 1999

Description of Analysis Tool: CAEn (close action environment) game/simulation. CAEn models individual personnel and vehicles on very high resolution terrain with a detailed surveillance and target acquisition model It has a built-in simulation mode allowing multiple replications of the battle gamed to be simulated.

Description of Scenarios: 1. Defence/delay in a village; 2. Defence of a keypoint; 3. Defence of an airfield perimeter against a large scale assault; 4. An ambush in close country.

Description of Own Forces: 1. Armoured infantry platoon; 2. Light infantry platoon (one third on duty); 3. and 4. Light infantry platoon.

Description of Threat Forces: 1. Motor rifle company; 2. Raiding platoon; 3. Sapper reinforced infantry company; 4. Light infantry company.

Mission/Function of APM: 1. Protect AT mines, prevent dismounted infiltration; 2. Keypoint protection; 3. Defend against mass infantry assault; 4. Ambush/cover withdrawal.

Summary of Results: The effect of APM varied by scenario: 1. The APM's role was support of AT mines and LAW, APM was not key to a successful battle outcome but formed a synergy with AT mines and LAW and increased their effectiveness; 2. Warning was essential to protect the keypoint, without it Blue lost ; 3. Canalization and delay were the contribution of APM in this case, Blue won comfortably with AP mines, without Blue lost unless the mines were replaced by other systems, where casualties were always heavier than the APM case; 4. A disadvantage was found in that Red flank guards encountered the APM and triggered the ambush early.

Power Point Presentation: See Volume II, Annex United Kingdom.

Study no 3

Study Name: The value of Anti-handling devices

Study performed at: United Kingdom, Fort Halstead

Point of Contact: Mr. Fred Hood, DSTL Analysis

Start and End Dates for Study: April-October 1999

Description of Analysis Tool: ACE (assessment of countermeasure effectiveness) simulation. Represent breaching operations at up to brigade level, modeling the allocation of breaching resources at each breach site.

Description of Scenarios: As a baseline for the study cases were run with AP mines to examine the resistance to breaching of minefields with no AHD and no APM, with either and with both. Standard minefield layouts were modeled being breached by the Red forces in several modes.

Description of Own Forces: Abstract representation of covering fire, based on an armoured infantry company limited by Red smoke and taken from analysis of Janus games.

Description of Threat Forces: Tank battalion and motor rifle battalions, with higher level engineer assets attached. Mounted and dismounted breaches were modeled.

Mission/Function of APM: To delay hand breaching.

Summary of Results: Where hand breaching is required, the time to breach increased by a factor of 2 to 6 over the standard minefield. In cases where AT minefields were strongly resistant to mounted breaching, the time taken to complete such a breach was increased by 30%. Where large areas need to be cleared (e.g. ADW obstacles) by hand personnel casualties become heavy.

Power Point Presentation: None available.

F.8 United States

No of studies: 4

Study no 1

Study Name: Battlefield Utility of Antipersonnel Landmines for NATO

Study performed at: Lawrence Livermore National Lab (LLNL), Livermore California

Point of Contact: Robert Greenwalt Jr, LLNL

Start and End Dates for Study: March 2000 - September 2000

Description of Analysis Tool: Tactical modeling was conducted in-house using version 2.4 and 3.0(beta) of the Joint Conflict and Tactical Simulation (JCATS), a lineal descendant of Janus, the Army's current entity-level interactive model. JCATS is a multi-sided, interactive, entity-level conflict simulation employing actual three-dimensional terrain, and physics-based movement, acquisition, probability of hit (Ph), and probability of kill (Pk) algorithms. The Department of Defense Joint Warfighting Center sponsors JCATS and maintains configuration control.

Description of Scenarios: One large battle was used as a base to extract seven engagements for analysis. The battle consisted of a brigade defense in compartmented European terrain (EUR1). Engagements were chosen to examine specific APM usage, but the battle then was allowed to continue to see the later effects.

Description of Own Forces: Equipment was based on current force structure. The force was a Hungarian mechanized brigade attached to a US mechanized division. Close combat systems were Hungarian, supported by additional US artillery and attack helicopters.

Description of Threat Forces: Threat forces used Soviet equipment from the 1970s and Soviet tactics. The threat attack was by a motorized division with three motorized rifle regiments and a tank regiment supported by additional artillery and aviation. Threat forces outnumbered friendly forces by ratios of 6:1 up to 36:1, depending on the particular engagement.

Mission/Function of APM: APM had two major functions in this study: protect the antitank mines in a mixed minefield (performing the fixing function), influence dismounted maneuver in a pure APM turning minefield, and contribute to the close defense in a pure APM protective minefield.

Summary of Results: The most common use of a mixed minefield is to fix the enemy for destruction by other weapons. Three engagements employing fixing minefields (EUR(610), EUR(611), and EUR(612)) were selected from the European scenario. All three of these had a defender fighting in broken terrain with short engagement ranges against a threat equipped with an earlier generation of equipment. APM caused the attacker to lose from 2 to 3 times the number of tanks during the minefield breach that he lost in the NoAPM case. In the extended battle through the overwatching defensive positions, APM caused Red losses of 3 to 10 times the losses in the NoAPM case. In all four engagements, the attacker used dismounted breaching techniques in the NoAPM case. This allowed him to hold his antitank systems back until the breach lanes were completed, then to rush them through the lanes. In the APM case, the attacker typically lost all of his tank-mounted breaching equipment while conducting the breach and then had to meter his force through those lanes that had been completed.

Continuing the battle through the brigade rear showed the impact of Red's early losses on Red success. With APM, Blue won with 42% of his antitank systems surviving and all Red destroyed. Without APM, Blue loses with only 10% of his antitank systems surviving.

APM pure tactical minefields were examined in EUR(612) where they were used in unobserved, close terrain to force dismounted attackers into a limited space where they could be effectively attacked with artillery. Without the APM, the attacker had freedom to move through a large area. The APM case doubled the Red casualties.

A protective minefield was examined in the same EUR(612) scenario. This engagement has a defending platoon facing a dismounted attack out of the forest by two companies. The engagement range is about 400 meters. The protective obstacle is located about 200 meters in front of the defender. The APM made the win-lose difference. Red never wins when APM are present. Without APM, Red retained 25% of his force after overrunning the Blue position. With APM, the Red force was totally destroyed.

Power Point Presentation: See Volume II, Annex United States.

Study no 2

Study Name: Battlefield Utility of Antipersonnel Landmine Alternatives for NATO

Study performed at: Lawrence Livermore National Lab (LLNL), Livermore, California

Point of Contact: Robert Greenwalt Jr, LLNL

Start and End Dates for Study: November 2000 - February 2001

Description of Analysis Tool: Tactical modeling was conducted in-house using version 2.4 and 3.0(beta) of the Joint Conflict and Tactical Simulation (JCATS), a lineal descendant of Janus, the Army's current entity-level interactive model. JCATS is a multi-sided, interactive, entity-level conflict simulation employing actual three-dimensional terrain, and physics-based movement, acquisition, probability of hit (Ph), and probability of kill (Pk) algorithms. The Department of Defense Joint Warfighting Center sponsors JCATS and maintains configuration control.

Description of Scenarios: One large battle was used as a base to extract an engagement for analysis. The battle consisted of a brigade defense in compartmented European terrain (EUR1). The engagement was an isolated platoon defending from a woodline across a meadow facing another woodline approximately 400 meters away.

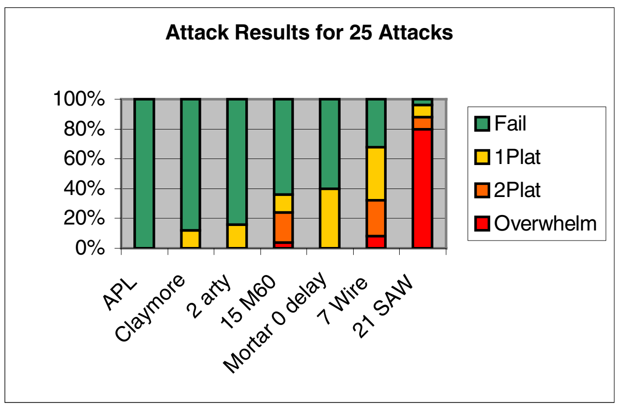
Description of Own Forces: Equipment was based on current force structure. The force was a US mechanized infantry platoon dismounted in a prepared defensive position. Non-materiel alternatives examined were: adding medium machineguns, adding light automatic rifles, employing extensive wire obstacles, providing dedicated artillery, providing dedicated mortars, and employing remote DFDs with remote demolition firing devices.

Description of Threat Forces: Threat forces used Soviet equipment from the 1980s. The threat attack was by two dismounted infantry companies, providing a force ratio of 7.1:1 in Red's favor.

Mission/Function of APM: APM had a single function in this study: contribute to the close defense in a pure APM protective minefield.

Summary of Results: Base case results showed Red losing 94% of his force with APM versus 25% without APM. Red never overran the defenders when APM were present, but always did when they were absent. When alternatives were examined, Blue won 90% using DFDs, 85% with two dedicated artillery batteries firing with no delay, 65% with 15 medium machineguns, 60% with dedicated mortars with no delay, 32% with seven barbed wire obstacles installed in front of the position, and 5% with 21 light automatic rifles.

The figure compares the alternatives:



The key shows how well the attacker fared. Yellow meant he ended with one platoon on the defending position, orange meant he had two platoons, and red meant he ended the engagement with over two platoons on the defending platoon position. Green meant he failed. From this, the two best solutions were the DFD alternative, or two dedicated artillery batteries firing with zero delay (if that were possible through use of sensors or some other means to predict when the artillery must be fired).

Power Point Presentation: See Volume II, Annex United States.

Study no 3

Study Name: Utility of Self-healing Minefield Concepts and Utility in Battle

Study performed at: Lawrence Livermore National Lab (LLNL), Livermore, California

Point of Contact: Dr Douglas Magnoli

Start and End Dates for Study: January, 1999 - January, 2000

Description of Analysis Tool: Analysis of the self-healing minefield (SHM) was done using a Fortran program designed specifically for this purpose. This model was used to examine certain minefield parameters (e.g., density, how far mines should move, in response to what event should mines move, etc.). Once that had been accomplished, tactical modelling was conducted using version 1.2 of the Joint Conflict and Tactical Simulation (JCATS), a lineal descendant of Janus, the Army's current entity-level interactive model. JCATS is a multi-sided, interactive, entity-level conflict simulation employing actual three-dimensional terrain, and physics-based movement, acquisition, probability of hit (Ph), and probability of kill (Pk) algorithms. The Department of Defense Joint Warfighting Center sponsors JCATS and maintains configuration control.

Description of Scenarios: The battle examined was a vignette taken from HiRes 43, a standard scenario from TRADOC (the Training and Doctrine Center). Three Blue platoons have positions on a ridge overlooking a highway where Red, a North Korean mechanized infantry battalion, approaches with the goal of destroying the Blue position. The terrain is very hilly with light brush.

Description of Own Forces: Defenders (Blue force) are arrayed in three platoon positions. The force is composed of three rifle platoons, each with 3 Dragon antitank missiles, 3 designated light antitank weapon (AT-4) gunners, two 7.62mm (M60) machineguns; plus ten 5.56mm M16 rifles, six 5.56mm squad automatic rifles (SAW), and three rifle-mounted 40mm grenade launchers (M203). Each rifleman not designated as a light antitank weapon gunner also carries one AT-4. The rifle company has been augmented with one-half of the battalion's antitank platoon, which consists of three TOW antitank missile systems and three MK19 automatic grenade launchers. It is also supported by three 60mm mortars and the fires of one battery (six guns) of 105mm artillery. The position has a stockpile of six TOW missiles/launcher, six Dragon missiles/tracker, 1365 rounds of 7.62mm ammunition/M60 machinegun, 1200 linked 40mm grenade rounds/ Mk19 launcher, and 480 high explosive rounds/mortar. Ninety personnel are deployed in prepared fighting positions on the three battle positions.

Description of Threat Forces: The Red force, a North Korean mechanized infantry battalion, is composed of one company mounted in twelve BTR60 wheeled armored personnel carriers, and two companies carried in ZIL trucks. An armor company consisting of nine T-72 tanks augments the battalion. Each company employs nine 7.62mm machineguns (PKM), eighteen 5.45mm squad automatic weapons (RPK74), nine grenade launchers, six rocket-propelled grenade launchers, and sixty-six 5.45mm AK74 rifles. Three hundred twenty-four infantry are available for dismounted assault. Nine mortars and two artillery battalions (six batteries, thirty-six guns) of 122mm artillery support the attackers.

Mission/Function of APM: The role of the APM in this study was to protect the anti-tank (AT) mines. When the SHM was used, no APM were required. The purpose of the AT minefield was to slow the attack and to fix Red in a position where he would be vulnerable to other weapons.

Summary of Results: The scenario was run four different ways: without mines, with AT mines only, with both AT and APM, and with the SHM. Red won, killing all of Blue, in all cases except with the SHM, when Blue won, killing all of Red and losing half of its own force. Without mines, Red casualties were approximately 20% of the force. With AT mines only, Red lost about 50%, and with the mixed minefield, Red lost approximately 65% of his force. In those three cases, Blue casualties were 100%. Force exchange ratio, the percentage of Red casualties divided by the percentage of Blue casualties, was 0.25 with no mines, 0.5 with AT mines only, 0.7 with the mixed minefield, and 2.0 with the SHM. The tactic Red used to breach the SHM was to clear a very wide (25 m) lane so the mines, which could move 10 meters, would be unable to reach the central five meters of the lane, leaving this clear for tanks to move through. Because of the large Red infantry force involved in clearing such a wide lane, Red casualties during the breach were extremely high with the SHM. Without mines, Red lost no one to breaching. With AT mines only, Red lost 23 to the breach effort. With the mixed minefield, Red had 60 breach casualties, and the SHM cost 178 Red troops to breach, leaving only about half the Red force to attack the Blue position.

Power Point Presentation: Is not provided.

Study no 4

Study Name: Battlefield Utility of Antipersonnel Landmines and Alternatives, Track III

Study performed at: Lawrence Livermore National Laboratory, Livermore, California

Point of Contact: Robert Greenwalt Jr, LLNL

Start and End Dates for Study: October 1999 – July 2001

Description of Analysis Tool: Tactical modeling was conducted in-house using version 2.4 and 3.0(beta) of the Joint Conflict and Tactical Simulation (JCATS), a lineal descendant of Janus, the Army's current entity-level interactive model. JCATS is a multi-sided, interactive, entity-level conflict simulation employing actual three-dimensional terrain, and physics-based movement, acquisition, probability of hit (Ph), and probability of kill (Pk) algorithms. The Department of Defense Joint Warfighting Center sponsors JCATS and maintains configuration control.

Description of Scenarios: Five battles were used as a base to extract eleven engagements for analysis. The battles consisted of a brigade attack up a desert mountain valley in Southwest Asia (SWA1), a battalion defense on the same Southwest Asian terrain (SWA2), a battalion defense in hilly Korean terrain (NEA1), a brigade defense across rice paddies in Korea (NEA2), and a brigade defense in compartmented European terrain (EUR1). The scenarios covered a variety of terrain, from open desert to compartmented forests and fields, to heavily vegetated hills. They also included a variety of forces sizes and force ratios. Some engagements Blue should win, some should be doubtful, and some Blue should lose.

Description of Own Forces: Forces varied by scenario. Equipment was based on 2006 projected forces. Size of the force in a particular engagement included a dismounted mechanized infantry platoon, a light infantry comany, a tank company (-), a tank company, and a mechanized infantry battalion task force.

Description of Threat Forces: Threat forces were of two types – a force that used Soviet equipment from the 1970s and a force that used Soviet equipment freely available on the market (T80 and BMP2 class). Threat forces outnumbered friendly forces by ratios of 6:1 up to 36:1, depending on the particular engagement

Mission/Function of APM: APM had two major functions in this study: protect the antitank mines in a mixed minefield (performing the functions of fix, turn, block) and contribute to the close defense in a pure APM protective minefield.

Summary of Results: The most common use of a mixed minefield is to fix the enemy for destruction by other weapons. Three engagements employing fixing minefields (EUR(610), EUR(611), and EUR(612)) were selected from the European scenario. All three of these had a defender fighting in broken terrain with short engagement ranges against a threat equipped with an earlier generation of equipment. A fourth engagement was selected from the NEA2 scenario where both the defender and attacker had comparable equipment, but the engagement ranges were long. APM caused the attacker to lose from 3 to 9 times the number of antitank systems he lost in the NoAPMcase. In all four engagements, the attacker used dismounted breaching techniques in the NoAPM case. This allowed him to hold his antitank systems back until the breach lanes were completed, then to rush them through the lanes. In the APMcase, the attacker typically lost all of his tank-mounted breaching equipment while conducting the breach and then had to meter his force through those lanes that had been completed.

Turning obstacles are of particular importance where the terrain doesn't naturally canalize the attacker into a confined engagement area. This is especially true where engagement ranges are very long, and the attacker can avoid defending fire by simply remaining out of range. Two engagements where turning obstacles were important were selected from the battles SWA1 and SWA2. In the absence of APM, the attacker was able to breach through the minefields with dismounted soldiers without risking his armor. The minefields did not force him to turn, and he was able to directly attack the defending unit. When APM were present, he did not risk his vehicles breaching and turned to bypass. Because of this, the obstacles accomplished the defender's intent. Not only did the attacker lose far more tanks (on the order of twice as many) in the presence of APM, he also took significantly more casualties to all of his antitank systems.

Blocking obstacles are designed to force a significant battle with the aim of stopping the advance along a particular avenue. The blocking obstacle at the end of the valley in SWA2(W) was used to examine this function. The APM made a considerable difference. Red lost seven times as many tanks when he was forced to conduct a mounted breach under fire as when he could breach with dismounted forces. A similar result happened across the board with all antitank systems (tanks as well as BMP infantry fighting vehicles). Due to the nature of the blocking obstacle, the APM is critical to its function.

Protective minefields were examined in two scenarios, NEA1 and EUR(612). The NEA1 engagement has a dismounted infantry battalion attacking through very close terrain into the flank platoon of a defending infantry company. The infantry company is protected by a protective minefield in the 400 meter open area to its front. APM made the difference between winning and losing. In the absence of APM, all defenders died while the attacker lost 60% of his force. With the APM protective obstacle, the attacker lost his entire force, while the defender lost only 33%. The other protective obstacle vignette came from the EUR(612) engagement. This engagement has a defending platoon facing a dismounted attack out of the forest by two companies. The engagement range is about 400 meters. The protective obstacle is located about 200 meters in front of the defender. Blue suffers serious losses in both cases, while Red loses more than three times as much of his force in the APM case than in the NoAPM case. The main difference APM makes is whether Red wins or loses. Red never wins when APM are present, and loses almost all of the assaulting force.

Non-materiel alternatives (using existing units and systems to accomplish the APM mission) were examined in the same engagements. Possible non-materiel alternatives to APL were identified by the Warfighters' Conference held at Fort Leavenworth in July 1999, the TRADOC Integrated Concept Team meeting held at Fort Leonard Wood in August 1999, and the Warfighters' Conference held at Carlisle Barracks in November 2000.

For mixed minefields, none of the proposed alternatives achieved equivalent results to the APM case. Adding infantry to protect the original AT minefield showed a slight increase in Red casualties compared to the pure NoAPM case. Making the minefield deeper was far more effective essentially doubling Red casualties. Adding infantry to the deeper minefield provided an additional 10% to Red casualties. However, a significant increase in the number of Blue casualties occurs when infantry are added to either case. This occurs because there are more Blue forces present to be targets. Additional tanks were added to add long-range antitank lethality. In the EUR(610) engagement, the number of tanks was doubled to two companies. Because of the constricted terrain, this doubling of firepower successfully produced the same Red casualties as the APM case. The Blue AT system casualties tripled, however! The number of Blue tanks was also doubled in the NEA2 engagement. Because of the large number of Red long-range AT systems, this produced only 4% more Red casualties, for the loss of all of the additional Blue tanks. Adding additional Blue forces as an alternative causes a large increase in Blue force casualties in every case examined.

Because of the unique nature of the protective minefield, where the attacker doesn't have the option of breaching, the non-materiel alternatives selected were methods designed to add lethality to the defender. The intent was to replace the casualty-causing ability of the APM with some other casualty-causing mechanism. Mechanisms were: M60 machineguns, SAW, barbed wire obstacles, dedicated artillery, dedicated mortars, and DFDs with remote firing devices.

Power Point Presentation: Is not provided

Annex G

Nations Constraints or Limitations

This annex contains constraints or limitations provided by each nation. Although nations may group them slightly differently, they are addressed under the headings of:

Guidance and Policy	Political/Legal
Technical	Humanitarian Constraints
Operational	Warfighting Constraints
Budget or Force Structure Resources	Programmatic

BELGIUM

Guidance and Policy

Total compliance with all applicable existing international treaties and national laws. If "gray zone" study on a case-by-case base. ("gray zone" - political interpretation of particular cases)

BE Law prohibits APM, booby traps and similar equipment.
(current concentration of BE is 2015 - so APM-A is not getting too much exposure)

APM-A must be:
  listed in the inventory
  training required
  user's instruction

Besides military acceptance, political and public opinion support is required

If lethal, effect must discriminate; no residual hazard; recoverable & reusable &/or self-destructing

If non-lethal effect must affect personnel temporarily can affect materiel either permanently or temporarily

Awareness of immediate and long-term effects on personnel, materiel and environment

No obligation of use

APM-A complement to conventional lethal systems/weapons

Should not require APM-A specialized unit to employ

Advanced training devices and systems required

If necessary, APM-A should be immovable (AHD incorporated). The AHD must inflict a penalty to the "disturber" otherwise the device just clears the minefield

1. In Dec 97, BELGIUM signed the Convention on the Prohibition of the Use, Stockpiling, Production and Transfer of Anti-personnel Mines and on their Destruction. Early in 95, BELGIUM adopted national laws related to Anti-personnel Mines, Booby-traps and Similar Devices that imposed broader restrictions than the "OTTAWA Treaty".

2. The Belgian legislation defines as *"Anti-personnel mine, booby-trap or similar device*, any device to be placed under, on or near any surface area, and designed or adjusted to be detonated or exploded by the simple presence, proximity or contact of a person." *"Anti-personnel mine* means a mine designed to be exploded by the presence, proximity or contact of a person and that will incapacitate, injure or kill one or more persons. Mines designed to be detonated by the presence, proximity or contact of a vehicle as opposed to a person, that are equipped with anti-handling devices, are not considered anti-personnel mines as a result of being so equipped". According to the Belgian legislation, anti-

personnel mines, booby-traps (regular and improvised ones) and similar device (such as Mixed Munitions containing both anti-tank and anti-personnel mines) are prohibited.

3. On the entire Belgian national territory, the legal prohibitions apply to all Belgian and foreign military Forces personnel. Outside of the national territory, in a multinational context, they apply to all Belgian Armed Forces personnel, whatever the command and subordination relationships are.

4. In a multinational context, although BELGIUM strongly discourages the use of anti-personnel mines by other nations, this would not prevent nations that are not State Parties to the OTTAWA Treaty from retaining the right to decide on a unilateral basis to plan or to use anti-personnel mines for their own national benefit.

- BELGIUM may participate in multinational operations, training and exercises alongside with other forces from a nation that is not State Party to the OTTAWA Treaty. The participation in military activities with foreign contingents from non State Party nations can in no way be considered as assistance, encouragement or incitement of anybody to get involved in prohibited activities.

- The legal provisions are applying strictly to all Belgian Forces personnel. As illustration, Belgian Armed forces personnel may not plan, participate in the planning process or use prohibited anti-personnel mines, shall under no circumstances suggest, recommend, encourage or order to lay or use anti-personnel mines, may not use the capabilities of foreign units to have anti-personnel mines laid for the benefit of Belgian units, may not accept, agree or approve any document, including operational plan, envisaging the use of anti-personnel mines, may not agree to Rules of Engagement (ROE) prescribing the use of anti-personnel mines.

- Through the Belgian national territory, the transit of anti-personnel mines is prohibited.

- If Belgian Forces personnel are being commanded by other nationalities, they will inform through the multinational chain of command about the prohibitions and restrictions of their military actions their national legislation is imposing; Belgian Forces personnel may not carry out any order requiring to undertake any prohibited activities related to anti-personnel mines and that would not be in compliance with the provisions of the Belgian national legislation.

- Countermine education and training of Armed Forces personnel is permitted when conducted in accordance with the terms of the appropriate regulations, and strictly for the purposes of: Education and training in “mine awareness”, Education and training of personnel specialised in mine clearance and explosive ordnance disposal, Research, development and testing of equipment and techniques for mine detection or clearance purposes as well as for the training in these techniques.

5. Additional remarks

a. The potential alternatives to anti-personnel mines are to be in compliance with the applicable international Treaties and other national laws.
b. The immediate and long-term effects and impacts of the use of alternatives on personnel, materiel and environment should be assessed.
c. Advanced training devices and systems are required.
d. Interoperability of the systems and procedures between NATO Allies should be addressed.
e. Besides the military validity, political and public acceptance is required.
f. It is not the intention of BELGIUM to conduct any future simulation or study on the effects of munitions that are already strictly prohibited.
g. The definitions as contained in the annex of this study are for information purposes only.

CANADA

Guidance and Policy

No member of the Canadian Forces (CF) can be involved in the planning, delivery or implementation of any activity involving APM (e.g., CF personnel cannot be involved in staff activities which include the intent to use AP mines)

Political/Legal
Canadian Forces personnel engaged in the planning for the use of anti-personnel mines are liable to criminal prosecution under Canadian law.

Warfighter Constraints
Canada may participate in combined operations with a state that is not Party to the Convention. Canadian Forces may not, however, use anti-personnel mines and they may not request, even indirectly, the use of anti-personnel mines by others.

The use of anti-personnel mines by the combined force will not be permitted in cases where Canada is in command of a combined Force.

Technical

Man-in-the-Loop discrimination for lethal effect
Simple and secure C3
Easy to install and use
No residual risk

Operational

No extra logistics
Existing transportation assets
No extra manpower or training
Interoperable (comms, C2, etc.)

Programmatics

Cost Effective

DENMARK

Guidance and Policy

- Full compliance with Ottawa Convention
- National legislation / interpretation
- All APMs were destroyed in 1999

Operational

- Easy and safe to use
- Limited extra logistics
- Limited extra manpower and training
- Compatible with doctrines and tactics used for other weapon systems

Programmatics

- Cost Effective

FRANCE

Guidance & Policy:
- Respect of international laws
- **Respect of national laws**
- Respect of environment preservation (no pollution of the ground)
- Multinational engagement including nations having or not ratified the Ottawa Convention(cf. NATO)

Warfighter constraints
- Necessity to identify precisely the personnel (discriminate civilians, combat soldiers, friends, foes …)
- Accuracy of terminal effect (to hit nothing else than the aimed target - no collateral effects)
- Interoperability (doctrine, procedures)
- Logistic: Weight, volume and bulk increased because of the different components to fulfil all the functions of APM (300 g→ several kg)
  Storage constraints (hardware and software separated)
- Training: Users training for implementation more complex

Humanitarian constraints
- Not to design devices that can be compared with APM (perception by public opinion ; ONG 's, associations against armaments)
- Not to design devices that can be reused by other people
- Not to design devices that can be used by combat soldiers or irregular troops (guerillas…) apart from their regular use (trap or non lethal → lethal)

Technology
- Technological gap for accurate identification
- Standardization or compatibility of systems or/and equipments between the Allied

Programmatic constraints
- Cost
- Delay to achieve technological gap (5 to 10 years)
- Reduction of strength (personnel)

GERMANY

Guidance & Policy

Respect of international laws
Respect of national laws (Ottawa convention became national German law in March 1999)
Respect of environment preservation (no pollution of the ground)
Multinational engagements including nations having not ratified the Ottawa convention will be possible only, if the ROE's are applicable to the German involvement and respect German national law

Programmatic constraints

Low costs
Delay for technology development (estimated up to 5 years)
Need solutions, which are not personnel intensive

Humanitarian constraints

Public acceptance (e.g. public opinion, opponents etc.)
System security (not usable by unauthorized persons)
Minimizing collateral effects

Warfighter Constraints

According to doctrine and procedures
Easy and safe to handle
Deployable with existing or future systems
Minimized weight and volume, easy to store and maintain
Easy to train with

Technology

Technological gap for providing accurate & discriminate identification
Mechanically deployable, reusable, remote controlled
Self neutralizing or self destroying
Low power consumption

HUNGARY

Guidance & Policy

2-4 December 1997, Ottawa Convention, Hungarian Government signed, Laws in Hungary 1998
Development of APM were stopped in 1997
All APM were destroyed 30 June 1998
R&D effort seeking a nearly equivalent solution (alternative)

- Nearly equivalent military effectiveness
- Safety of use
- Minimum risk to non-combatants

Warfighter Constraints

Until alternatives fielded: Hungary can use other remaining engineering means

Humanitarian Constraints

Safe to use

Programmatic Constraints

Cost Effective

ITALY

Guidance and Policy

In accordance to National law, Italy will not use any device, which may be classified as an APM according to the following definition:

> "An APM is defined as a device which may be placed above, under, inside or next to any surface and adjusted or adapted with specific measures in order to explode, cause an explosion or release incapacitating substances as the result of presence, proximity or contact of a person"

In a multinational environment, Italian forces will be allowed to accomplish military tasks and to be part in a military operation complying with the international laws and conventions. (It seems to be a prevalence of the international laws, but only in multinational / international formations / missions)

Only non-lethal alternatives allowed

Technical

Non-Lethal technologies

Programmatic

Costs
Time

NETHERLANDS

Guidance & Policy

Full compliance with Ottawa and Amended Protocol II
National Law/Policy
Mixed systems not acceptable (with APM)
AHD (in an ATM) and directional fragmentation devices are permitted by NL Minister of Defence guidance
Non-signatory forces not allowed to use/store APMs on NL territory
NL forces will not assume control or responsibility of obstacles possessing APM (in joint operations)

Warfighter Constraints

No significant increase to personnel needed for logistics, emplacement and control (constant MITL control)

Priority one: Force protection in close and rear battle zones. But we also have concerns about the loss of deep battle capacity having no longer available effective remotely emplaced target and situation orientated (AT) minefield systems.

Humanitarian Constraints
No UXO should remain as a threat to civilians and troops after the conflict, to include environmental hazards. For these reasons, lethal APM-As should have attributes such as: self-neutralizing, and/or switch on/off or selectable operational time settings. During the conflict, APM-A must not pose a threat for friendly forces and/or non-combatant, therefore alternatives must be discriminating or not target activated.

Programmatic Constraints
More troops to compensate for the loss of APM are not an acceptable non-materiel alternative for both financial and ethical reasons. (Due to the costs associated with generating and sustaining more units and the generation of higher casualties when such forces are employed as a non-materiel APM alternative.)

General Remarks –
We do make a distinction between “a total conceptual alternative” and “partial and/or situational alternatives” (Total conceptual alternative: MITL controlled fragmentation device, A partial alternative, just addressing one function: tripwire sensors, or a situational alternative for one of the key missions such asprotective minefield: dedicated artillery support).

We do not expect, at this time, to find an overall, all-in-one alternative. But we do expect to be able to attain a balanced pallet of partial and situational alternatives.

In MOOTW it is required to have the capability to switch, select or prepare the “field” from lethal to non-lethal depending on the threat situation and tasks assigned.

NORWAY

Technical

Discriminating power
Effectiveness of non-lethal weapons
Response time
Communication
Robustness (environment, counter measures)

Operational

Limited manpower
Logistics
Easy and quick deployment

Programmatics

Affordable

Political

Ottawa Convention
International legislation
National legislation/interpretation
Public opinion

UNITED KINGDOM

Guidance & Policy

Ottawa Convention
UK and International law
Rules of Engagement (e.g. OOTW complex rules, conditions to be met …..)

Organizational

Existing force structure/organization
Examinations of firepower on squad & platoon section level
Logistics

Warfighter Constraints
Command activated area defense weapons permitted (MITL - OK)
AHDs permitted
Interoperability: no constraints on working with allies; can take over / battle hand over as long as they maintain field markings
Can not lay AP mines and would not be required to lift / clear field

Humanitarian Constraints

Laws of Armed Conflict
Safe to use
Minimal residual hazards after conflict
Lethal alternatives cannot be target activated

Programmatic Constraints

Cost effective
Manpower

UNITED STATES

Guidance & Policy

US APM/Mixed Mines (MM) Policy per Presidential Decision Directive 64 (PDD-64)
Retain APM/MM capability while seeking suitable alternatives to APM/MM,
Equivalent military effectiveness, safety of use, minimize risk to non-combatants,
Use governed by Convention on Conventional Weapons (CCW) Amended Mines Protocol II
Mission Need Statement (MNS) & Developing Operational Requirements Documents (ORDs)

Warfighter Constraints

Until alternatives fielded: US reserves the right to unilaterally employ APM/MM in any operation in which US forces are involved (But, will end use of pure APM outside Korea by 2003)

Humanitarian Constraints

Safe to use
Minimal residual hazards after conflict
Lethal alternatives cannot be target activated

Programmatic Constraints

Cost Effective
Manpower

Annex H

Compilation of Nation's Materiel System/Concept Descriptor

Material aspects of APM-Alternatives

The following paragraphs contain descriptions and characteristics of the material aspects of systems or concepts possibly used as APM-A, provided by nations to the SAS-023 Study group. Belgium, Denmark and Italy are currently not running programs for developing APM-As.

The proposed APM-As are listed by country, and the description of each system/concept has the following format: 1.APM Functions, 2. Characteristics, 3. System/Concept Descriptor, 4. APM Missions, and 5. Availability/Project Status. Where provided a picture of the system/concept completes the description.

Timeline (Availability) for each system/concept is given as **N**ear Term (≤2003), **M**id Term (2004-2008), or **L**ong Term (>2008). (O – nation did not provide availability data.)

- Canada
  - **N** Automatic Grenade Launcher
  - **N** Directional Fragmentation Device Field
  - **M** Remote triggered Directional Fragmentation Devices
- France
  - **N** MODER
  - **N** MODER Plus
  - **M** SPECTRE
  - **M** SUZON, Track 1
  - **L** SUZON, Track 2
- Germany
  (Initial list of R&D Non-lethal APM-A concepts)
  - **M** NILPFERD
  - **M** NILPFERD (short range)
  - **M** CHAMÄLEON
  - **M** BOVIST
  - **M** SESAM
  - **M** Launcher Tubes
  - **M** Fog Launcher
- Hungary
  - o Area Defence Weapon System
- Netherlands
  - **N** MITL Directional Fragmentation Devices
  - **N** MODER PlusType System
  - **M** Improved Anti-Handling Device
- Norway
  - **N** ADWS – M19/M100 with MITL
  - **M** OPAK+ (Stationary)
  - **L** OPAK+ (Portable)
- United Kingdom
  - o ADDER
  - **N** Spiked Net
  - o Area Sensors
  - o Semi-Autonomous Weapon (Too early to evaluate)
- United States
  - o Non-Self Destruct Alternative
  - o RADAM (Not Ottawa Compliant)
  - **L** Self Healing Minefield
  - **L** Tags/MGM Feasibility Study (Too early to evaluate)
  - **L** APLA, Track III (Too early to evaluate)

Canada

Automatic Grenade Launcher

APM Functions

- Area Denial and Close Protection

Characteristics

- Video Sight for detection
- 1 m accuracy eye-safe laser
- 2000 m range
- 40 mm Grenades- lethal (5m) / some non-lethal rounds
- Man-in-the-loop

System/Concept Descriptor

Sense (Detect)	Comms (Alert)	Decision Support	Comms (data/cmds)	Discriminate	Weapons Effects
• Human	• Visual • None	• Display • MITL	• Manual trigger • Electrical solenoid	• Human	• Lethal Remote

APM Missions

Primary: Key Point Protection (Rear), Mass Infantry Assault (Close), Dismounted Infiltration (Close)
Secondary: Protect Obstacles (Close), Protect Anti-Tank Minefields (Deep)

Availability/Project Status

Available in Near Term (to be acquired).

Picture

Field of Directional Fragmentation Devices

APM Functions

Area denial and close protection using a mix of sensors, wire obstacles and Directional Fragmentation Devices.

Characteristics

- Ground sensors for detection
- Wire obstacles
- Directional Fragmentation Devices with electrical wires (Range 100m)
- Man-in-the-loop

System/Concept Descriptor

Sense (Detect)	Comms (Alert)	Decision Support	Comms (data/cmds)	Discriminate	Weapons Effects
• Human (Visual)	• None	• None (MITL)	• Electrical • Pyrotechnical	• Human	• Lethal In-field

APM Missions

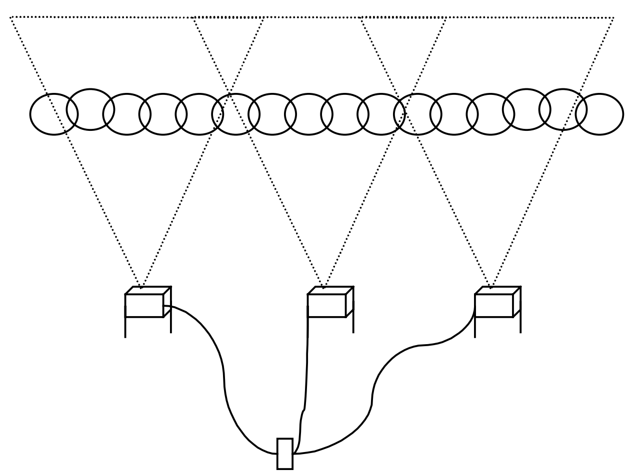
Primary: Key Point Protection (Rear), Mass Infantry Assault (Close), Protect Obstacle (Close), Dismounted Infiltration (Close)

Secondary: Protect Anti-Tank Minefields (Deep)

Availability/Project Status

Available in Near Term

Picture



Remote triggered Directional Fragmentation Devices

APM Functions

Area denial and close protection using a mix of sensors, wire obstacles and Directional Fragmentation Devices.

Characteristics

- Sensors for detection
- Wire obstacles
- RF links for Comms (Range 2-5 km LOS)
- Directional Fragmentation Devices – lethal response
- Man-in-the-loop

System/Concept Descriptor

Sense (Detect)	Comms (Alert)	Decision Support	Comms (data/cmds)	Discriminate	Weapons Effects
• Human • Tripwire • Optics	• None • RF link	• Display • MITL	• RF data	• Human	• Lethal In-field • Lethal remote

APM Missions

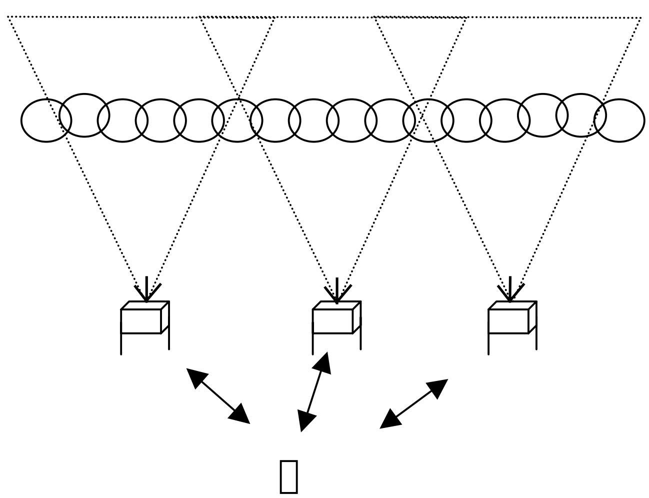
<u>Primary:</u> Key Point Protection (Rear), Mass Infantry Assault (Close), Protect Obstacles (Close), Dismounted Infiltration (Close)

<u>Secondary:</u> Protect Anti-Tank Minefields (Deep)

Availability/Project Status

Available in Mid Term (Concept only)

Picture



France

MODER

APM Functions

Deny, protect

Characteristics

- Several seconds effective delay time
- Covered area, 50 m radius, angle 140°
- 150 m effective sensing range
- Deployed by hand

System/Concept Descriptor

Sense (Detect)	Comms (Alert)	Decision Support	Comms (data/cmds)	Discriminate	Weapons Effects
• Human (Direct view)	• None • Human	• MITL	• Electro-pyrotechnical	• Human	• Lethal (Galix 4, fragmentation) • Non-lethal (Galix 19, sound)

APM Missions

<u>Primary:</u> Key Point Protection (Rear), Protect Obstacle (Close), Dismounted Infiltration (Close)

Availability/Project Status

Near Term, in service

Picture

MODER SYSTEM

GALIX 4 Ammunition

GALIX 19 Ammunition

MODER Plus

APM Functions

Deny, protect

Characteristics

- Several seconds to several minutes effective delay time
- Deployed by hand

System/Concept Descriptor

Sense (Detect)	Comms (Alert)	Decision Support	Comms (data/cmds)	Discriminate	Weapons Effects
• Human • Contact with tripwire • Night vision • Binoculars • Camera	• Light (Illuminating pyrotechnic device)	• MITL	• Remote control RF • Optical fibre • Several devices in network	• Human	• Lethal (Galix 4, fragmentation) • Non-lethal (Galix 19, sound)

APM Missions

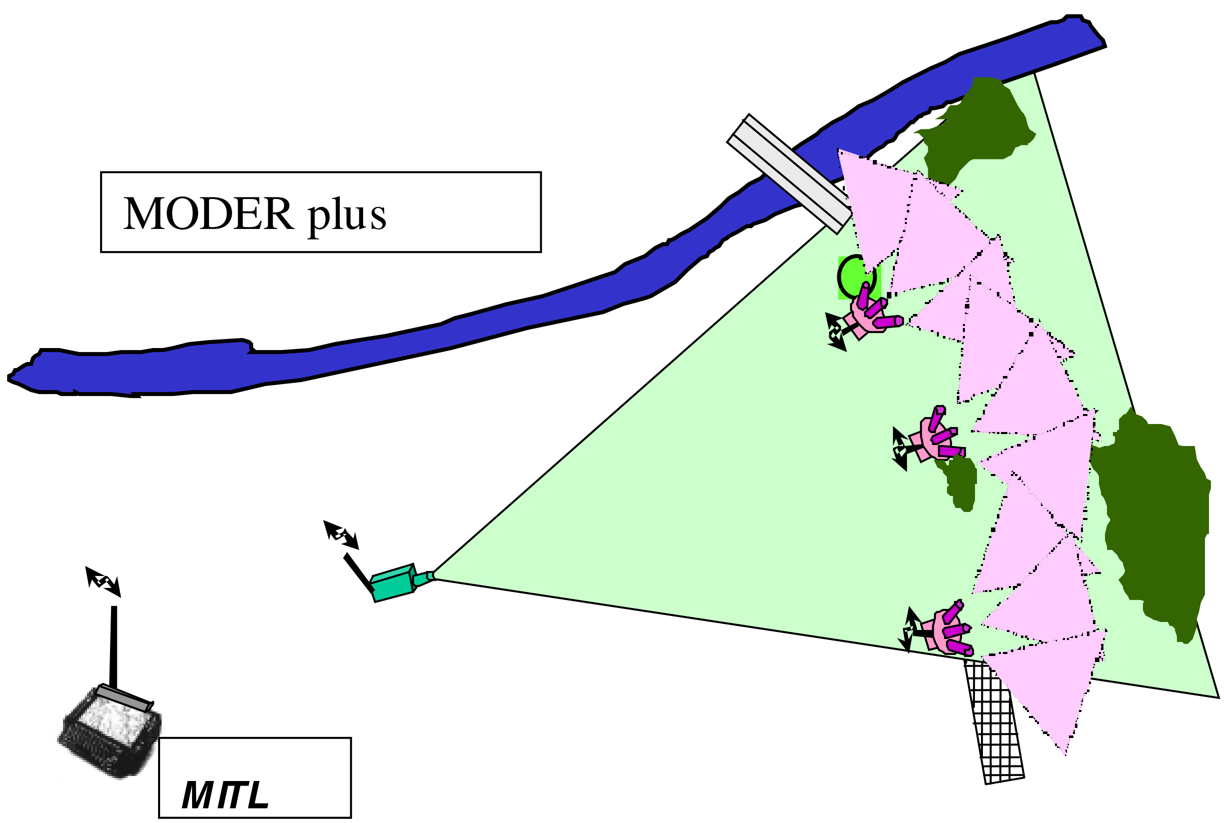
Primary: Key Point Protection (Rear), Protect Obstacle (Close), Dismounted Infiltration (Close)

Secondary: Mass Infantry Assault (Close)

Availability/Project Status

Available in Near Term, still under development

Picture



SPECTRE

APM Functions

Deny, protect, disrupt, block. Future system for protection of land deployments

Characteristics

- Combination of detection sensors, C2 systems and weapons
- Several seconds to several minutes effective delay time
- Effective weapon range from several tens of meters to several hundreds of meters
- Effective sensing range from 100 m to 1000 m
- Deployed by hand

System/Concept Descriptor

Sense (Detect)	Comms (Alert)	Decision Support	Comms (data/cmds)	Discriminate	Weapons Effects
• Human • Radar (passive / active) • Seismic + magnetic + acoustic sensors • IR CCD (as part of smart sensors) • Tripwire (laser beam sensors)	• Cable links • Optic fibre	• Partly included in smart sensors • Display/ MITL • Database consultation • Sensor fusion (low level) • Network management system (coms, sensors)	• RF coms • Cable links • Optical fibres • Mechanical • Pyrotechnical • GMS type Data compression Algorithms • Possible integration in the future area remote control system (SUZON) • Compatible with battlefield digitisation	• Man assisted (Image from sensors)	• Selectable effects: Non lethal/ lethal in-field

APM Missions

<u>Primary:</u> Key Point Protection (Rear), Protect Obstacle (Close), Dismounted Infiltration (Close)
<u>Secondary:</u> Mass Infantry Assault (Close)

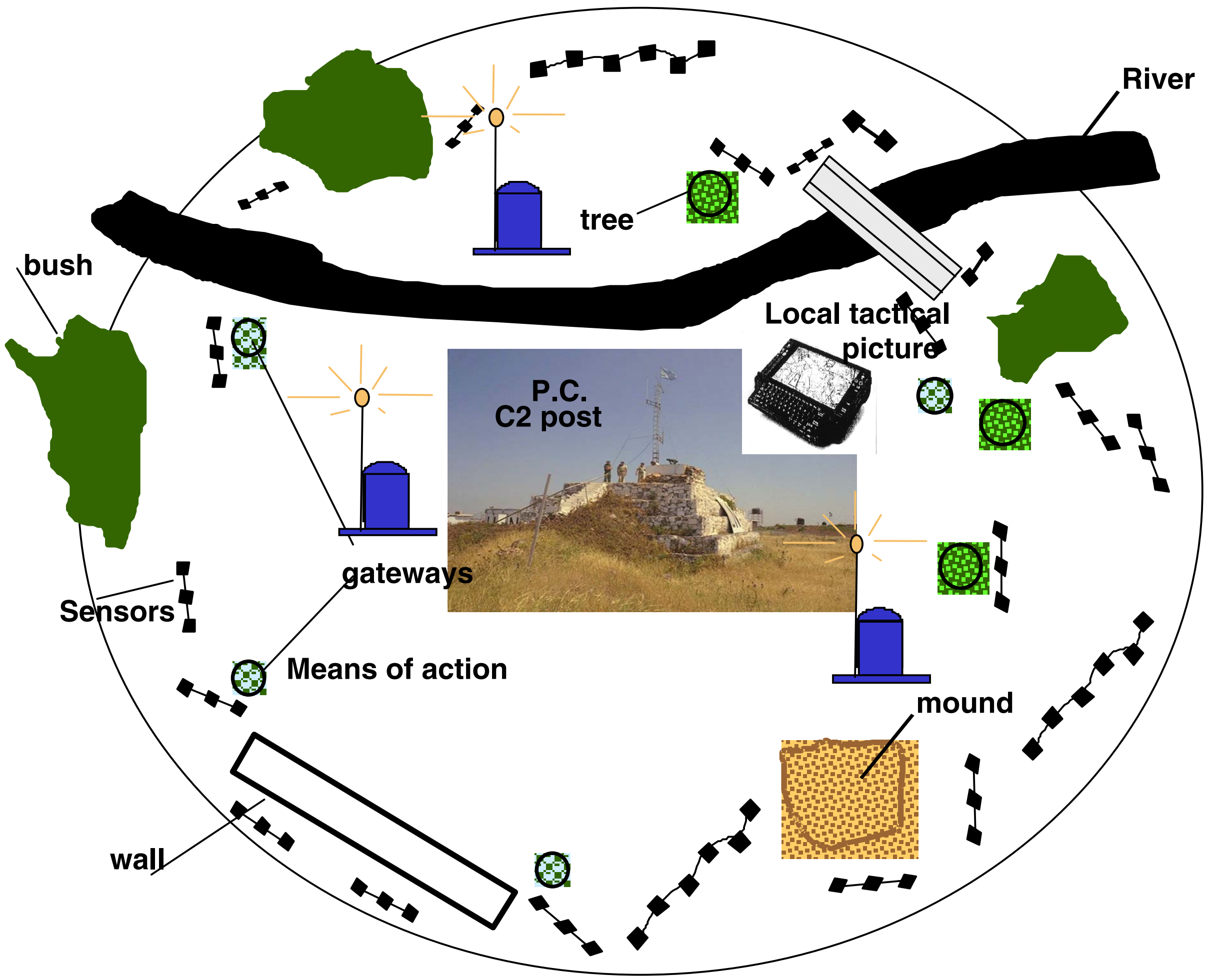
Availability/Project Status

Available in Mid Term, still under study

Picture

SPECTRE Perimeter Protection

Managing of several unitary devices using a intelligence network



SUZON, Track 1

APM Functions

Deny, fix, block, disrupt

Characteristics

- Mix of existing systems and devices to construct an architecture of systems with sensors, C2, and artillery
- Several tens of minutes to several hours effective delay time
- Effective weapon range of 30 to 60 km
- Effective sensing range, some Km
- Sensors can be deployed by hand or by air

System/Concept Descriptor

Sense (Detect)	Comms (Alert)	Decision Support	Comms (data/cmds)	Discriminate	Weapons Effects
• All target acquisition systems • Human • UAV's	• Cable link • Optic fibre • RF Comms	• Included partly in smart sensors • Low level fusion • Low autonomy (man controlled, MITL)	• RF Comms	• Man assisted (Image from sensors) • IFF	• Existing means of action available (artillery, helicopters, tanks, infantry)

APM Missions

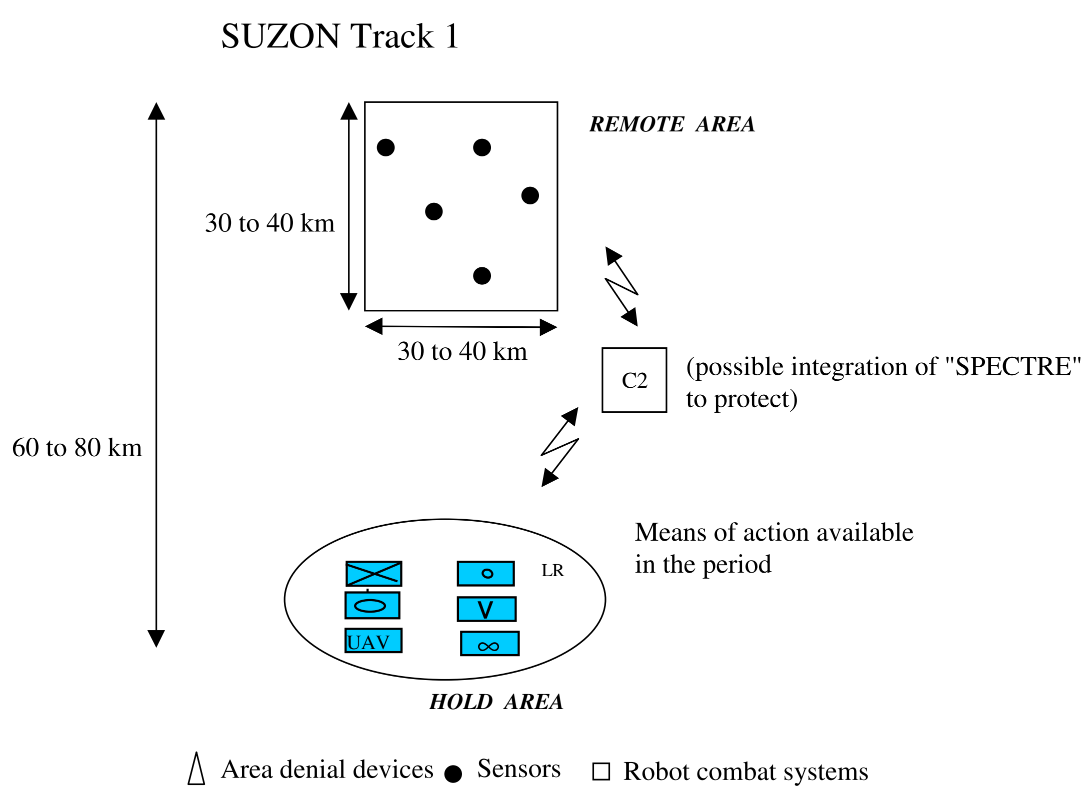
Primary: Mass Infantry Assault (Close), Protect Obstacle (Close), Protect Anti-Tank Minefields (Deep)

Secondary: Key Point Protection (Rear), Dismounted Infiltration (Close)

Availability/Project Status

Available in Mid Term, 2006-2008

Picture



SUZON, Track 2

APM Functions

Deny, disrupt, fix, block, protect

Characteristics

- Utilization of complementary devices: detection sensors, coms, weapons etc
- Self configuration and reconfiguration of area denial devices; sensors robot combat systems located in the remote area
- High man assistance to discriminate and high level of autonomous activation required
- Several tens of minutes to several hours effective delay time
- Effective weapon range up to 60 km
- Effective sensing range, several km required
- Sensores can be deployed by hand, by air or by artillery

System/Concept Descriptor

Sense (Detect)	Comms (Alert)	Decision Support	Comms (data/cmds)	Discriminate	Weapons Effects
• Unattended ground sensors (UGS) • UAV's, satellites • Human • Multi hyperspectral sensors • Chemical & Biological sensors	• LAN + CPM relay (UAV, SAT) • Optic fibre • RF coms	• Intelligent systems • Distributed system management • Virtual reality generator • Large autonomy (man as manager of extensions, veto)	• Broadband RF coms • Lasercoms + Relay (UAV/ SAT)	• Data fusion • Data base consultation • Network reconfiguration • IFF	• Future means of action • All lethal and non-lethal in-field and remote

APM Missions

Primary: Mass Infantry Assault (Close), Protect Obstacle (Close), Protect Anti-Tank Minefields (Deep)

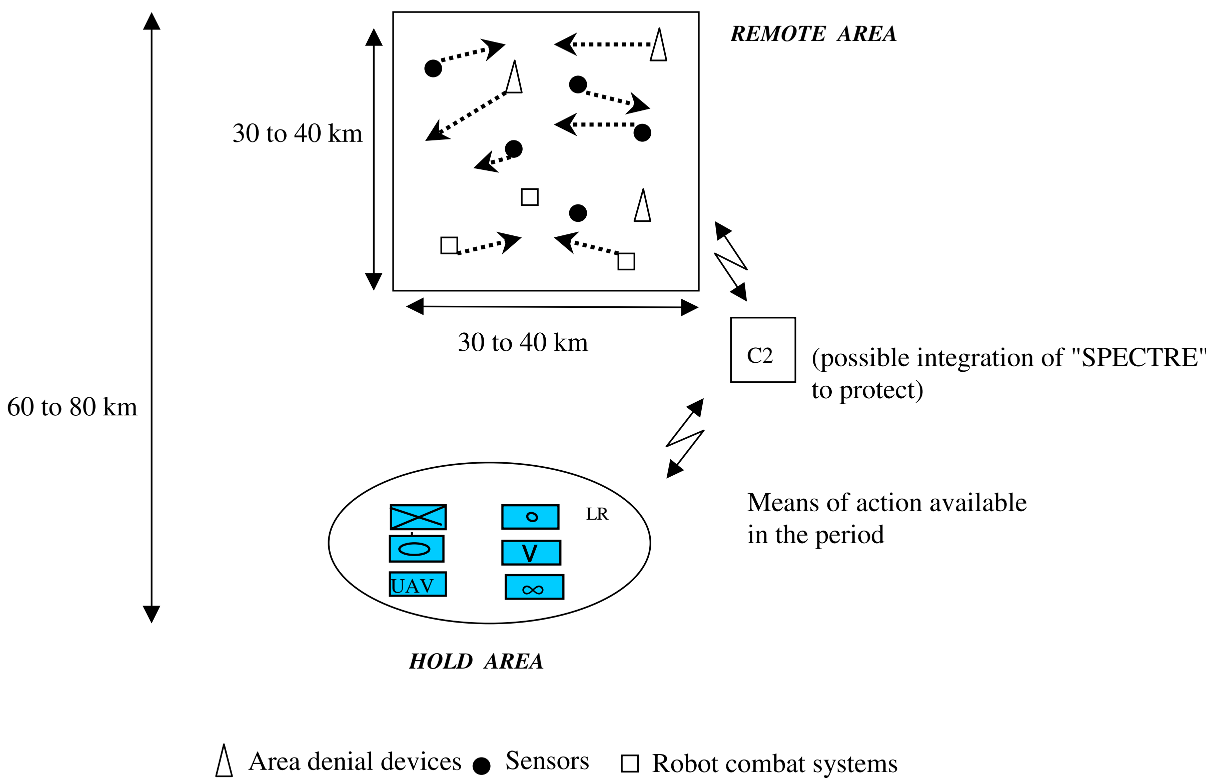
Secondary: Key Point Protection (Rear), Dismounted Infiltration (Close)

Availability/Project Status

Study now in progress
Long Term solution (2010/2015)

Picture

SUZON Track 2



Germany

NILPFERD

APM Functions

Fix

Characteristics

- Pop-up container for vertical dispersion of nets combined with shock pulse generator (Rotating dispenser) against single persons or groups of persons.
- Effective delay time: 30 min
- Effective range: up to 20 m, 360°
- Mechanical/ electrical weapon effect to fix person(s).
- Range of sensor: 20 m
- Deployed by hand

System/Concept Descriptor

Sense (Detect)	Comms (Alert)	Decision Support	Comms (data/cmds)	Discriminate	Weapons Effects
• IR • Seismic	• Pyrotechnically	• IR imaging	• Electromagnetic		• Non-lethal in-field

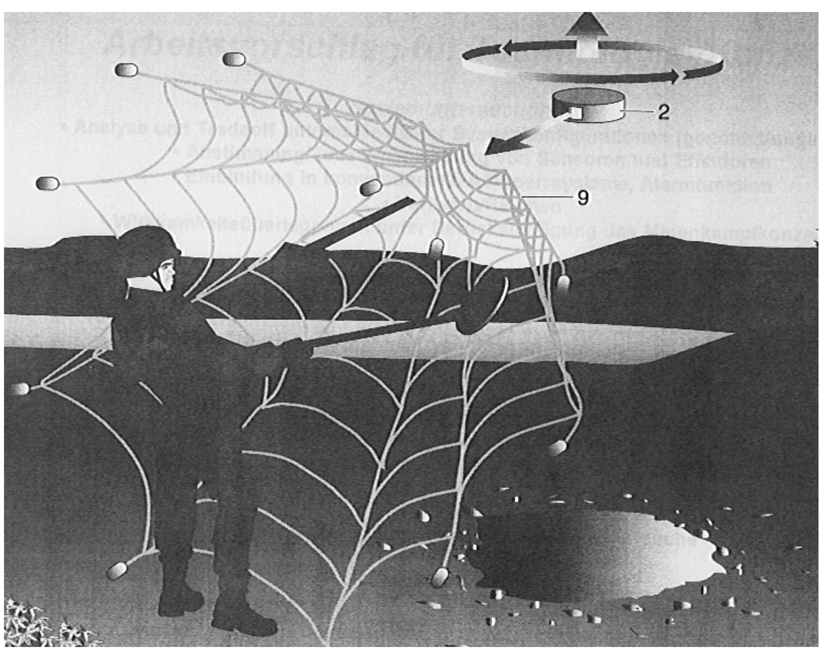
APM Missions

Primary: Dismounted Infiltration (Close)

Availability/Project Status

Assessed to be available in Mid Term if program decision is made.

Picture



NILPFERD (short range)

APM Functions

Fix

Characteristics

- Pop-up container for vertical dispersion of nets (Non-rotating dispenser) against single persons or groups of persons
- Effective delay time: Low
- Effective range: Up to 10 m, 360°
- Mechanical/electrical weapon effect to fix person(s)
- Range of sensor: 5 m
- Deployed by hand or automatic layer

System/Concept Descriptor

Sense (Detect)	Comms (Alert)	Decision Support	Comms (data/cmds)	Discriminate	Weapons Effects
• IR • Seismic	• Pyrotechnically		• Electromagnetic		• Non-lethal in-field

APM Missions

Primary: Dismounted infiltration (Close)

Availability/Project Status

Assessed to be available in Mid Term if program decision is made.

Picture

see NILPFERD (non-rotating dispenser)

CHAMÄLEON

APM Functions

Fix

Characteristics

- Hunting snare against single persons: Horizontal dispersion and retraction of rotating ropes out of a buried container
- Effective delay time: Medium
- Effective range: Some meters
- Mechanical weapon effect to fix person(s)
- Range of sensor: 5 m
- Deployed by hand or automatic layer

System/Concept Descriptor

Sense (Detect)	Comms (Alert)	Decision Support	Comms (data/cmds)	Discriminate	Weapons Effects
• Seismic	• Pyrotechnically		• Pyrotechnically		• Non-lethal in-field

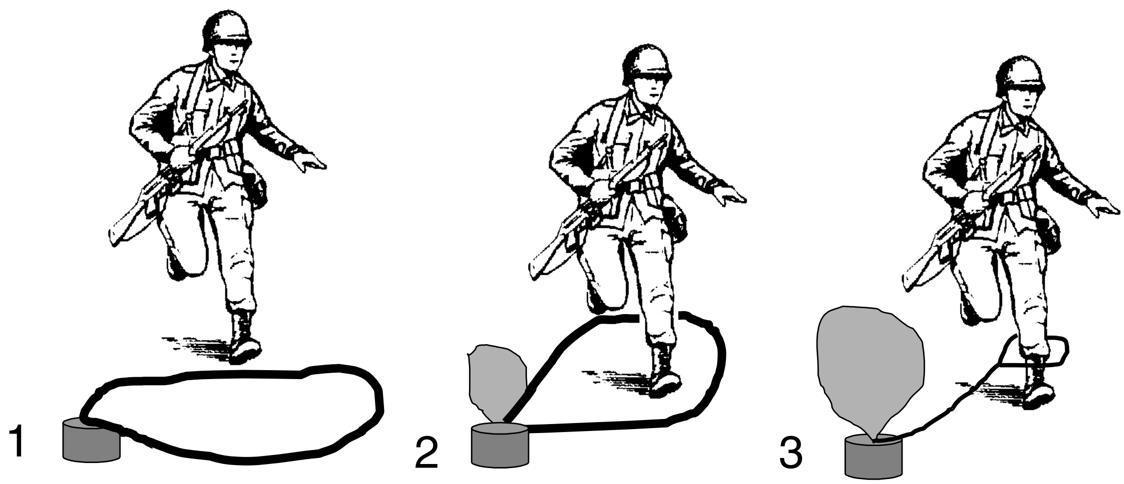
APM Missions

Primary: Key Point Protection (Rear), Mass Infantry Assault (Close), Protect Obstacle (Close), Dismounted Infiltration (Close), Protect Anti-Tank Minefields (Deep)

Availability/Project Status

Assessed to be available in mid term if program decision is made.

Picture



BOVIST

APM Functions

Block, turn

Characteristics

- Pop-up-container dispersing OC or strong smelling liquid against single persons or group of persons
- Effective delay time: 20 min
- Effective range: 10 m, 360°
- Chemical effect to disable persons by stunning
- Range of sensor: 5 m
- Deployed by hand or automatic layer

System/Concept Descriptor

Sense (Detect)	Comms (Alert)	Decision Support	Comms (data/cmds)	Discriminate	Weapons Effects
• IR • Seismic	• Pyrotechnically	• ?	• Electromagnetic	• ?	• Non-lethal in-field

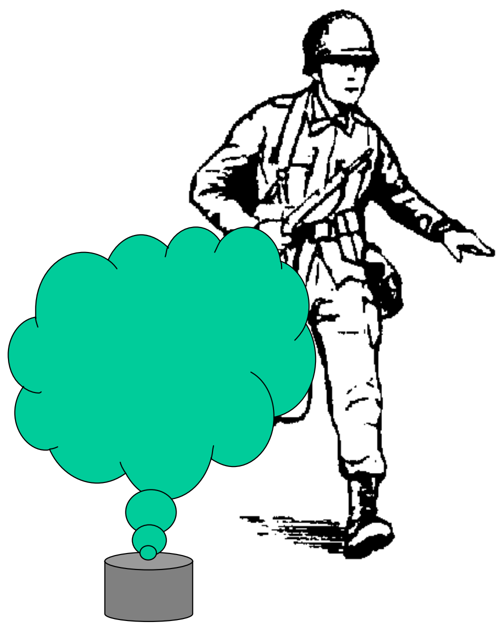
APM Missions

Primary: Key Point Protection (Rear), Mass Infantry Assault (Close), Protect Obstacle (Close), Dismounted Infiltration (Close), Protect Anti-Tank Minefields (Deep)

Availability/Project Status

Assessed to be available in Mid Term, but constraints by national law.

Picture



SESAM

APM Functions

Fix

Characteristics

- Step trap against single persons without any explosives, two possible states of effect.
- Effective delay time: Low, up to 30 min
- Effective range: Step wide
- Mechanical or combination of chemical/electrical effect to fix persons to ground
- Range of sensor: 0 m
- Deployed by hand or automatic layer

System/Concept Descriptor

Sense (Detect)	Comms (Alert)	Decision Support	Comms (data/cmds)	Discriminate	Weapons Effects
• Pressure			• Mechanical		• Non-lethal in-field

APM Missions

Primary: Key Point Protection (Rear), Mass Infantry Assault (Close), Protect Obstacle (Close), Dismounted Infiltration (Close), Protect Anti-Tank Minefields (Deep)

Availability/Project Status

Assessed to be available in Mid Term if program decision is made.

Picture

Not available at this time

Launcher tubes

APM Functions

Turn, disrupt, deny

Characteristics

- Lightweight launcher tubes of high cadence / salvoes with many alternative effects (rubber ammunition, OC, net, flash-bang, fog or combinations)
- Effective delay time: variable, up to 30 min
- Effective range: up to 300 m
- Mechanical or combination of chemical/electrical effect to fix persons to ground
- Range of sensor: >50 m
- Deployed by hand

System/Concept Descriptor

Sense (Detect)	Comms (Alert)	Decision Support	Comms (data/cmds)	Discriminate	Weapons Effects
• IR	• Pyrotechnically		• Pyrotechnically		• Non-lethal in field

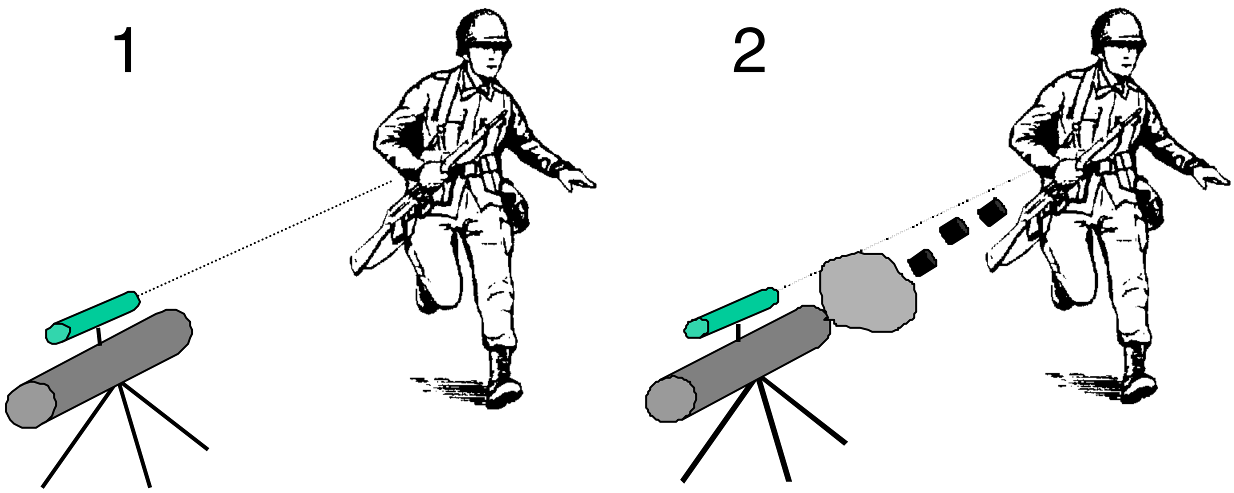
APM Missions

Primary: Dismounted Infiltration (Close)

Availability/Project Status

Assessed to be available in Mid Term if program decision is made.

Picture



Fog Launcher

APM Functions

Turn, disrupt, block

Characteristics:

- Directed launching of fog grenades in high cadence or salvoes
- Effective delay time: few min
- Effective range: up to 300 m
- Chemical or physical effect to fix or disorient persons
- Range of sensor: >50 m
- Deployed by hand or automatic layer

System/Concept Descriptor

Sense (Detect)	Comms (Alert)	Decision Support	Comms (data/cmds)	Discriminate	Weapons Effects
• Visual	• Pyrotechnically	• Human	• Electrical/wire		• Non-lethal in-field

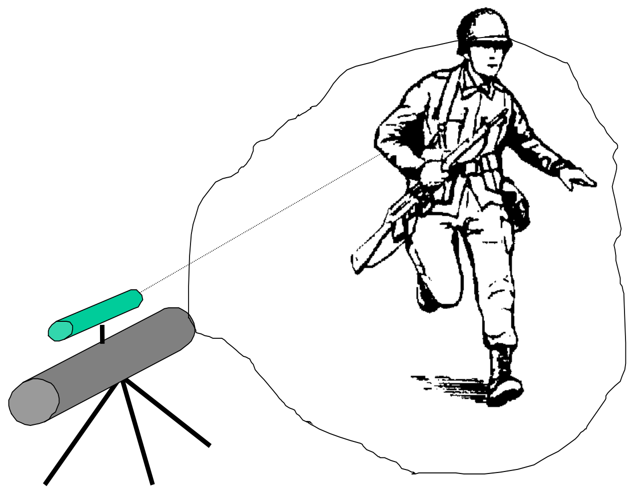
APM Missions

Primary: Key Point Protection (Rear), Mass Infantry Assault (Close), Dismounted Infiltration (Close)

Availability/Project Status

Assessed to be available in Mid Term if program decision is made.

Picture



Hungary

Area Defence Weapon System

APM Functions

Turn, disrupt, block

Characteristics:

- Area denial and close protection using a mix of signal mines, wire obstacles (concertina) and area defence weapons
- Directional Fragmentation Charge MON-50 - 0.7 kg explosives / 485 fragments, 1.5 g each, total 2.1 kg, max. effective range of 50 m, the shrapnel spreads in an arc of 60° to cover a frontage of 45 m
- Directional Fragmentation Charge MON-100 - 2.0 kg explosives / 400 fragments, total 5.0 kg, the shrapnel spreads to a diameter of 9,5 m at the max. effective range of 100 m
- Directional Fragmentation Charge MON-200 - 12.0 kg explosives /900 fragments, total 25.0 kg, the shrapnel spreads to a diameter of 14,5 m at the max. effective range of 200 m
- Man-in-the-Loop
- Fuze options: remote controlled electrical by EDPr detonator

System/Concept Descriptor

Sense (Detect)	Comms (Alert)	Decision Support	Comms (data/cmds)	Discriminate	Weapons Effects
• Visual (Human)	• Visual (light) • Noise (pyrotechnical blast)	• MITL (Human)	• Electrical	• MITL (Human)	• lethal in-field

APM Missions

<u>Primary:</u> Mass Infantry Assault (Close), Protect Obstacle (Close), Dismounted Infiltration (Close), Protect Anti-Tank Minefields (Deep)
<u>Secondary:</u> Key Point Protection (Rear)

Availability/Project Status

Developing two new types of Directional Fragmentation Charge for the change of old charges

Picture

N/A

Netherlands

ADWS – M19 with MITL

APM Functions

Fix, deny, protect

Characteristics

- Directional fragments against dismounted personnel (M19)
- Man-in-the-loop
- Fired by Non-Electric Shock Tube or remote (radio) control, up to 5 km
- M19: Charge 0.9 kg, 923 fragments á 0.42 gr. Total weight 1.9 kg

System/Concept Descriptor

Sense (Detect)	Comms (Alert)	Decision Support	Comms (data/cmds)	Discriminate	Weapons Effects
• Human (Visual)	• None	• None (MITL)	• Pyrotechnical • Electromagnetic	• Human	• Lethal in-field

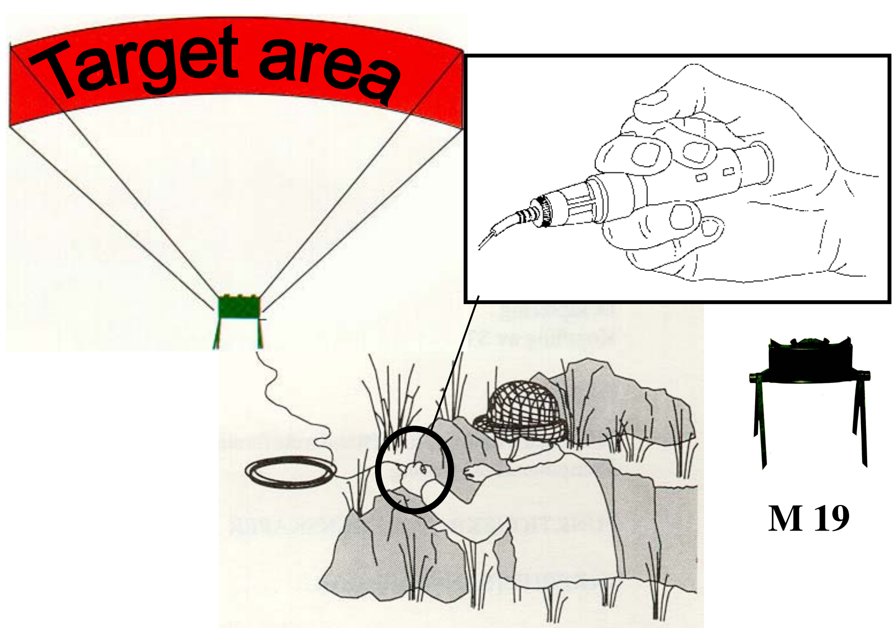
APM Missions

Primary: Mass infantry assault (Close), Protect Obstacle (Close), Dismounted Infiltration (Close)
Secondary: Key point protection (Rear)

Availability/Project Status

Already in service with Dutch Airmobile Brigade.

Picture



MODER Plus Type System

APM Functions

Deny, protect

Characteristics

- Several seconds to several minutes effective delay time
- Deployed by hand

System/Concept Descriptor

Sense (Detect)	Comms (Alert)	Decision Support	Comms (data/cmds)	Discriminate	Weapons Effects
• Human • Contact with tripwire • Night vision • Binoculars • Camera	• Light (Illuminating pyrotechnic device)	• MITL	• Remote control RF • Optical fibre • Several devices in network	• Human	• Lethal (Galix 4, fragmentation) • Non-lethal (Galix 19, sound)

APM Missions

Primary: Key Point Protection (Rear), Protect Obstacle (Close), Dismounted Infiltration (Close)
Secondary: Mass Infantry Assault (Close)

Availability/Project Status

Available in Near Term, still under development

Picture

See French MODER Plus system

Improved Anti-Handling Device for Anti-Vehicle Mines

APM Functions

Turn, disrupt, block, fix

Characteristics

- In-line with amended Protocol II
- The AT mine is self-neutralising, including the Anti-Handling Device
- Artillery and helicopter delivered AT minefields

System/Concept Descriptor

Sense (Detect)	Comms (Alert)	Decision Support	Comms (data/cmds)	Discriminate	Weapons Effects
• To be defined	• None	• None	• None	• None	• lethal

APM Missions

<u>Primary:</u> Protection of AT minefields (deep)

Availability/Project Status

Planned to be in service in mid term

Picture

N/A

Norway

ADWS – M19/M100/FFV-013R with MITL

APM Functions

Fix, deny, protect

Characteristics

- Directional fragments against dismounted personnel (M19) and soft skin vehicles (M100/FFV-013R)
- Man-in-the-loop
- Fired by Non-Electric Shock Tube or remote (radio) control, up to 5 km
- M19: Charge 0.9 kg, 923 fragments á 0.42 gr. Total weight 1.9 kg
- M100: Charge 5.4 kg, 842 fragments á 3.55 gr. Total weight 10 kg
- FFV-031R: Charge 10 kg, 1200 fragments á 5 gr. Total weight 20 kg

System/Concept Descriptor

Sense (Detect)	Comms (Alert)	Decision Support	Comms (data/cmds)	Discriminate	Weapons Effects
• Human (Visual)	• None	• None (MITL)	• Pyrotechnical • Electromagnetic	• Human	• Lethal in-field

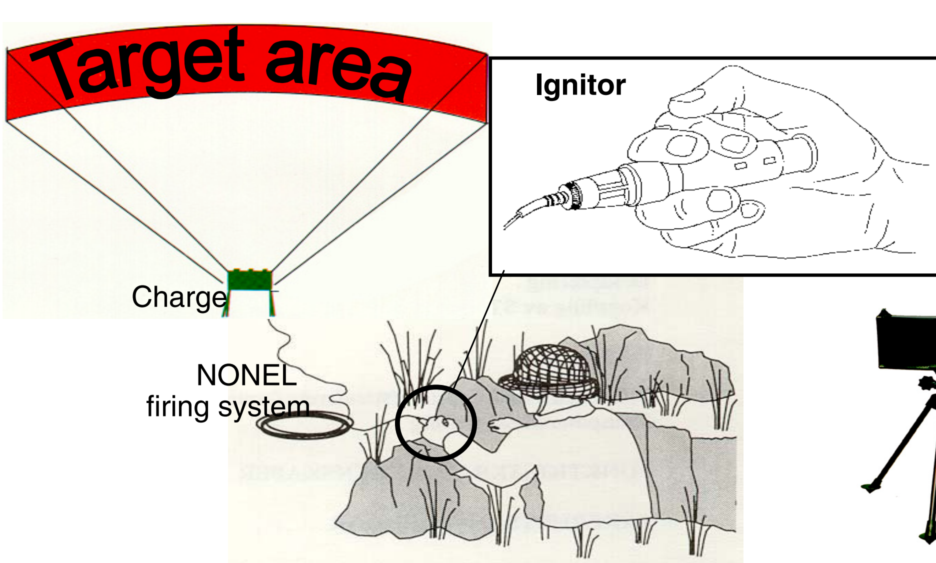
APM Missions

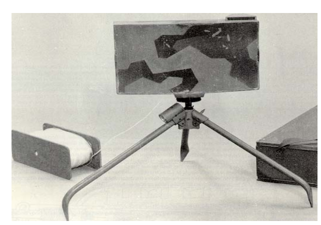
Primary: Mass infantry assault (Close), Protect Obstacle (Close), Dismounted Infiltration (Close)
Secondary: Key point protection (Rear)

Availability/Project Status

Available in Near Term (exists with Non-Electric Shock Tube; was redesigned from APM to ADWS in 1999)

Picture(s)





FFV-013R

M 100

M 19

OPAK+ (Stationary)

APM Functions

Fix, deny, protect, alert

Characteristics

- Camera based surveillance system combined with ADWS (e.g. Sector Charges)
- Designed primarily for protection of fixed installations
- Set of cameras monitoring object or its periphery
- Artificial illumination of object or its periphery
- Image processing for extraction and presentation of essential information to operator
- Alert and verification given when intruder is detected
- Classification of intruder into categories
- Accurate estimation of intruder's position
- Permits Warning time > Reaction time
- High detection probability and low false alarm rate
- Verification and triggering of weapon by operator (Man-in-the-loop)

System/Concept Descriptor

Sense (Detect)	Comms (Alert)	Decision Support	Comms (data/cmds)	Discriminate	Weapons Effects
• Acoustic • Electro-optical (Visual, IR)	• Visual • Audio	• Image processing • Classification	• Electromagnetic (Cable)	• Automatic • Human	• Lethal in-field

APM Missions

<u>Primary:</u> Key Point Protection (Rear), Dismounted Infiltration (Close)

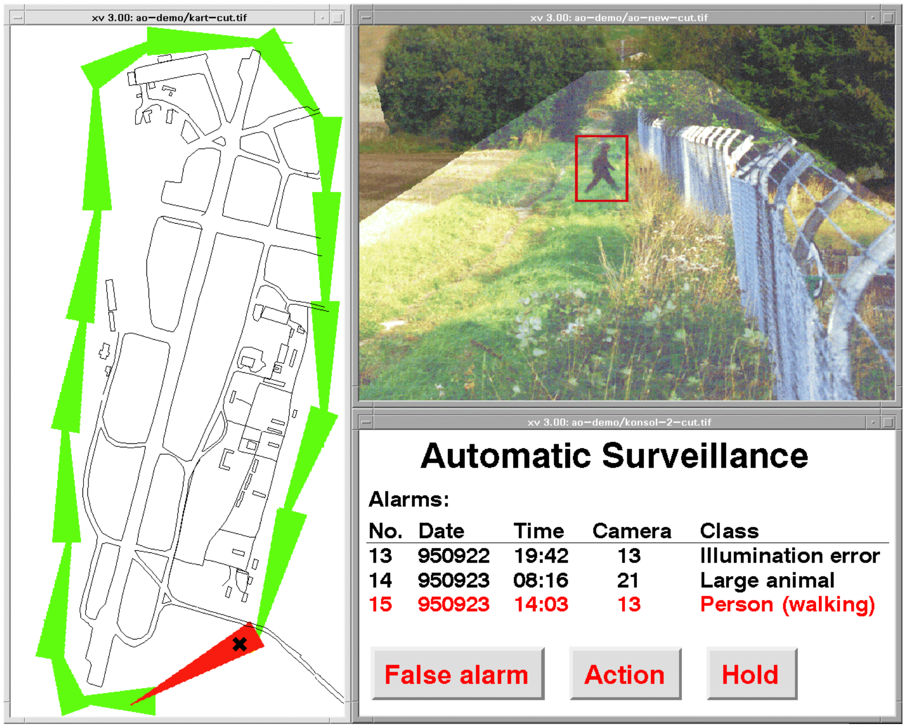
<u>Secondary:</u> Protect Obstacle (Close), Protect Anti-Tank Mines (Deep)

Availability/Project Status

Available in Near to Mid Term (Depending on program decision; the surveillance system is implemented at Gardermoen air force base)

Further development is towards a smaller, deployable system for semi-stationary and mobile objects/installations.

Picture



OPAK+ (Portable)

APM Functions

Fix, deny, protect, alert

Characteristics

- Camera based surveillance system combined with ADWS (e.g. Sector Charges)
- Designed primarily for protection of mobile and semi-mobile objects (command posts, radars, communication links, defence positions, etc)
- Adverse weather and night capability
- The whole system can be carried by one squad
- Set of battery driven thermal cameras monitoring object or its periphery
- No artificial illumination of object or its periphery
- Terrain modelling by ladar
- Wireless communication and data transfer
- Camera near image processing for extraction and presentation of essential information to operator
- Alert and verification given when intruder is detected
- Classification of intruder into categories
- Accurate estimation of intruder's position
- Permits Warning time > Reaction time
- High detection probability and low false alarm rate
- Verification and triggering of weapon (remotely) by operator (Man-in-the-loop)
- System power consumption (5 camera system): 65W*
- System weight (not including the charges): 65 kg + 18kg/24 hours operation (batteries)*

  * Moderate improvement in battery and sensor technology is anticipated

System/Concept Descriptor

Sense (Detect)	Comms (Alert)	Decision Support	Comms (data/cmds)	Discriminate	Weapons Effects
• Acoustic • Electro-optical (IR)	• Visual • Audio	• Image processing • Classification	• Electro-magnetic (Wireless)	• Automatic • Human	• Lethal in-field

APM Missions

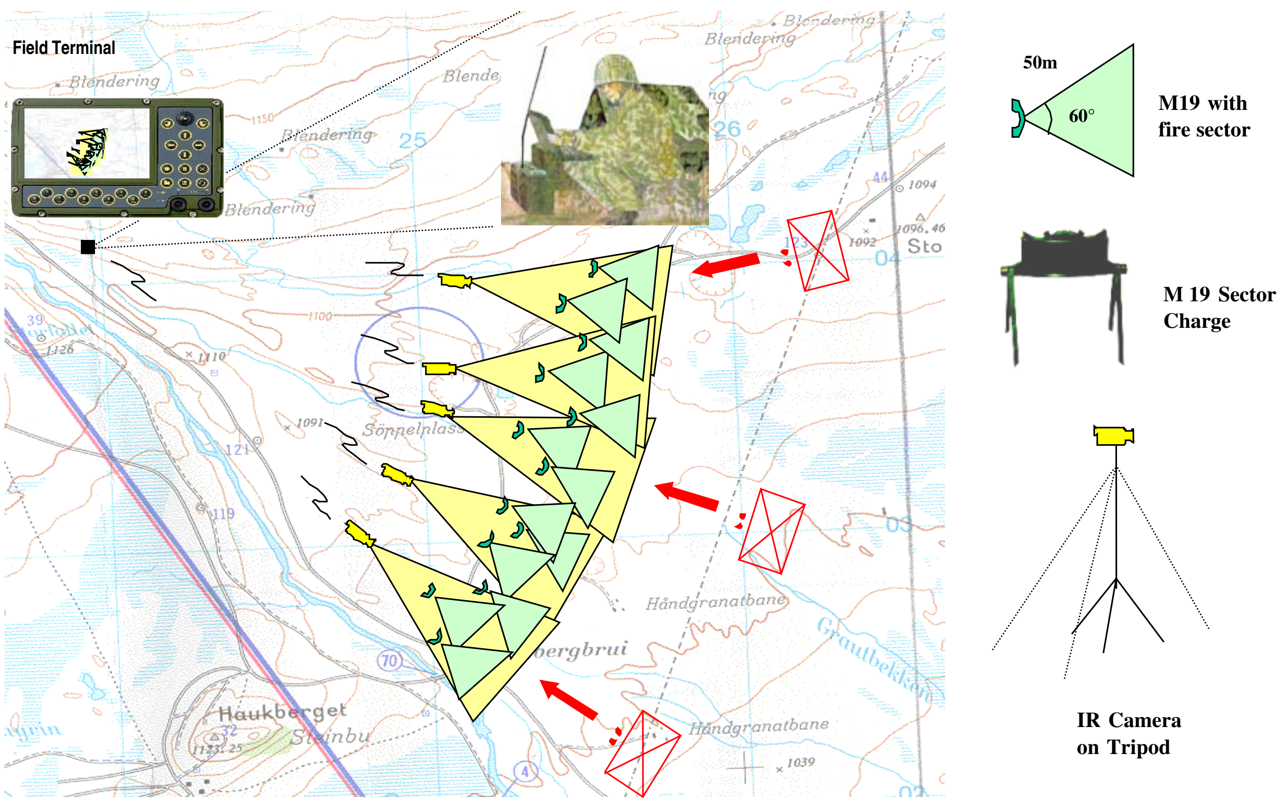
Primary: Key Point Protection (Rear), Protect Obstacle (Close), Dismounted Infiltration (Close)

Secondary: Mass Infantry Assault (Close), Protect Anti-Tank Mines (Deep)

Availability/Project Status

Available in Mid to Long Term (Depending on program decision)

Picture



United Kingdom

ADDER

APM Functions

ADDER is designed to provide the warning and alerting capability lost with APL. It will be particularly useful for covering dead ground (e.g. woods, gullies, cuttings) where other surveillance assests have poor performance.

Characteristics

- Low-cost, scatterable sensors linked to a control unit, and from there to a local or remote response (may be non-lethal or lethal)
- Potential for non-lethal response (e.g. TASER)
- Mix of simple personnel detectors with area detection capability and CMOS imaging sensors to give positive alerts.
- Pattern recognition techniques employed to pick out advancing personnel – does not rely on a single alert.

System/Concept Descriptor

Sense (Detect)	Comms (Alert)	Decision Support	Comms (data/cmds)	Discriminate	Weapons Effects
• Contact sensors (prototype) • NLOS sensor (under research)	• Basic information on non-physical support (radio)	• MITL	• Not defined	• MITL	• Postulated lethal remote

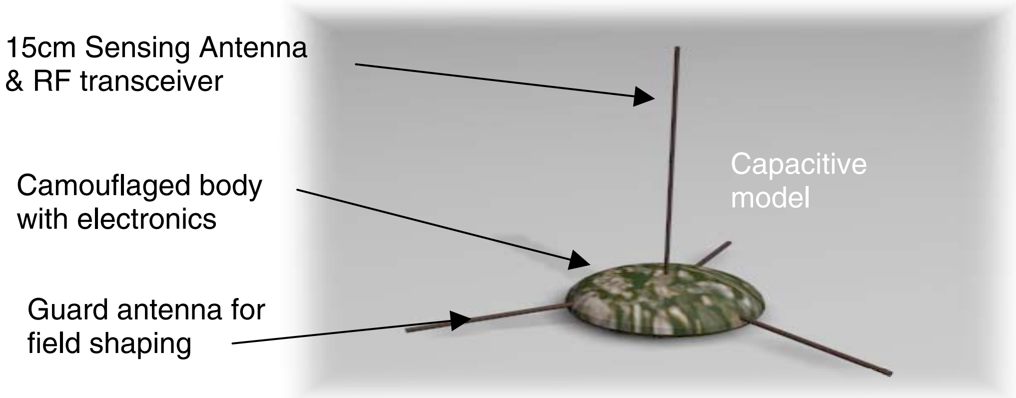
APM Missions

Primary: Key Point Protection (Rear), Protect Obstacles (Close), Protect Anti-Tank Mines (Deep), Dismounted Infiltration (Close)

Availability/Project Status

Ongoing research into low power area sensing

Picture



Spiked Net

APM Functions

Potential to provide delay component of APM capability in protective role

Characteristics

- Combination of nets and caltrops.
- Net with spikes at the knot.
- Net discourages fast movement.
- Spikes discourage prone position.
- Causes delay
- Requires observation and covering fire to affect battle outcome

System/Concept Descriptor

Sense (Detect)	Comms (Alert)	Decision Support	Comms (data/cmds)	Discriminate	Weapons Effects
• Contact (trip or pressure)	• NONE	• NONE	• NONE	• NONE	• Non lethal

APM Missions

<u>Primary:</u> Mass Infantry Assault (Close)

Availability/Project Status

Concept, available in near term if required

Picture(s)

N/A

Area Sensors

APM Functions

Detection and warning in more open terrain. Current ground surveillance radar systems overspecified for task. Thermal imaging alerting device based on air defence technology

Characteristics

- Cheap, simple to operate and short ranged (few km) ground surveillance radar.
- Thermal imager with autonomous target detection and tracking.
- Both LOS limited.

System/Concept Descriptor

Sense (Detect)	Comms (Alert)	Decision Support	Comms (data/cmds)	Discriminate	Weapons Effects
• LOS, Long range, RADAR	• Smart information on wire link	• Human operator	• NONE	• NONE	• NONE

APM Missions

Primary: Key Point Protection (Rear), Protect Obstacles (Close), Protect Anti-Tank Mines (Deep), Dismounted Infiltration (Close)

Availability/Project Status

Concept status

Picture

N/A

Semi-Autonomous Weapon

APM Functions

Area Denial with high degree of psychological impact. Conceptually similar to a multi-shot anti-personnel Area Defence Weapon (ADW).

Characteristics

- Machine gun or grenade launcher with autonomous pointing.
- Thermal sensor for detection and aiming, possible other sensors for warning.
- Restrained by human operator with dead man switch.
- Regular coded input to prevent automatic shutdown.

System/Concept Descriptor

Sense (Detect)	Comms (Alert)	Decision Support	Comms (data/cmds)	Discriminate	Weapons Effects
• Line of sight Thermal imager	• Smart information on undefined link (thermal picture, motion detection)	• MITL, (operating dead man switch, if tripped weapon may become autonomous for a limited period)	• On mpount, target tracking, information sent to operator)	• Command sent on information link	• Lethal remote (support weapon, MG or AGL)

APM Missions

Primary: Key Point Protection (Rear), Mass Infantry Assault (Close), Protect Obstacles (Close), Protect Anti-Tank Mines (Deep)

Availability/Project Status

Concept, yet to be tested in detailed modelling.

Picture

N/A

United States

Non-Self Destruct Alternative (NSD-A) – Track 1 program

APM Functions

Deny Terrain, Complicate Obstacle/Delay Breach, Force Protection

Characteristics

- Man-in-the-loop unless non lethal
- Integral intrusion detector
- Hand emplaced
- Command Destruct/Neutralize
- Reset Self-Destruct/Neutralize
- Re-deployable (prior to firing/SD commands)
- Command Fire
- Location reporting (GPS on controllers)
- Prevents fratricide
- Alternative to M14/M16

System/Concept Descriptor

Sense (Detect)	Comms (Alert)	Decision Support	Comms (data/cmds)	Discriminate	Weapons Effects
• Tripwire	• RF data message	• Display • MITL	• MITL selection • RF data message	• Overwatch • Other sensors & Intell sources	• Lethal infield

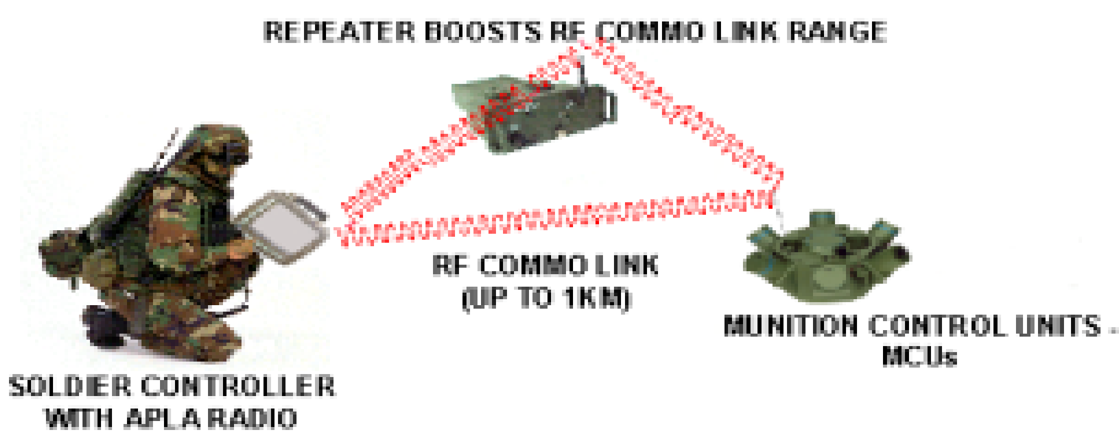
APM Missions

Primary: Key Point Protection (Rear), Mass Infantry Assault (Close), Protect Obstacle (Close), Dismounted Infiltration (Close)
Secondary: Protect Anti-Tank Mines (Deep)

Availability/Project Status

TBD

Picture



Remote Area Denial Artillery Munition (RADAM) – Track 1 program

APM Functions

Deny Terrain, Complicate Obstacle, Force Protection

Characteristics

- **Not Ottawa compliant**
- 155mm Artillery Projectile
- Mixed AT/AP Payload From ADAM & RAAM Projectiles
- Contain 7 AT and 5 AP Mines
- Short & Long Self-destruct Times (4h and 48h)

System/Concept Descriptor

Sense (Detect)	Comms (Alert)	Decision Support	Comms (data/cmds)	Discriminate	Weapons Effects
• Tripwire APM • Magnetic ATM	• Audio/ Explosion				• Lethal Infield

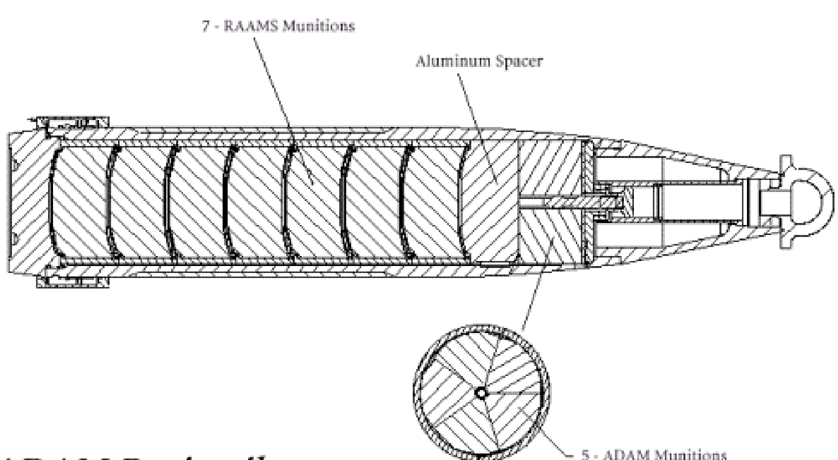
APM Missions

Primary: Mass Infantry Assault (Close), Protect Obstacle (Close), Protect Anti-Tank Mines (Deep)

Availability/Project Status

TBD

Picture



RADAM Projectile

Tags/MGM – Track 2 program

APM Functions

Force protection through detection, warning and engagement of enemy dismounted assets in all terrain.

Characteristics

System concept consists of a radio frequency tag picked up by enemy dismounts as they traverse the battlefield. The tag provides for detection, warning and location of enemy dismounts via a distributed relay network. Minimally guided munitions provide an inexpensive, organic weapon that utilizes the information provided by the tag and post-apogee course correction to rapidly engage dismounts minimizing sensor-shooter latency.

System/Concept Descriptor

Sense (Detect)	Comms (Alert)	Decision Support	Comms (data/cmds)	Discriminate	Weapons Effects
• None • Motion of Tag device	• RF data message from Tag device	• Display • MITL	• MITL selection • RF data message	• Overwatch • Other sensors & Intell sources	• Lethal Remote

APM Missions

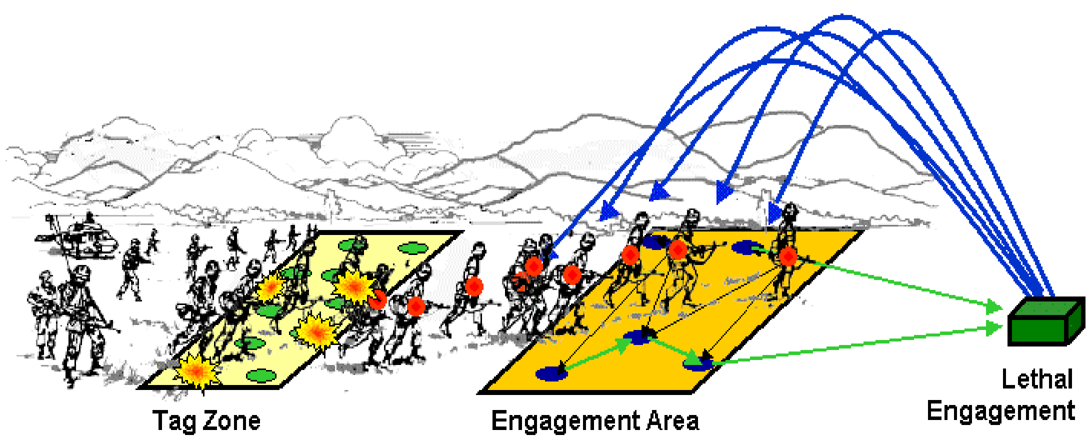
Primary: Key Point Protection (Rear), Mass Infantry Assault (Close), Protect Obstacle (Close), Dismounted Infiltration (Close)

Secondary: Protect Anti-Tank Mines (Deep)

Availability/Project Status

The TAGS/MGM concept is currently undergoing a technical feasibility study to establish technical and concept of operation risks. Decision to proceed to a research and development phase is dependent on the results of the current feasibility study. The concept could possible be used as a long term solution to fill the APM gap.

Picture



Self-Healing (Anti-Tank) Minefield – Track 2 program

APM Functions

The current Mixed Systems use anti-personnel landmines to complicate dismounted breaching and clearance of Anti-Tank Minefields. The Self-Healing Minefield, which consists of only mobile, intelligent, Anti-Tank Mines, acts like a fluid to achieve the same effect.

Characteristics

- *Dynamic* Anti-Tank Minefield that preserves the obstacle
- Scatterable ATM similar to Volcano or Gator in size and delivery method.
- Minefield detects a breaching attempt through mine-to-mine communication, interaction or collective sensing
- Individual mines respond to the breaching attempt by reorganizing (moving) to fill in the open lane
  ⇒ Thus the barrier is re-established
- Minefield is an autonomous distributed network with decentralized control
  ⇒ No man-in-the-loop
  ⇒ Minefield behaviours dependent on enemy attack

System/Concept Descriptor

Sense (Detect)	Comms (Alert)	Decision Support	Comms (data/cmds)	Discriminate	Weapons Effects
• Magnetic and acoustic sensing of vehicles • Breach sensed through network changes	• Loss of RF links between mines	• None – autonomous minefield operation	• Reach-back if desired	• ATM using vehicle signature	• Lethal – vehicle in field

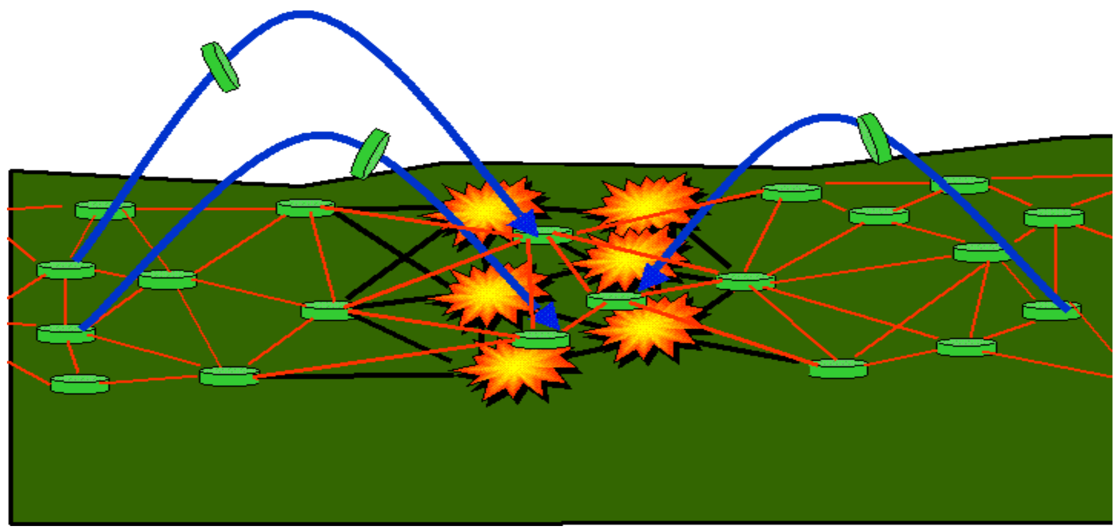
APM Missions

Primary: Protect Anti-Tank Mines (Deep)

Availability/Project Status

The (long term) Self-Healing Minefield program is completing the first year of a three-year effort to demonstrate the enabling technologies required for an autonomous network of prototype AT Mines. Focus is on mine mobility, mine-to-mine communication and networking, and algorithms for autonomous responses to breaching.

Picture



Mixed Alternatives or APL-A, Track 3 (a.k.a. RATTLER)

APM Functions

Deny Terrain, Complicate Obstacle, Force Protection

Characteristics

The objective of the APLA Track 3 program is to provide a replacement for existing US mixed (remotely delivered AP and At munitions with self-destruct capability) systems. At this time the Track 3 program consists of five parallel concept development and evaluation efforts along with several supporting technology efforts. All five concepts deal solely with alternatives to mixed systems, no alternatives to "pure" APL have been defined under the Track 3 effort. The concepts range from remote sensor systems with autonomous anti-materiel weapons to collocated AP and AT systems linked to manned overwatch systems. Track 3 is being referred to as the RApid Tactical Terrain LimitER (RATTLER).

System/Concept Descriptor

Sense (Detect)	Comms (Alert)	Decision Support	Comms (data/cmds)	Discriminate	Weapons Effects
• Systems include a wide array of sensors	• EPLRS • SUO/SAS • SINCGARS	• Display • MITL	• MITL command for lethal AP • Autonomous decisions based on ROE	• Overwatch • Cued Imaging • Visible & UCIR imagers • Omni directional UCIR	• Lethal infield • NL in and prior to field

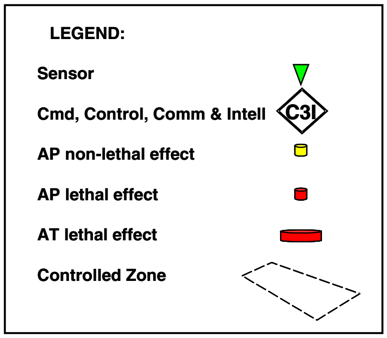
APM Missions

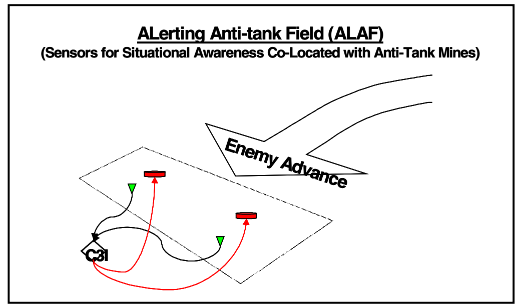
<u>Primary:</u> Protect Anti-Tank Mines (Deep), Protect Obstacle (Close), Dismounted Infiltration (Close)
<u>Secondary:</u> Mass Infantry Assault (Close), Key Point Protection (Rear),

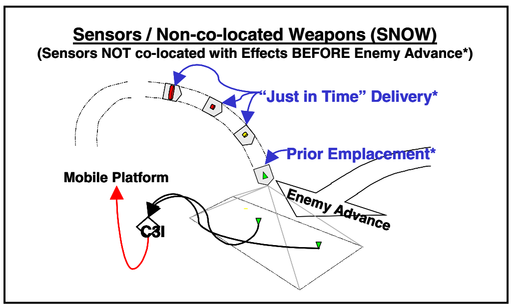
Availability/Project Status

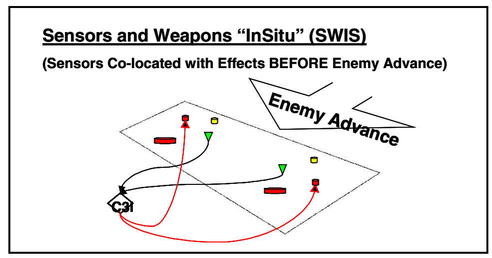
Concept Exploration Phase (CEP), 2QFY08 IOC

Picture(s)


LEGEND:
Sensor
Cmd, Control, Comm & Intell
C3I
AP non-lethal effect
AP lethal effect
AT lethal effect
Controlled Zone


ALerting Anti-tank Field (ALAF)
(Sensors for Situational Awareness Co-Located with Anti-Tank Mines)
Enemy Advance
C3I


Sensors / Non-co-located Weapons (SNOW)
(Sensors NOT co-located with Effects BEFORE Enemy Advance*)
"Just in Time" Delivery*
Prior Emplacement*
Mobile Platform
Enemy Advance
C3I


Sensors and Weapons "InSitu" (SWIS)
(Sensors Co-located with Effects BEFORE Enemy Advance)
Enemy Advance
C3I

Annex I

Compilation of Non-Materiel System/Concept Descriptor

The SAS-023 working group participated in a landmine non-materiel alternative workshop held from 8-10 November 2000 at Carlisle Barracks, Pennsylvania. Participants met to postulate, define, and examine non-materiel alternatives to landmine systems over a spectrum of threats in tactical and operational environments. To compliment previous U.S. work on non-materiel alternatives to landmines, attendees to the Carlisle Barracks' conference were to postulate non-materiel concepts capable of being implemented in the mid-term (2006-2012) or long-term (2012 and beyond) timeframes. The conference used as a backdrop two operational scenarios where the employment of landmine devices could play critical roles (such as the forced entry of light airborne infantry or an amphibious landing).

The Carlisle conference participation was extensive, representing a mix of academic, military schools, military (U.S. and other NATO coalition partners) organizations, retired senior military leaders, and research and development laboratories and organizations. Conference participation included representatives from Theater Commander in Chief (CINC) staffs, U.S. Army Training and Doctrine Command's (TRADOC) Schools and Centers, the U.S. Marine Corps Combat Developmental Command (MCCDC), U.S. Army Developmental Commands and members of Service and Joint Staffs. NATO participation included thirteen (13) representatives from six member nations (United Kingdom (4), Germany (1), France (2), Canada (2), Netherlands (2), and Norway (2)). Additionally, seven retired Army and Marine Corps General Officers (Graybeards) assisted in facilitating the conference discussions due to their operational experience in the employment and uses of APLs. The resulting non-materiel concepts outlined during the conference were provided to Lawrence Livermore National Laboratory for inclusion in their ongoing modeling and analysis assessments.

The timeframe of 2010 was employed to postulate APM non-materiel alternatives against expected new concepts of military operations and potential new equipment fielding timelines. An additional conference goal was to gain information and data to be used for modeling and simulation of alternative concepts. Two scenarios were presented to the group to provide a diverse setting for discussions on the use of anti-personnel landmines and potential non-materiel alternatives. The first scenario involved a forcible entry operation in the Persian Gulf with follow-on operations in Kuwait; the second scenario involved NATO-Coalition military in a peacekeeping operation in Kosovo with a rapidly deteriorating security situation. Attendees were divided into two work groups.

Prior to initiating discussions on alternatives, the Carlisle conference discussed the following landmine employment issues in order to focus their development of non-materiel alternatives:

- **Purpose**: The military purpose of employing landmines in varying levels of military operations or varying degrees of stringency on rules of engagement was one of the issues viewed as important in determining landmine use in future military operations. Examples of military purpose would be: route protection; making an airstrip inoperable; defensive combat operations; peacekeeping; security; etc.,
- **Time**: Discussing the time period over which the landmine alternative affect is required provided a means by which to examine measures of effectiveness and required characteristics of alternative concepts. Time periods associated with the mission purpose were discussed. Mission profiles such as: a forced entry operation could employ a temporary foam barrier on an enemy runway to deny enemy use but yield subsequent easy access to the secured runway. Similarly, Military Operations in Urban Terrain (MOUT) might employ construction barriers to temporarily restrict local traffic routes and avoid permanent infrastructure destruction. However, long-term barriers such as the Korean peninsula may require a more technically complex solution.
- **Environment**: Discussions on the military operational environments were conducted. Amphibious landings, air assaults, MOUT, desert operations, trafficability issues, mountainous, constricting, open terrain types, desert, dry, cold, wet climate types were also briefly discussed. Possible employment of any alternative was subject to most, if not all, operational and environmental conditions discussed.
- **Type of Organization**: The type of military organization involved in the operation could limit the type of solution that could be proposed. The exploration of alternatives should address the type of units that would be anticipated to have this capability (Brigade level, Battalion, or specific types (i.e., MP's)),
- **Level of Training**: The associated level of training required to the unit type provided a capability should also be examined further. Was the alternative designed to be employed by the individual soldier/Marine, or a specified Military Occupational Specialty (MOS) such as MP's, engineers, or technicians.

The two groups' discussions were set around two scenarios with various excursions and vignettes. The first scenario was a Southwest Asia terrain and situation, dealing with opening Sea Lines of Communication (SLOC) through a amphibious landing, followed by the forced entry of both airborne and amphibious based forces developing into a show of force operation. The second scenario was focused in the Balkans with initial police enforcement operations escalating due to political and military actions by the surrounding countries and populations. Both scenarios were fabricated specifically for the conference, thereby allowing total freedom to adjust or modify events without subjecting the results to unnecessary scrutiny and criticism due to the "invalidating of approved" threat forecasts or CINC warplans.

Key observations from the non-materiel conference were as follows:

- NATO Forces did not use anti-personnel landmines indiscriminately. Their employment required approval from senior commanders.
- Hand emplacement of anti-personnel landmines are labor intensive and in fact can be an obstacle to friendly force maneuver. Therefore, they are generally used when friendly forces are at a distinct disadvantage and self-defense is critical.
- An advantage of "dumb" APL is that, without a Man-in-the-Loop, the latency (sensor-to-shooter time) is minimal. Without APL, latency increases and most alternatives provide an opportunity to the enemy to counter or interrupt the engagement response.
- Landmines are employed to provide a temporary advantage to help combat the enemy's strengths. These tactical uses are:
    - To provide alert and warning to friendly forces
    - To deter, delay, and deny enemy progress or maneuver
    - To combat increasing enemy forces
- The loss of anti-personnel landmines impacts small unit infantry forces the most significantly.
- There are many seemingly simple or obvious non-materiel alternatives to the use of anti-personnel landmines; however, upon detailed examination none provide the same degree of timely alert, response and protection or are without serious operational drawbacks and implications.
- Each proposed non-materiel alternative is more complicated (technically and operationally) and involves increased time delays from the alert/detection until effective combat power can be brought to bear on the enemy. These time delays could mean the difference between success and failure and the cause of increased NATO casualties. Doctrine, training and organizational changes must be made to reduce these increased latencies between sense and engagement response.
- Although not solely a non-materiel solution, the best method of providing effective responsiveness in the absence of APMs is to greatly increase the surveillance, firepower, lethality, range, and accuracy of small infantry units.
- The completion of efforts/programs to develop a robust common operating picture (total battlespace awareness) will contribute greatly to the success of non-materiel alternatives.
- Training combined arms at the lowest possible level (company team) is a necessity.
- Continued emphasis of joint training to synchronize maneuver concepts, fires and support is necessary.
- An increase in the lethality (volume, range and precision) of small units in the direct firefight is essential to success of small unit operations without landmines.

- Future forces must be capable of reducing their logistic and C2 footprints.
- Training must increase to compensate for the added complexities associated with digitization and the numerous degraded modes that potentially could occur.
- The need exists to decrease the latency in sensor-to-trigger decision cycles and to ensure C4 assets are fully linked to sensors Intelligence, Surveillance and Reconnaissance.

Additionally, the list of non-materiel ideas developed during the conference was distributed across the categories of Doctrine, Organization, Training, Leadership and Personnel.

Doctrine: The doctrinal issues proposed focused on deficiencies in current doctrine rather than developing new doctrine. There is a requirement to refine doctrine associated with force protection for both non-article 5 CRO and war operations and doctrine associated with Joint/coalition fires. Doctrine-based non-materiel concepts were:

- Update base camp security doctrine, to include layered defense for peace keeping operations
- Greater reliance on Intelligence Preparation of the Battlespace (IPB)
- Increase emphasis on deception and recon "pull"
- More efficient command and staff planning process; streamline decision making
- More fully integrate the use of UAV's into doctrine
- Decrease the latency in sensor-to-trigger decision cycles by C4 fully linked to sensors (ISR)
- Synchronize intelligence, surveillance, and reconnaissance (ISR) assets and dissemination of intelligence to commanders
- Reduce the "footprint of the force" and move more often, conduct dispersed operations
- Update base camp security doctrine, layer defense
- Review Joint CAS tactics, techniques and procedures
- Review Joint fires TTPs (e.g., coordinate fires from one service's zone into another service's zone).
- Review employment of Naval Fire Support (NFS), location, and use of NFS (e.g., closer to shore, increased range).

Organization: The organizational issues dealt with the location and structure of where systems are held and tasked from (i.e., Brigade, Theater). They addressed issues associated with early warning, sensor systems, and dedicated artillery. Organizational changes and areas to examine further included:

- How to organize ISR personnel
- Avoiding "stovepipes" across mediums (land, sea,air, space)
- Allocation of sensors and early warning systems to tactical units
- Smaller command posts
- Indirect fires use of dedicated battery concept for better response

- Engineer assets task, purpose and allocation
- Provide non-lethel chemicals to small units
- Re-examine small unit organization (infantry, cavalery, armor, special forces) to compensate for no anti-personnel landmines

Training: Training issues revolved around a significant increase in force protection training, in areas of patrolling, and the emplacement of obstacles for security; significant training emphasis on the use of digital systems, reading and understanding sensors, decision making and the rapid dissemination of information to all levels. There was also a universal feeling that more joint training especially in the application of joint fires was imperative. Certainly given the operational tempo of NATO forces and the tight funding for training and readiness, more funds and more training time would be beneficial. Specific training issues are integration and synchronization, force security, and information operations. Additionally, examining initiatives to provide the following:

- Training must account for the complexity of digitization in order to speed down flow of information
- Increase the focus on patrolling (for security and HUMINT) and deception
- Cross service and joint training (e.g. Army and Air Force CAS TTP) Syncronize the concept for maneuver, fires and support
- Increase training for intelligence analysts, engineers, sensor monitors and R&S teams
- Emphasize the use of fires to protect AT minefields
- Use of command detonated claymores, physical barriers (especially barbed wire, tangel foot etc.) and non lethal chemicals
- Increase the training of information operations at all levels.
- Awarness training of non lethal alert devices from sensors to alert dogs, geese and guinea hens.

Leadership and Personnel: Leadership ability to adapt to rapidly changing opportunities on the battlefield. To empower leaders at the lowest level possible it was recognized that training in a decentralized environment and all modes of technology was necessary.

- Decentralization is critical to ensure timely decisions and reduce the latency in sensor to trigger decision cycles
- Challenge to leadership is the increased requirement to integrate the rapidly expanding technology in both the full and degraded mode
- Separate military occupational specialty for "sensor monitor"

Combination

- Increased patrols, sensors (Doctrine, Traininig, Organization)
- Syncronization of joint systems (fires, intelligence, C3I) (Doctrine, Training)
- Use of snipers in built up areas (Doctrine, Training)
- Animals and birds as sensors (dogs, geese, guinea hens, etc.) (Organization, Training)

- Shorten sensor to trigger link (Orgranization, Training, Materail)
- Assess munitions mix used to compensate for loss of APLM (Doctrine, Training, Organization)

Furthermore, to compensate for the loss of APM's, recommend joint field experiments to explore opportunities to:

- Reduce the delays, streamline, and simplify the procedures for the use of firepower from one service by another service.
- Reduce the delays and improve responsiveness of Joint Close Air Support to Army and Marine ground forces.
- Reduce the delays in passing sensor data up and down service and joint level of command.
- Expedite the generation and distribution of intelligence summaries rapidly and accurately to the lowest level of command of all services.

Additional Issues

The following statements summarize the issues and insights derived during the non-materiel conference.

(1) The difficulty in developing non-material alternatives to anti-personnel landmines is adequately compensating for the increased latency or delay when the automatic sense-to-detonate response of a current APM is prohibited in alternatives. When an APM is replaced by a sensor or mechanism indicating only an enemy intrusion, then friendly forces must either apply their own direct fire weapons (thereby revealing their location and force size) or request fire support such as artillery, attack helicopters or tactical air. Either action (direct or indirect fire) has associated with it a delayed response and increased latency between sense and engage. The potential for weapon-responsive latencies causing ineffective fire is the critical issue with many of the non-material alternatives.

(2) Another key issue complicating the formulation of effective alternatives is the nature of the individual service and joint fire support systems, and access to fire support. The fire support system used by NATOforces is a competitive system, which aggregates fire support assets at higher levels of command. Tactical Air is apportioned at the theater level, Army attack helicopters at the divisional level, and field artillery in the direct support mission at the brigade level. However, flexibility also leads to competition in priority of fires. Rifle platoons and companies must compete with other claimants within a brigade for artillery, within the division for attack helicopters, and with all other theater forces for tactical air. The competing process in assigning priority takes time. Again resulting in trade-offs between sense and engage times, sensor ranges and engagement ranges.

(3) Non-lethal systems as APM alternatives may provide some capability but most likely will not be appropriate for all threat/situations.

(4) Employment and greater reliance on many of the high-tech and operationally complex alternatives postulated present problems when contrasted by recommendations to *reduce* consumption levels, *reduce* the force, and, *reduce* the logistic footprint of a deployed force. The operational techniques and technology requirements to support alternatives discussed during the conference introduce potential cost-effective vulnerabilities that could be exploited by hostile forces.

(5) There are some doctrinal issues that, if resolved, could potentially mitigate the absence of anti-personnel landmines. But generally, the ideas that were surfaced involved doing things better, faster, or bypassing echelons of command.

(6) Anti-personnel landmines have the most immediate and significant impact on the forward deployed dismounted infantry forces of platoons and companies. Removing the timely effects of anti-personnel landmines places soldiers at a disadvantage and increased risk.

Unconstrained Listing of Potential APM Alternatives

Throughout the meetings of the SAS-023 working group members a list of alternatives were developed that could provide capabilities that would offset the loss of APM in identified missions. The following lists the postulated alternatives by the SAS-023 members. Specific analysis or quantification of these alternatives were not conducted.

<u>Potential Common Alts to achieve APM Block, Fix, Disrupt, Deny, Protect, Protect ATMs or Turn effects</u>

Obstacles (more, increase effectiveness)
Obscurants (smoke)
Ground Direct Fires (Small arms)
Ground Direct Fires (Armor)
Indirect Fires
Close Air Support (CAS)
Attack Helicopter
Combat Personnel
Change Doctrine (battlespace, force structure, ...)
Change Tactics, Techniques and Procedures
Area Defense Weapon

<u>Potential Additional Alts to achieve APM Turn effects</u>

Deception (Physical and Command/misinformation)

<u>Potential Additional Alts to achieve APM Fix effects</u>

Deception (Physical and Command/misinformation)
Mark (Tag threat with dye,...)

<u>Potential Additional Alts to achieve APM Disrupt effects</u>

Deception (Physical and Command/misinformation)
Attack enemy Command and Control (C2)

<u>Potential Additional Alts to achieve APM Deny effects</u>

Deception (Physical and Command/misinformation)
Contaminant (ordorless ,..)
Destroy (infrastructure)

Potential Additional Alts to achieve APM Protect effects
Surveillance and Sensors
Camouflage, concealment and deception (Obscurants)
Survivability

Potential Alts to achieve specific APM Alert contributions
Combat Personnel
Change Doctrine (battlespace, force structure, ...)
Change Tactics, Techniques and Procedures
Warning devices (tripwires, flares)
Technical Sensors
Intelligence Electronic Warfare (Signal, Comm)
Sensory aide enhancement devices
Animals

Potential Alts to achieve specific APM Produce Casualties contributions
Obstacles (more, increase effectiveness)
Ground Direct Fires (Small arms)
Ground Direct Fires (Armor)
Indirect Fires
Close Air Support (CAS)
Attack Helicopter
Combat Personnel
Change Doctrine (battlespace, force structure, ...)
Change Tactics, Techniques and Procedures
Area Defense Weapon
NBC weapons
Lasers, acoustic or other energy based weapons

Potential Additional Alts to achieve specific APM Protect ATMs contributions
Sensors
Anti-Handling Device (AHD)
AT Resistance to countermeasures
Camouflage, Concealment, and Deception (CCD)

Potential Alts to achieve specific APM Protect Obstacles contributions
Reinforce individual obstacles (more, increase effectiveness)
Camouflage, Concealment, and Deception
Ground Direct Fires (Small arms)
Ground Direct Fires (Armor)
Indirect Fires
Close Air Support (CAS)
Attack Helicopter
Combat Personnel
Change Doctrine (battlespace, force structure, ...)
Change Tactics, Techniques and Procedures
Area Defense Weapon

<u>Potential Alts to achieve specific APM Harassment contributions</u>
Obstacles (more, increase effectiveness)
Obscurants (smoke)
Ground Direct Fires (Small arms)
Ground Direct Fires (Armor)
Indirect Fires
Close Air Support (CAS)
Attack Helicopter
Combat Personnel
Change Doctrine (battlespace, force structure, ...)
Change Tactics, Techniques and Procedures
Deception (Physical and Command/misinformation)
Attack enemy Command and Control (C2)
NBC Weapons
Un-manned Aerial Vehicles (UAVs)
Non-lethals
Psyops

<u>Potential Alts to achieve specific APM Surprise contributions</u>
Obstacles (more, increase effectiveness)
Ground Direct Fires (Small arms)
Ground Direct Fires (Armor)
Indirect Fires
Close Air Support (CAS)
Attack Helicopter
Combat Personnel
Change Doctrine (battlespace, force structure, ...)
Change Tactics, Techniques and Procedures
Attack enemy Command and Control (C2)
Camouflage Cover and Deceptions (CCD)

<u>Potential Alts to achieve specific APM Psychological contributions</u>
Obstacles (more, increase effectiveness)
Obscurants (smoke)
Combat Personnel
Deception (Physical and Command/misinformation)
PSYSOPS
Indirect fire
Snipers

Non-Materiel Alternatives Modeling and Analysis
Three nations (Canada, United Kingdom, United States) examined potential alternatives based on currently available weapons using computer based combat simulations. Canada looked at adding remote fired claymores, additional wire obstacles, and Mk19 automatic grenade launchers – in various combinations. Results were as shown in Figure 3.

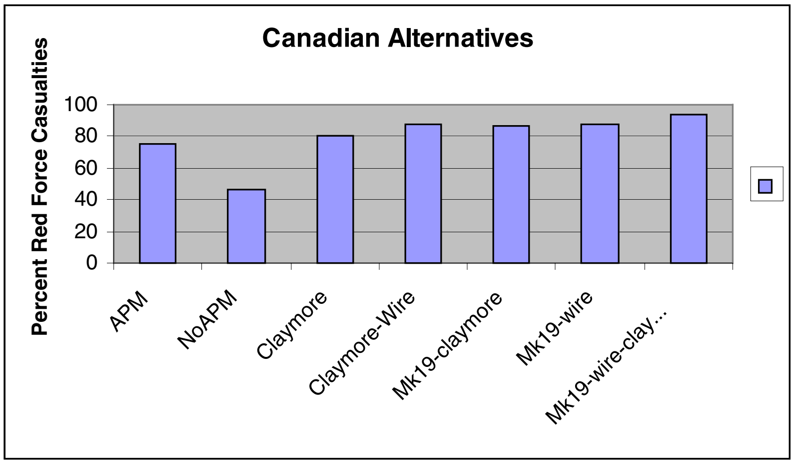


Figure 3

The United Kingdom examined alternatives including additional machineguns, mortars, claymores, and also non-lethal alternatives including nets, caltrops, GSR, and Tasers. Results are compared in figure 4.

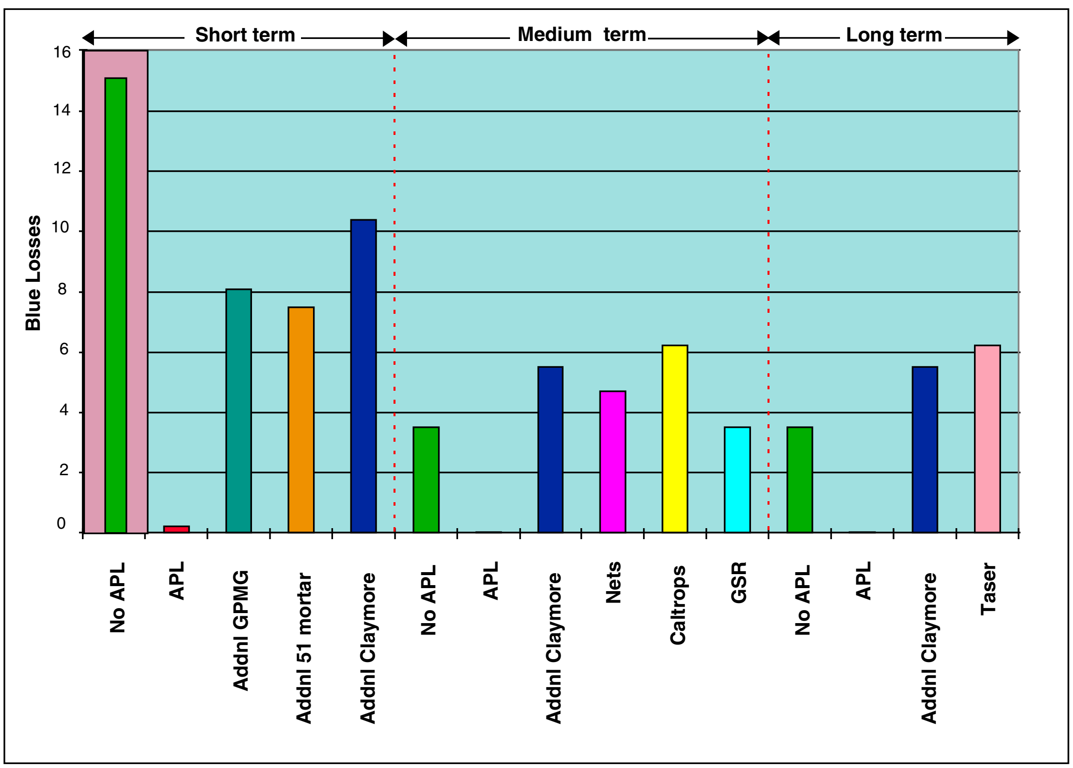


Figure 4

The US examined similar alternatives, but also switched from the generic weapons data used in the first case to using the actual classified data for US systems. This caused the APM to be somewhat more significant to the US defense. The US examined adding additional machineguns, adding additional automatic rifles, providing dedicated artillery, providing dedicated mortars, adding additional wire obstacles and adding remote fired claymore munitions. US results are as shown in Figure 5.

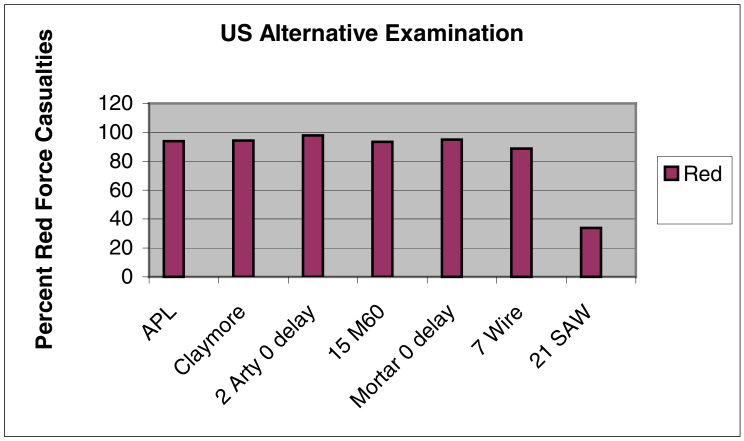


Figure 5

All three combat simulation-based studies demonstrated it is possible to compensate for some of the lost APM capabilities by employing different mixes of weapons at the small unit level. However, each potential alternative comes with increased uncertainty in the outcome of the battle and increased risk to the Blue force.

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Annex J

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Annex K

RTO Presentation/Publication Release and Clearance Certificates

NATO C3 Agency, Dr. Gernot Friedrich

CANADA, Mr. Roger Roy

UNITED STATES, Joint Staff

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Landmines	Simulation

14. Abstract

The study examines the impacts of no longer having Anti-Personnel Landmines available to the NATO warfighter. The report considers alternative systems and/or concepts for replacing any resulting capability shortfall. The systems and concepts were to be either materiel (technical solutions) or non-materiel (doctrinal or procedural) in nature. The study provides tactical and operational impact statements of conducting military operations without Anti-Personnel Landmines available to NATO forces. The report provides a method to address the functionality of alternatives and to assess their capability to address barrier-type mission parameters.

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