MINISTÈRE DE LA DÉFENSE

B01

LE ROLE DE LA TECHNOLOGIE DANS LA POSTURE DE DEFENSE

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Jacques PIERRON, Alain PIZEL, Patrick TEXERAUD

(Mai 1995)

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ETUDES PARTICULIERES A OPTION

CYCLE 1994-1995

LE ROLE
DE LA TECHNOLOGIE
DANS
LA POSTURE DE DEFENSE

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1. INTRODUCTION

David utilisant sa fronde contre Goliath, le Radar permettant aux britanniques de gagner la bataille d'Angleterre, la bombe atomique américaine à Hiroshima et plus récemment le succès de la coalition lors de la guerre du Golfe, tous ces exemples mettent en évidence le rôle de la technologie dans les opérations militaires.

Cette constante de l'histoire des conflits garde toute son importance à notre époque.

Si durant la confrontation Est-Ouest il a été possible de bâtir des systèmes d'armes et une défense cohérents par symétrie avec les moyens et la doctrine adverses, dès lors que la menace devient à la fois plus diffuse et plus proche, le problème est d'identifier parmi les technologies émergentes celles qui sont essentielles pour l'avenir.

Il semble qu'il n'existe pas de réponse dans l'absolu à cette question. Les publications permettent cependant d'obtenir des éléments pour mieux définir les paramètres des choix.

L'examen du cadre d'action à venir a permis d'en déduire les caractéristiques ou les fonctions essentielles des systèmes futurs. Les différentes technologies ressortant de l'étude bibliographique ont été passées au prisme de ces caractéristiques dans le but de déterminer le rôle de chacune de ces technologies matérielles ou non dans la posture de défense.

2. FACTEURS DETERMINANTS ET MODES D'ACTION

2.1. Facteurs importants à prendre en considération

2.1.1. Les conflits envisagés:

La parution récente du livre blanc 94, a fait suite à l'étude de modèles d'armées 2000 datant de 1984. Celui-ci permet de cerner précisément la typologie des cas d'intervention futurs. Ainsi, les crises auxquelles nous pouvons nous attendre ont-elles été classées en six scénarios[1] non exclusifs, dont le dernier peu vraisemblable actuellement, est non dimensionnant. Aussi, est il possible, de ce fait, de mieux définir les moyens militaires nécessaires aux interventions potentielles ainsi clairement définies.

D'autre part, il convient de souligner que l'avènement de ce document favorise une meilleure cohérence entre notre politique et nos moyens de défense. Les ressources nécessaires devraient même être fournies : « Le niveau des ressources consacrées à la défense doit répondre au projet politique du pays et aux exigences de sa sécurité » peut-on lire dans le livre blanc[2]. Tout au moins, il semble donc fortement probable que les priorités qui découleront de cette classification, et les moyens correspondants (systèmes d'armes développés en particulier), seront, au moins initialement, en conformité avec les objectifs visés.

2.1.2. Un partenariat incontournable

Les interventions définies précédemment, potentiellement multithéâtres, se placeront, la plupart du temps, dans un cadre multinational. La nécessité de pouvoir utiliser nos systèmes d'armes dans ce contexte est donc essentielle. Cela souligne la nécessité, au plan opérationnel, d'un développement des systèmes d'armes, en coopération avec nos partenaires.

D'autre part, le poids des contraintes financières est tel, que notre défense future sera limitée par son budget. Or l'interface entre moyens civils et militaires s'élargit, et la frontière entre les uns et les autres s'estompe, comme c'est déjà le cas entre les notions de matériels « tactiques » et « stratégiques ». C'est pourquoi, il est nécessaire de développer des systèmes et des technologies « duaux »[3], à double vocation militaire et civile, et ce en coopération avec nos partenaires, pour maintenir les coûts d'équipement les plus faibles possibles.

Toutefois, la réflexion de défense (et de sécurité) doit se placer dans une perspective clairement définie, qu'elle soit nationale, européenne, ou mondiale. Mais elle ne doit se faire ni au détriment d'alliances d'opportunité possibles, voire souhaitables dans ce contexte absent d'adversaire désigné, ni, à plus forte raison, au détriment de nos partenaires potentiels.

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[1] Scénario 1- Conflit régional ne mettant pas en cause nos intérêts vitaux.
Scénario 2- Conflit régional pouvant mettre en cause nos intérêts vitaux.
Scénario 3- Atteinte à l'intégrité du territoire national hors métropole.
Scénario 4- Mise en oeuvre des accords de défense bilatéraux.
Scénario 5- Opérations en faveur de la paix et du droit international.
Scénario 6- Résurgence d'une menace majeure contre l'Europe occidentale.

[2] Page 139 du document officiel.

[3] Des projets existent déjà. C'est le cas, en particulier, du projet EUCLID qui est défini comme étant "une initiative européenne de coopération en matière de recherche et de technologie intéressant la Défense", qui a l'ambition de faire directement exécuter en coopération, au niveau européen, les projets de recherche et de technologie.

2.1.3. Principaux objectifs de la politique de défense française

Notre capacité à travailler avec des partenaires dans un contexte multinational ne doit toutefois pas se traduire par une dépendance à l'égard de ceux-ci. Elle doit aller de pair avec le maintien d'une autonomie suffisante, nous laissant la capacité d'agir seul le cas échéant, conformément à ce que prévoient les scénarios du livre blanc.

Nos forces doivent avoir une « aptitude propre à contribuer à la prévention, à la limitation ou au règlement par la force si nécessaire, des crises ou des conflits régionaux ne présentant pas un risque d'escalade aux extrêmes ». Nos moyens conventionnels sont donc appelés à « jouer un rôle dans notre stratégie sous trois formes, la prévention, l'action et la protection »[4].

2.1.4. Conséquences principales

Notre stratégie de défense a pour objectif prioritaire de prévenir l'apparitionde crises, puis au cas ou la prévention échouerait, à contenir ces crises en tentant de les maintenir au niveau le plus bas possible. Cette volonté impose un couplage « prévention - renseignement » permettant l'anticipation nécessaire à tout action de prévention. Elle sous-entend de plus, une globalisation de la manoeuvre du renseignement qui pourrait comprendre des moyens non exclusivement militaires.

Dans le cadre des conflits envisagés, les actions militaires doivent être le plus souvent d'ampleur limitée. Elles ont pour but de réaliser le maintien ou le rétablissement de la paix. Ces missions constituent les priorités de notre stratégie. Or, généralement l'opinion publique et des dirigeants considèrent que l'usage de la violence est illégitime. Il semble donc que les systèmes d'armes futurs devront s'adapter à cette contrainte pour garantir aux actions militaires leur nécessaire légitimité. Cela pourrait modifier, en particulier, les effets non nécessairement meurtriers et la précision des armes.

D'autre part, l'extension du terrorisme d'état, les besoins consécutifs en renseignement, laissent envisager une globalisation des problèmes de prévention de sécurité et de protection. Cette évolution pourrait, en particulier, se traduire par la prise en charge partielle, par les armées de missions de sécurité publique. Dans cette hypothèse, une coopération avec les services publics concernés (Police en particulier) s'imposerait.

2.2. Actions menées de manière autonome

2.2.1. Défense interne du territoire métropolitain

La défense interne du territoire recouvre les cas d'action où les autorités civiles font appel à des forces militaires pour contribuer au maintien de l'ordre :

- soit en complétant des actions de défense civile,
- soit par transfert aux autorités militaires de la responsabilité de la défense intérieure du territoire.

Cela suppose des structures de commandement et des systèmes de forces capables d'opérer dans le cadre de ces deux hypothèses.

[4] Page 59 du livre blanc 94 sur la défense.

2.2.2. Défense du territoire métropolitain contre une agression extérieure

Il s'agit de l'hypothèse où les alliés de la France ne s'estimeraient pas concernés par des menaces extérieures à l'encontre du territoire français.

Cela imposerait la connaissance précise de notre environnement politico-stratégique et la conservation des capacités que nous avons acquises d'agir unilatéralement pour contrer toute mise en cause de nos intérêts vitaux.

2.2.3. Défense de nos possessions d'outre-mer

Si la menace est de faible ou moyenne intensité, la disposition sur place de forces prépositionnées est indispensable à l'exercice d'une action dissuasive.

Contre des menaces d'un niveau plus important, un renforcement rapide de ces moyens prépositionnés est nécessaire, et ceci est possible par la disposition de capacités de projection de forces.

2.2.4. Interventions extérieures

Ces interventions en Europe ou hors d'Europe nécessiteront :

- l'emploi d'une manoeuvre de renseignement,
- la possession de moyens dissuasifs à partir de moyens conventionnels plutôt que nucléaires.
- des capacités de projection de forces et de projection de puissance.

2.3. Actions menées en coopération

Quel que soit le théâtre, les interventions futures seront en général menées en coopération. Trois aspects particuliers peuvent être examinés :

- Les différents types d'action
- Les modes de coopération
- Les domaines possibles

2.3.1. Les différents types d'action

Trois types d'actions peuvent être menées

- Action dans le cadre d'alliance de droit, ou les rapports sont codifiés et évoluent en fonction de l'environnement géostratégique et politique. C'est le cas en particulier de l'Alliance atlantique.
- Coopération dans le cadre d'alliances d'opportunités. Ce sont des alliances résultant de situations de circonstance face auxquelles plusieurs Etats décident de réagir ; c'est le cas, par exemple de la guerre du Golfe.
- Coopération sous le patronage d'organisations internationales ou intergouvernementales. Ici les opérations sont conduites par une autorité reconnue dans des structures, sous la responsabilité de l'organisation ; c'est le cas pour l'ONU.

2.3.2. Les modes de coopération

Ils sont divers, depuis la concession de facilités jusqu'à l'engagement des forces sous un commandement et une autorité uniques.

- L'apport d'aide est un niveau modeste de coopération qui permet à celui qui la reçoit de rester autonome.
- La coopération dans le cadre d'opérations de faible intensité implique la présence de forces multinationales réunies par des impératifs politiques.
- La coopération avec maintien d'autonomie dans le cadre d'opérations importantes interdit de s'impliquer seul face aux possibilités de l'adversaire en même temps que l'on souhaite garder une autonomie de décision et/ou d'action.
- La coopération avec intégration de forces multinationales mises sous commandement opérationnel de l'alliance en place.

2.3.3. Les domaines possibles

Ces domaines principaux sont les suivants :

- Utilisation de procédures communes,
- Interopérabilité des forces,
- Unité de commandement.

2.4. Le champ d'opérations du futur

2.4.1. L'élargissement des missions dévolues aux armées

Le champ d'action des armées s'ouvre aujourd'hui bien au delà du seul champ de bataille dans lequel elles étaient traditionnellement confinées. Le livre blanc avalise aujourd'hui l'emploi des forces armées dans des missions de service public et de sécurité en général. C'est le cadre d'action dans lequel il convient de les considérer.

2.4.2. Contraction du temps

Le champ d'opérations sera caractérisé par une contraction du temps qui sera possible par les performances accrues des moyens SIC (C3I) qui assureront la transmission rapide des ordres et comptes rendus.

2.4.3. Unicité du champ de bataille

Le champ d'opérations tendra par ailleurs à s'unifier en devenant plus interarmées et en intégrant les dimensions spatiale et maritime.

2.4.4. Transparence du champ d'opérations

Le nombre et les performances des moyens de renseignement conduiront à une grande transparence du champ d'opération. Les effets de cette transparence seront amplifiés par la large diffusion des informations rendue possible d'une part grâce à l'accroissement des moyens de communication satellite individuels, et d'autre part grâce à l'action des médias.

3. CARACTERISTIQUES ET PRINCIPES GENERAUX DES SYSTEMES FUTURS

L'aperçu des principales caractéristiques du champ d'opération futur permet de déterminer les principes militaires qu'il impose. Ces principes sont les principaux composants de la trame de l'ensemble militaire considéré.

A la différence du D.O.D américain nous n'avons pas retenu les sept axes d'effort (seven Thrusts)[5] qui nous ont semblés être des modes d'action plus que des fonctions générales. Les caractéristiques qui sont définies dans cette deuxième partie sont les fonctions essentielles que tout système de Défense doit remplir.

3.1. Primauté et omniprésence du renseignement et des contre mesures

La condition première pour l'évaluation d'une situation sur le théâtre d'opérations, pour apprécier des menaces ou surveiller la mise en oeuvre des accords est la capacité de renseignement.

Le renseignement est à la base de toute action militaire. Les systèmes d'information et de communication qui permettent de le véhiculer prennent de plus en plus d'ampleur et d'importance.

La recherche du renseignement, son analyse et son exploitation resteront une condition première à toute réalisation de mission. Ce renseignement doit être régulièrement actualisé, il doit couvrir des domaines variés et sa recherche doit être menée selon des modes diversifiés et complémentaires.

Les contre mesures omniprésentes dans tout conflit, vont de pair avec le renseignement. Elles influent tant favorablement que défavorablement sur l'efficacité des systèmes de renseignement, et de ce fait doivent être considérées pour juger les performances de ceux-ci .

3.2. Modularité

Les systèmes futurs, pour être souples, adaptables ou reconfigurables devront pour l'essentiel être modulaires. On entend par modulaire pour un système de forces, le fait que l'on puisse choisir dans ce système un élément (module) autonome par nature. En complément à d'autres modules il permet de s'adapter à la situation à laquelle on a décidé de faire face. Il doit être « projetable » dans les délais convenables sur le théâtre où l'action doit être menée.

[5] Surveillance globale et communication; Frappe de précision; Supériorité aérienne et défense; Contrôle maritime et supériorité sous-marine; Combat terrestre; Environnement de synthèse; Technologies d'acquisition.

3.3. Besoins de mobilité et capacité de projection

La diversité des théâtres d'engagement possibles, l'imprécision de localisation et les incertitudes sur les possibilités de l'adversaire imposent désormais de disposer de forces et de systèmes mobiles et projetables.

Ceci implique que tout système (ou toute force) puisse être déployé quel que soit le théâtre, indépendamment des contraintes du milieu et dans des délais raisonnables pour faire face à l'urgence de la situation.

L'accent devra être mis sur :

- La capacité de transport à grande distance
- La capacité de projection de puissance aussi instantanée et efficace que possible.

3.4. Coordination et interopérabilité

Les actions en coopération de plus en plus nombreuses imposeront à toute organisation au dela d'un certain niveau d'être interarmées et surtout interopérable, sans remettre en cause la spécificité et l'efficacité de ses systèmes.

L'interopérabilité consiste pour tout système, unité ou organisme dont les structures, les procédures et l'organisation sont différentes, à être apte à opérer de concert.

Elle devra exister dans deux domaines :

- Celui des doctrines et des procédures d'emploi des forces.
- Celui des personnels et des matériels servants ou utilisés dans les forces.

Un agencement des moyens en vue d'obtenir une efficacité maximale s'imposerait en même temps.

3.5. Flexibilité des forces, de leurs architectures et de leurs équipements

La notion de flexibilité dépasse celle de polyvalence. Elle souligne la faculté d'opérer des revirements soudains pour s'adapter à des situations variées. Ces situations étant inconnues, il s'agira donc de la capacité soit de couvrir un large éventail de situations, soit de pouvoir s'adapter dans des délais très courts, à toute évolution de situation.

3.6. Continuité et permanence opérationnelle

La continuité est considérée dans le temps où elle qualifie l'aptitude à durer et dans l'espace où elle caractérise la qualité d'une structure.

- Aptitude à durer :

Cette notion recouvre l'absolue nécessité d'un système ou d'une force à exercer son fonctionnement ou son action efficacement durant une période de temps de durée indéterminée et arbitrairement prolongée, indépendamment des variations de l'environnement pour lequel il a été conçu.

- Continuité structurelle :

Il s'agit de la qualité structurelle à constituer un tissu dense, cohérent, permettant aux systèmes (ou aux forces) d'avoir de puissantes relations de solidarité de nature à optimiser leur efficacité.

- Permanence opérationnelle :

La permanence est la capacité d'un système ou d'une structure à répondre à n'importe quel moment, et sans contrainte de préavis, à sa fonction.

3.7. Puissance de destruction

La puissance de destruction d'une arme ou d'un système d'arme doit être appréciée en considérant ses effets de neutralisation sur les cibles pour lesquelles elle a été conçue. Cet effet doit être obtenu grâce aux qualités intrinsèques de l'arme, ou du système d'arme considéré, au contexte d'emploi (condition météorologiques, ambiance électromagnétique...) et à la compétence des opérateurs de tir.

La puissance de destruction ne se mesure donc plus exclusivement à l'importance des effets obtenus avec peu de moyens, mais bien en considérant les qualités propres de l'arme lui permettant d'obtenir précisément et systématiquement les effets attendus.

4. ANALYSE DE LA PERFORMANCE DES TECHNOLOGIES

Après avoir défini les fonctions essentielles que tout système de défense doit remplir, cette troisième partie propose un inventaire des technologies émergentes retenu dans la plupart des documents accessibles traitant de ce sujet. La liste la plus exhaustive correspond à l'analyse proposé par le D.O.D des Etats unis d'Amérique, c'est celle qui a été retenue.

4.1. Air breathing propulsion (Propulsion aérobie)

Définition : Propulsion aérobie[6] permettant un fort rapport poussée masse et une faible consommation spécifique.

Renseignement : Ce type de propulsion améliore l'efficacité des vecteurs transportant les systèmes d'acquisition du renseignement. On peut citer en exemple :

- Les avions de reconnaissance et les drones dont la vitesse peut être accrue et la durée d'observation étendue.
- Les missiles de mise en orbite de satellite de type « Pegasus ».

Par ailleurs, ce type de propulsion améliore la discrétion des vecteurs.

Mobilité et projection de forces : L'apport peut être dans ce cas très appréciable comme le montre les objectifs fixés par les ETATS-UNIS.

Flexibilité des forces : ce type de propulsion permet d'abréger les délais de réaction grâce aux fortes vitesses atteintes.

Coordination et interopérabilité : Participe à la coordination par le déploiement rapide d'un système de satellites de communication à l'aide de missiles de mise en orbite.

Permanence et continuité : propulsion qui par ses caractéristiques permet d'augmenter l'autonomie des systèmes de défense.

4.2. Biotechnology (Biotechnologie)

Définition : Utilisation de la biologie dans les systèmes d'armes. Cette technologie regroupe l'étude des processus, des matériaux et des capteurs.

Renseignement : Fabrication de capteurs hypersensibles capables de détecter une seule molécule ou un seul photon dans un environnement bruité.

Mobilité et projection de forces : Matériaux haute résistance et faible poids (matériaux composites à base de bio-céramiques).

Puissance de destruction : toxiques persistants à bas coût. Agents de décontamination sélectif. Protection balistique et camouflage par immobilisation d'ensembles complexes protéïne-pigment. Protection laser par biomolécules au propriétés optiques non linéaires.

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[6]aérobie : Se dit d'un moteur qui fait appel à l'oxygène de l'air pour alimenter la réaction de combustion développant l'énergie utilisable.

4.3. Composite materials (Matériaux composites)

Définition : Matériau composé de deux ou plusieurs matériaux combinés de façon à obtenir des propriétés sélectionnées supérieures à chacun des matériaux.

Renseignement : Ces matériaux sont utilisés pour les structures des systèmes d'observation qu'ils allègent et renforcent. Ils participent à la discrétion en particulier électromagnétique des systèmes de défense.

Mobilité et projection de forces : Ils procurent un gain de masse important.

Permanence et continuité : Ils améliorent la survie des combattants et des équipements.

4.4. Computational fluid dynamics (calcul numérique d'écoulements fluides)

Définition : Simulation d'écoulements fluides complexes afin d'améliorer de minimiser le coût et les délais de conception.

Renseignement : La simulation permet d'apprécier les capacités techniques de l'adversaire. Elle contribue à l'étude de réduction des signatures.

Mobilité et projection de forces : Contribue à l'amélioration des performances aérodynamiques et hydrodynamiques des vecteurs.

Permanence et continuité : Augmentation de l'autonomie des différents vecteurs.

Puissance de destruction : Amélioration de la connaissance de l'effet des ondes de choc pour les projectiles hypervéloces. Amélioration des performances intérieures et extérieures des armes.

4.5. Data fusion (fusion de données)

Définition : L'interprétation et/ou l'intégration, par ordinateur, de données et leur représentation sous une forme accessible à l'opérateur humain.

Renseignement : Permet de réaliser une première synthèse des données brutes recueillies par les différents capteurs. La fusion des images optiques et radar d'origine spatiale en est un bon exemple.

Mobilité et projection de forces : Permet le développement de bases de connaissances des différents modules de forces.

Flexibilité des forces : Capacité à partir d'une base de données de présenter à l'opérateur humain la situation tactique selon des angles différents.

Modularité : Facilite la modularité des capteurs de reconnaissance en intégrant à posteriori plusieurs sources d'origines différentes.

Coordination et interopérabilité : Procure une synthèse des différentes données indispensables à la coordination.

Permanence et continuité : La permanence dans le temps ainsi que la continuité sont améliorée compte tenu de l'automatisation de la fusion. La permanence dans l'espace est augmentée par l'intégration de capteurs d'origines différentes. Par exemple, un satellite radar complétera utilement un satellite optique ou des radars au sol.

4.6. Flexible manufacturing (Organisation reconfigurable de la production)

Définition : Intégration et capacité d'adaptation des processus de conception et de fabrication par la normalisation des données (CALS).

Mobilité et projection de forces : Impact sur la Logistique (SLI).

Modularité : Prise en compte dès la conception.

Coordination et interopérabilité : Obtenues grâce à la normalisation.

Permanence et continuité : Reconfiguration de l'outil de production pour faire face à l'évolution du besoin.

4.7. High energy density materials (Matériaux à grande densité d'énergie interne)

Définition : Etude des matériaux possédant une grande énergie interne utilisés comme explosifs ou propergols. La technologie comprend les applications détonique, explosifs et propergols.

Renseignement : Augmentation du champ d'action des vecteurs.

Puissance de destruction : Augmentation des capacités de pénétration et de destruction. Accroissement des portées de tir. Amélioration des contre-mesures (blindage actif, leurres ...).

4.8. High performance computing (calculs à hautes performances)

Définition : La technologie inclut les domaines des systèmes d'ordinateurs à hautes performances (teraflops), les logiciels et les algorithmes de pointe (architecture parallèle, bibliothèque de défense et compatibilité), les réseaux à haute performance.

Renseignement : Gestion et synthèse de grands flux de données provenant de sources hétérogènes.

Mobilité et projection de forces : Optimisation des mouvements, déploiement et de la logistique des forces.

Flexibilité des forces : Améliorée grâce aux systèmes multitâches multiutilisateurs fonctionnant en temps réel.

Modularité : Améliorée par les systèmes en réseaux.

Coordination et interopérabilité : Améliorées par les systèmes en réseaux et par la meilleure compatibilité.

Permanence et continuité : Capacité de grandes bases de connaissances.

4.9. Hypervelocity projectiles and propulsion (Propulsion et projectiles hypervéloces)

Définition : Projectiles se déplaçant à des vitesses supérieures aux vitesses conventionnelles (> 2 km/s). La technologie comprend la conception du projectile, la propulsion du projectile et l'interaction projectile cible.

Puissance de destruction : Augmentation de la capacité de destruction. Diminution du délai de trajectoire.

4.10. Machine intelligence and robotics (Robotique et intelligence artificielle)

Définition : Insertion au sein de machines informatiques de certains aspects de l'intelligence humaine afin d'assurer à l'aide de dispositifs mécaniques des fonctions « intelligentes ».

Renseignement : Ces techniques permettent d'exploiter des milieux hostiles à l'homme tels que les océans et l'espace. Les capteurs automatiques spatiaux et océaniques sont essentiels pour le renseignement des forces.

Mobilité et projection de forces : L'intelligence artificielle peut permettre de résoudre des problèmes complexes de déploiement de forces.

Flexibilité des forces : Les techniques de l'intelligence artificielle permettent de proposer rapidement une ou plusieurs solutions en cas de changement brutal de la situation.

Coordination et interopérabilité : L'interopérabilité de systèmes à commande numérique peut paraître plus aisée à obtenir.

Permanence et continuité : Les systèmes automatisés permettent une permanence dans le temps ainsi que la continuité et améliore la permanence dans l'espace en exploitant des milieux hostiles à l'homme.

Puissance de destruction : La reconfiguration automatique d'une arme en fonction du contexte peut être envisagée grâce aux techniques d'intelligence artificielle.

4.11. Passive sensors (Capteurs passifs)

Définition : Capteurs n'émettant pas de signaux pour : détecter des cibles, surveiller l'environnement, et déterminer l'état ou les conditions de fonctionnement d'équipements.

Principaux domaines de recherche :

- Capteurs de recherche passifs
- autodirecteurs infrarouges
- Imagerie infrarouge
- optiques à diffraction
- intégration de capteurs pour l'acquisition de cibles
- antennes passives avancées
- surveillance passive des fréquences radio
- surveillance acoustique
- capteurs en fibre optique pour la surveillance de l'état des systèmes et de l'environnement.
- capteurs à supraconduction

Renseignement : permettent d'obtenir discrètement des informations.

Flexibilité des forces : Ces capteurs mettent à jour en temps réel la situation tactique en toute discrétion et donnent des informations quant à l'état du système de forces (capteurs en fibre optique).

Permanence et continuité : Améliorent la permanence dans le temps (capacité jour/nuit des capteurs infrarouges).

4.12. Photonics (Photonique)

Définition : La photonique est l'usage de la lumière pour la représentation, la manipulation et la transmission de l'information. La technologie de la photonique rassemble les techniques pour fabriquer des photons à des fréquences, longueurs d'ondes et amplitudes extrêmement sélectionnées (lasers) ; pour guider cette lumière dans des régions spécifiques (fibre optique) ; pour analyser le spectre électromagnétique (fréquence, amplitude et polarisation) ; et pour développer des matériaux possédant des propriétés optiques voulues. Cette technologie recouvre donc :

- les équipements lasers
- les fibres optiques
- le traitement du signal optique
- les optiques intégrées

Renseignement : Amélioration des performances des capteurs optiques (matrices CCD de grande dimension). Augmentation du débit d'information (fréquences optiques).

Modularité : Induit par l'augmentation des débits d'information.

Permanence et continuité : Amélioration des capacités tous temps.

Puissance de destruction : Performances des lasers.

4.13. Pulsed power (Production de puissance impulsionnelle)

Définition : Génération à grande fréquence d'impulsions de très forte amplitude et de très courte durée à partir de dispositifs légers utilisables pour les armes et les capteurs. Cette technologie regroupe le stockage de l'énergie, la commutation, les circuits de conditionnement, les sources primaires d'énergie et les ondes micrométriques à haute puissance.

Renseignement : Laser radar. Radar à très large bande.

Mobilité et projection de forces : Mobilité tactique accrue les possibilités de déminage.

Puissance de destruction : Possibilité offerte par les canons électromagnétiques. Simulateur d'effet d'armes nucléaires. Faisceaux de particules. Laser de neutralisation ou de destruction. Blindage électromagnétique.

4.14. Semi conductor materials and microelectronic circuits (Matériaux semi-conducteurs et circuits micro-électroniques)

Définition : Ce domaine de technologie embrasse la production et le développement d'équipements de micro-électronique intégrée pour des calculateurs rapides, des récepteurs sensibles, de la commande automatique. Les principaux composants de ce domaine sont :

- les circuits intégrés à très haute densité
- la conception assistée par ordinateur pour les circuits complexes
- la lithographie à haute résolution
- les convertisseurs analogique-numérique
- les convertisseurs de puissance
- les sources et amplificateurs d'ondes micrométriques
- les modules et les matrices de transmission et de réception
- les composants de traitement du signal(DSP)
- la technologie du durcissement au rayonnement

Modularité : Amélioration grâce à la miniaturisation
Puissance de destruction : Amélioration des calculateurs embarqués.

4.15. Sensitive radars (radars sensibles)

Définition : Capteurs radars capables de détecter des cibles à faibles signatures et de traiter (classifier, reconnaître/identifier) des cibles non coopératives.

Renseignement : Le satellite apporte le renseignement stratégique qui permet la prévention. Les capteurs à hautes performances rendent le mouvement, l'émission et le feu très risqués et amplifient le rôle de la déception, des armes peu observables et autres capteurs.

Flexibilité des forces : Amélioration des capacités multifonction. La classification permet d'adapter l'arme à la menace.

Coordination et interopérabilité : l'identification aide à la coordination.

Permanence, Continuité dans le temps et dans l'espace :

- Indépendance vis à vis des conditions météorologiques
- localement permanent.

4.16. Signal and image processing (Traitement du signal et de l'image)

Définition : Le traitement du signal est la technologie utilisée pour extraire l'information utile du signal reçu par des capteurs, et de présenter une information utilisable par des opérateurs humains ou une machine. Le traitement du signal combine les technologies suivantes :

- développement des algorithmes
- réseaux de neurones
- techniques hybrides optique numérique
- commande du déphasage des matrices

Renseignement : Participe à l'amélioration des performances et de l'automatisation du traitement.

Permanence et continuité : Automatisation accrue des processus de prise de décision.

Puissance de destruction : Parade contre la furtivité.

4.17. Signature control (Maîtrise de la signature)

Définition : Cette technologie permet la modification des signatures émises par les systèmes d'armes afin de réduire leur probabilité d'être détecté, en altérant les caractéristiques utiles à la détection, la reconnaissance et la prise à parti. Elles incluent les signatures radar, infrarouge, visuelle, acoustique et magnétique, parmi d'autres, des aéronefs, véhicules terrestres, bâtiments et sous-marins.

Renseignement : Amélioration de la discrétion face au renseignement adverse.

Mobilité et projection de forces : Discrétion des mises en place.

Coordination et interopérabilité : Problème d'identification des amis imposant une plus forte coordination.

4.18. Simulation and modeling (Simulation et modélisation)

Définition : visualisation de processus complexes, test de concepts et d'architecture sans construction de maquettes.

Principaux domaines de recherche :

- le graphique temps réel
- la résolution des systèmes d'équations non linéaires
- la vérification et la validation des simulations

Renseignement : permet d'optimiser l'emploi des différents capteurs.

Mobilité et projection de forces : permet de vérifier la faisabilité d'un mode d'action.

Flexibilité des forces : permet de vérifier la versatilité d'un système soumis à un contexte fluctuant.

Modularité : identification des interdépendances des différents modules.

Coordination et interopérabilité : tests d'hypothèses de fonctionnement de l'ensemble des systèmes.

Puissance de destruction : permet d'estimer le pouvoir destructeur d'une arme (cas de l'arme nucléaire) et d'un système d'armes.

4.19. Software engineering (Ingénierie du logiciel)

Définition : Cette technologie a pour objectifs la génération, la maintenance et l'amélioration de logiciels fiables et accessibles. Cette technologie regroupe :

- les processus et les environnements de l'ingénierie des logiciels
- les logiciels temps réel et tolérant aux fautes
- la réutilisation et la conception
- les logiciels pour systèmes parallèles et hétérogènes
- le logiciel à haute fiabilité

Renseignement : fiabilité du système de renseignement

Flexibilité des forces : fiabilité de la reconfiguration

Coordination et interopérabilité : fiabilité des interfaces entre systèmes

Puissance de destruction : virus fiable à injecter dans les systèmes adverses.

4.20. Superconductivité (Supraconductivité)

Définition : Cette technologie utilise les propriétés de résistance minimale dans des conditions particulières de fonctionnement (basse ou haute température) de certains matériaux.

Renseignement : Améliore les capacités des capteurs infrarouges et de systèmes de communication et de surveillance.

Mobilité et projection de forces : Stockage de l'énergie pour la propulsion maritime.

Puissance de destruction : Développement de canons électromagnétiques.

4.21. Weapon system environment (Environnement des systèmes d'armes)

Définition : Connaissance détaillée de l'environnement naturel et de son influence sur la définition et les performances des systèmes. Cette technologie comprend :

- l'océanographie
- la caractérisation de l'environnement et les prédictions des conditions dans la zone d'une cible

Renseignement : Meilleure connaissance du champ de bataille. Utilisation optimale des capteurs en fonction de l'environnement.

Mobilité et projection de forces : Permet une meilleure utilisation du milieu (météo).

Coordination et interopérabilité : Incorporation en temps réel des effets de l'environnement sur le champ de bataille. Amélioration des communications ionosphériques.

Puissance de destruction : Adaptation des moyens et des armes.

4.22. Tableau récapitulatif

	Renseignement	Mobilité Projection	Flexibilité	Modularité	Coordination Interopérabilité	Permanence continuité	Puissance de destruction
Propulsion aérobie	■	■	■		■	■	
Biotechnologie	■	■					■
Matériaux composites	■	■				■	
Calculs numériques d'écoulements fluides	■	■				■	■
fusion de données	■	■	■	■	■	■	
Production flexible		■		■	■	■	
Matériaux à grande densité d'energie	■						■
Calculs à hautes performances	■	■	■	■	■	■	
Propulsion et projectiles hypervéloces							■
Robotique et intelligence artificielle	■	■	■		■	■	■
Capteurs passifs	■		■			■	
Photonique	■			■		■	■
Production de puissance impulsionnelle	■	■					■
Matériaux semi conducteurs et circuits micro electroniques				■			■
Radars sensibles	■		■		■	■	
Traitement du signal et de l'image	■					■	■
Maîtrise de la signature	■	■			■		
Simulation et modélisation	■	■	■	■	■		■
Ingéniérie du logiciel	■		■		■		■
Supraconductivité	■	■					■
Environnement des systèmes d'armes	■	■			■		■

5. Conclusion

La méthode employée pour cette étude, fondée sur la recherche bibliographique doit être considérée avec circonspection. La réponse à une question ne fait appel qu'à l'avis général et la part laissée à la réflexion est réduite à une action à postériori. La réponse est donc soumise à :

- un délai de retard du à la mise à jour des données et de la littérature ouverte.
- une éventuelle manipulation facile à réaliser afin d'entraîner d'éventuels concurents dans des surenchères catastrophiques.
- l'occultation volontaire des domaines sensibles.
- un décalage masqué du contexte interessant les différents systèmes.

Enfin, le choix ou l'éviction de technologies nous semble relever principalement du choix politique de dépendance acceptée.

ANNEXE 1

L'HORIZON 2030, QUELLES TECHNIQUES MILITAIRES ?

SOMMAIRE

1 - INTRODUCTION - L'HORIZON 2030, QUELLES TECHNIQUES MILITAIRES ?

Prévoir les innovations technologiques de nature à bouleverser la conception des systèmes d'armes mis en oeuvre en 2030 représente un exercice plein d'embûches.

L'écueil est, premièrement, d'extrapoler à partir de ce qui existe sans prendre en compte au préalable l'évolution du contexte géostratégique. L'histoire de la France recèle quantité d'exemples de ce type de raisonnement dans le domaine de l'armement.

Il importe deuxièmement de garder à l'esprit le fait que les grands armements de notre époque, loins de s'inscrire dans la continuité sont pour la plupart nés d'une rupture technologique. Qui en 1940 aurait pu imaginer l'importance en 1980, du missile balistique, de l'arme nucléaire, du Sous-Marin Nucléaire Lanceur d'Engins, de l'avion discret, du missile « tire et oublie » ?

Dans ces conditions, déterminer les moyens militaires qui seront ceux de 2030 par le seul examen des évolutions techniques prévisibles n'est guère pertinent. La répartition des menaces dans le monde doit être prise en compte dans la définition des axes de recherche. Il est clair par exemple qu'une force d'intervention classique du type de la Force d'Action Rapide aurait moins d'efficacité, celle-ci fut-elle très performante au plan technique, si le moindre pays disposait de l'arme nucléaire. Le contexte géopolitique et son évaluation conduiront à fixer les stratégies adaptées et les moyens les mieux appropriés pour les mettre en oeuvre.

Un troisième élément est également à considérer. Il s'agit de l'évolution des sciences et techniques qui apparaît de moins en moins liée aux programmes militaires. C'est à l'inverse, davantage une adaptation de techniques civiles existantes à des fins militaires qui prévaut aujourd'hui.

En définitive, les considérations politiques et économiques tenant compte de la localisation de la menace, de sa puissance, de sa rapidité de mise en oeuvre, du degré de fanatisme éventuel, religieux ou autre auront une influence majeure sur les programmes d'armement du futur.

A cet égard, les pays industrialisés anciens ou nouveaux, de même que quelques pays du tiers-monde verront vraisemblablement s'accroître leur niveau de vie, leurs capacités financières et donc leurs possibilités d'acquisition et de développement d'armes sophistiquées. Même si se maintient l'écart entre les plus riches et les autres, les évolutions techniques permettront à beaucoup l'accès à l'arme nucléaire. A la menace d'un déluge nucléaire à partir de sites de missiles fixes ou embarqués viendra s'ajouter le risque d'infiltrations terroristes avec pose d'engins nucléaires sur le territoire visé. Le fanatisme religieux, le déséquilibre démographique ou le désespoir sont de nature à favoriser des actions transitoires pouvant atteindre très vite ce type de seuil nucléaire.

D'autre part, il est probable que, notamment pour les pays du tiers-monde accédant à la puissance nucléaire, cette « acquisition » se fasse au détriment de forces conventionnelles de niveau adéquat, ne laissant en cas de conflit que peu d'alternatives à la politique du pire c'est-à-dire du feu nucléaire. Les puissances majeures devront tenir compte de cette nouvelle distribution des moyens nucléaires.

Pour un pays comme la France la menace deviendra véritablement tous azimuts : d'une part des pays dotés de forces classiques importantes et efficaces, disposant d'un vaste arsenal nucléaire, d'autre part de nombreux petits pays mal équipés en forces conventionnelles et possédant des engins nucléaires en nombres suffisants pour constituer un danger redoutable.

Les stratégies à mettre en oeuvre et les moyens nécessaires à leur exécution auront à tenir compte de ces données.

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Il faut, à ce stade, noter que la durée de développement d'un nouveau système d'armes est de l'ordre de 10 ans et sa durée d'utilisation de 25 à 30 ans. Les armes disponibles en 2030 auront donc été développées à partir des années 1990 à 2020.

Deux catégories d'armes seront ainsi utilisées en 2030 :

- celles qui s'inscriront dans la continuité, dont la conception procède d'une amélioration des performances des armes actuelles ;
- celles qui bénéficieront d'une rupture technologique permettant de s'adapter à un nouveau champ de bataille ou de développer une nouvelle stratégie.

C'est dans ce cadre, qui prend en compte le poids du passé que doit se poursuivre une réflexion constructive.

2 - QUELLE BATAILLE EN 2030 ?

Est-ce vraiment le combat dans la zone Centre Europe qui constitue l'hypothèse la plus probable sur laquelle il faut travailler ?

Actuellement, bataille signifie :

- combat entre forces antagonistes qui cherchent à s'affaiblir ou à se détruire physiquement ;
- destruction d'une zone géographique ;
- mort de militaires et de civils.

Un des éléments essentiels est le char d'assaut, outil de l'invasion physique du territoire.

Trois facteurs modifieront la notion de champ de bataille :

- l'amélioration des moyens de communication et des capacités de transport ; elle fait prendre de la valeur à l'occupation physique extensive du terrain ;

- le pouvoir de l'information et de la simulation : si l'adversaire savait par des moyens de simulation que toute velléité belliqueuse de sa part serait écrasée, ne risquerait-il pas d'accepter la domination sans combattre : c'est la guerre de simulation ;
- la dissémination de la capacité de dissuasion nucléaire.

Dans ce contexte, il importe que la France puisse continuer à faire reposer sa défense sur la dissuasion. A l'horizon 2030, cette dissuasion, toujours nucléaire, devra présenter un caractère tous azimuts et disposer d'une panoplie différenciée apte à répondre à toute agression quelle que soit son origine et quel que soit son niveau, comme cela vient d'être souligné.

Dissuader c'est :

- persuader l'adversaire qu'il a plus à perdre qu'à gagner dans un conflit ;
- lui montrer les moyens dont on dispose pour lui infliger des dommages (pertes humaines et matérielles) sans rapport avec le bénéfice qu'il pourrait tirer du conflit.

La dissuasion suppose :

- des moyens militaires d'efficacité reconnue ;
- des capacités de destruction suffisantes pour que l'adversaire éventuel reconnaisse le préjudice qu'il pourrait subir en les affrontant ;
- une variété de moyens militaires pour que l'adversaire ne puisse pas les détruire entièrement lors de la frappe initiale.

Il existe toutefois des affrontements indirects qui tout en favorisant des états de crise peuvent se limiter à porter un préjudice jugé acceptable à l'adversaire :

- terrorisme classique,
- alimentation de crises internes (guérilla ou soulèvements régionaux),
- désinformation visant à déstabiliser le pouvoir politique adverse,
- sabotage industriel ou informatique,
- pollution grave.

La marge reste très étroite entre certains de ces types d'affrontement et les actes de compétition admis par la morale internationale :

- guerre économique ;
- concurrence pour la domination de grandes entreprises dans des secteurs majeurs de l'activité ;
- lutte d'influence pour favoriser l'ascension politique d'un parti ami.

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Les conflits majeurs ont été étouffés à grande échelle depuis 40 ans par la dissuasion nucléaire mais qu'adviendra-t-il des capacités de dissuasion de la France à l'horizon 2030 ?

3 - QUELLE DISSUASION POUR 2030 ?

La crédibilité de la dissuasion repose aujourd'hui sur la capacité de pénétration des missiles et des têtes nucléaires, - objets éminemment petits et véloces en phase terminale - ainsi que sur l'invulnérabilité du porteur.

S'agissant de la capacité de pénétration, il apparaît difficile d'imaginer que, même à l'horizon 2030, les recherches menées dans le cadre du SDI puissent apporter une garantie absolue au plan de la défense.

Il est clair, dans ce contexte, que vis-à-vis des puissances majeures, un facteur essentiel de la dissuasion française restera fonction de l'invulnérabilité de nos sous-marins nucléaires lanceurs d'engins, capables, à tout moment, de délivrer de l'ordre de 300 coups nucléaires sur les intérêts vitaux de l'hostile déclaré.

3.1 - *L'INVULNERABILITE DES SOUS-MARINS LANCEURS D'ENGINS (SNLE)*

Cette invulnérabilité tient au caractère indétectable des sous-marins. Ceux-ci évoluent dans un milieu tridimensionnel opaque très hétérogène doté d'une vie biologique intense. Il ne s'agit en effet pas du tout du monde du silence comme on aime à le décrire! Tout le jeu consiste donc à se fondre dans l'environnement.

Historiquement, avant la guerre 1939-1944, la détection faisait appel à la vue, les sous-marins n'ayant pas la capacité de demeurer tapis dans les profondeurs. Ils évoluaient dans la couche 0-80m et devaient faire surface fréquemment afin de remplir leurs batteries à l'aide de leurs générateurs Diesel. De nos jours, le caractère anaérobie de la propulsion nucléaire des SNLE les autorise à demeurer quasi indéfiniment dans les grandes profondeurs.

Rien n'empêche toutefois de tenter une extrapolation vers les années 2030 des techniques probablement accessibles rattachées au domaine de détection optique.

La détection dans le domaine du visible ou du quasi visible

En 2030 les SNLE seront tapis à 1000m de profondeur ; la technologie du Titane permet dès maintenant une telle performance. La vue directe est et demeurera impossible. La détection infrarouge paraît improbable : comment imaginer en effet qu'une perturbation locale de quelques dizaines de degré puisse être discriminée lorsqu'elle remonte à la surface parmi les nombreux courants marins aléatoires qui existent, alors que les conditions de surface sont hétérogènes (masquage du soleil par des nuages ou non, effet du vent etc.). Aucune méthode sûre de détection par l'infrarouge ne paraît envisageable lorsque le SNLE se trouve en patrouille à grande profondeur. Par contre lorsque le SNLE s'approche des eaux peu profondes qui conduisent à son port d'entretien, le problème se pose en des termes différents. Il s'agit de la protection des atterages, sujet plus opérationnel que technique qui fait appel aux ruses de la guerre sous-marine.

Par conséquent, ni la vue directe ni l'infrarouge n'ont de réelles chances de constituer des méthodes de détection d'un sous-marin en patrouille à l'horizon 2030.

Reste la question des longueurs d'onde qui ont la faculté de pénétrer relativement profondément dans l'espace marin : il s'agit bien évidemment du laser bleu vert. Cette longueur d'onde est, d'ores et déjà, capable, semble-t-il, d'être réfléchie par un miroir disposé à 100m sous l'eau. En 2030 avec l'augmentation probable de la puissance des lasers embarquables sur avion ou satellite, une telle profondeur risque de s'accroître.

Se pose alors la question du balayage de zone : en effet s'il est aisé de focaliser un rayon laser bleu-vert sur un miroir dont la position est connue au préalable, la difficulté est grande de balayer une zone telle que l'Atlantique Nord dans un temps suffisamment court et d'interpréter la quantité de signaux reçus.

Seule une amélioration spectaculaire des capacités de traitement du signal, associée à des détecteurs satellitaires, peut permettre alors de détecter le sous-marin.

La détection acoustique

De 1943 à 1975, environ, le sonar actif a constitué le mode de détection privilégié des sous-marins. Il s'agissait d'émettre un signal sonore (BF ou HF) qui, après avoir rebondi sur sa cible, était interprété par l'émetteur. Cela permettait ainsi de détecter et localiser l'adversaire. Bien entendu ce signal est atténué par son cheminement sous-marin et comme il doit parcourir deux fois son trajet pour revenir à sa source, si l'adversaire potentiel possède des moyens d'écoute passive puissants, il pourra détecter lui-même l'émetteur du signal à une distance telle que le retour de ce signal l'atténue suffisamment pour que celui-ci demeure masqué dans le bruit de fond et n'atteigne jamais l'émetteur. C'est toute la dialectique du rapport signal sur bruit.

La portée d'un sonar actif est de l'ordre de quelques dizaines de kilomètres (pour des conditions de bathytermie données) et dès les années 1980 les performances des systèmes d'écoute passive à Extrêmement Basse Fréquence (ETBF) ont permis de repérer un intrus trois fois plus loin environ. Le combat était alors gagné par le sous-marin silencieux, et cela pour longtemps.

Cette situation est celle que nous vivons aujourd'hui et, en fonction des développements actuellement connus, elle prévaudra certainement jusqu'aux années 2015, 2020. En effet, les sous-marins ont atteint un tel degré de silence, ils sont dotés d'une telle capacité d'écoute (progrès des capteurs opto-électriques, progrès des capacités de traitement de signal embarquées) que leur avantage acoustique ne peut être raisonnablement franchi avant, au minimum, une vingtaine d'années. La situation est telle que deux sous-marins identiques ayant les capacités décrites ci-dessus, ne peuvent se détecter qu'à quelques kilomètres l'un de l'autre, ce qui est accessoirement de nature à poser des problèmes de sécurité de navigation dans certaines zones resserrées!

La seule recherche qui apparaît actuellement prometteuse dans le domaine de la détection acoustique concerne le sonar actif ETBF. Il s'agit d'émettre un signal de quelques Hertz qui se propage à plusieurs centaines de kilomètres. Le problème est que, plus la longueur d'onde est importante, plus la localisation est difficile. La discrimination présente une difficulté redoutable et rien ne permet d'affirmer que cette technique, tributaire comme celle des lasers bleu-vert de l'augmentation des capacités de calcul, débouchera avant d'autres : le laser bleu-vert ou la détection magnétique.

La détection magnétique

Le sous-marin constitue une masse métallique qui perturbe le champ magnétique local. Tout détecteur capable de mesurer cette perturbation est, en théorie, à même de détecter un sous-marin. Toutefois ces détecteurs (appelés M.A.D.) n'ont qu'une portée limitée et le SNLE se protège en plongeant profond et en essayant de compenser au mieux la perturbation magnétique qu'il représente (par des circuits parcourus par des courants).

D'importants progrès sont possibles en matière de protection mais également de détection.

En effet, les détecteurs S.Q.U.I.D. (Superconducting Quantum Interference Device) apparaissent au stade du laboratoire. Ils permettent un gain d'un facteur 1000 sur la sensibilité (ce qui approche la limite théorique physique). D'autre part, la technique de chasse, à l'aide de ce genre de capteur, s'appuie sur un balayage de zone par avions volant à basse altitude et comme pour le laser bleu-vert, les progrès attendus en matière de capacité de calcul rendent envisageables, à l'horizon 2030, une certaine percée dans ce domaine.

Il est, dans tous les cas, probable que cette technique représentera en 2030 un mode de détection au moins aussi performant que la détection acoustique active.

Détection acoustique, détection magnétique, détection par laser bleu-vert, tels sont les trois domaines qui risquent d'offrir des possibilités de détection de sous-marins en patrouille à cette échéance. Il importe toutefois de ne pas négliger ce qui pourrait constituer des technologies émergeant brutalement.

Les techniques de détection exotiques

Il s'agit des techniques de détection des radioéléments, de détection de sillage, de détection par radar S.A.R. (Synthetic Aperture Radars), ou de détection des rejets.

S'agissant de sous-marins français, dont les réacteurs sont dotés de circuits secondaires et dont les éléments combustibles sont extrêmement protégés, aucune détection par une méthode de ce type (rayons gamma, neutrons, etc.) n'est crédible.

Pour ce qui concerne les rejets (déchets, hydrogène, gaz carbonique etc.) les dispositions prises actuellement suffisent et peuvent être encore améliorées si la menace augmentait.

La seule technique susceptible de créer une rupture à l'horizon 2030 est probablement la détection de sillage. Parmi les différentes méthodes envisageables, la plus prometteuse semble être la détection par radar S.A.R. Il s'agit de repérer par ce type de radar les manifestations en surface d'une perturbation sous-marine de type sillage. Pour qu'une percée soit réalisable dans cette voie, trois conditions sont à remplir :

- bien maîtriser la théorie mathématique des ondelettes (et des avancées sur les questions des fractales et des théories du chaos pourraient créer la surprise) ;

- bien connaître, en détail et en temps réels, le milieu marin ;
- posséder les capacités de calcul adéquates car il s'agirait une fois de plus d'une technique de balayage de zone.

3.2 - *LA GUERRE DE LA DISCRETION AERIENNE*

En dehors des systèmes centraux, il sera nécessaire en 2030, nous l'avons vu, de dissuader toute une série d'adversaires potentiels dotés d'armes nucléaires de bas niveau.

A cette menace pourra répondre le vecteur atmosphérique discret.

Les travaux conduits par les Etats-Unis depuis la fin des années 1950 ont permis de mettre au point des avions et des missiles très discrets dans les gammes d'ondes utilisées par les systèmes de détection actuels. Dans ces bandes de fréquence la signature électromagnétique et infra-rouge des avions et des missiles peut devenir tellement faible que les systèmes de défense deviennent inopérants :

- les radars au sol voient les avions ou les missiles trop tardivement et ne permettent pas un temps de réponse suffisant pour les intercepter ;
- les avions de combat non furtifs, munis de radars, sont détectés et tirés par les missiles air-air emportés par les avions furtifs avant de les avoir détectés.

D'autres pays dans le monde ont entrepris des travaux importants dans le domaine de la discrétion, mais leurs compétences restent en retrait par rapport à celles des Etats-Unis. Ils parviendront aux mêmes niveaux de discrétion, à condition qu'ils aient la volonté et les moyens économiques de persévérer dans leurs programmes de recherche et de développement.

Pour réaliser des avions discrets, il est nécessaire d'effectuer les travaux suivants :

- calcul par ordinateur des signatures électromagnétiques et infra-rouge de l'avion ;
- optimisation des formes de l'avion pour éliminer les zones à forte signature (points brillants) ;
- recherches dans le domaine des matériaux : matériaux structuraux ayant des capacités d'absorption dans les gammes d'ondes adéquates, revêtement ou peintures absorbantes ;
- moyens d'essais pour mesurer les signatures et permettre par itération l'optimisation ;
- optimisation des concepts opérationnels : compromis/discrétion/contre-mesures par exemple ;
- réduction active de SER qui permet de renvoyer au radar adverse une onde de même nature que l'onde réfléchie mais en opposition de phase.

L'ensemble des connaissances et des moyens à acquérir représente une vaste gamme d'études et de recherches. Il convient également de noter que les performances du système de contre-mesures (ou d'aide à la pénétration) de l'avion ou du missile peuvent permettre à l'assaillant de pénétrer même si le niveau de discrétion intrinsèque est supérieur à la limite de détection : il y a complémentarité entre la discrétion de l'avion et les performances du système de contre-mesures qui est susceptible de brouiller les radars hostiles.

La limite de discrétion absolue dans une gamme de fréquences est atteinte lorsque la signature d'un objet est inférieure à celle du bruit de fond (autres objets volants, réflexions parasites...), dans la mesure où l'adversaire n'a pas connaissance du gabarit de cette signature.

Cependant il n'est pas possible de rendre discret un objet volant dans toutes les gammes de fréquences. La discrétion est envisageable uniquement dans une gamme de fréquence adaptée (qui est choisie aujourd'hui par rapport aux radars existants). La possibilité demeurera toujours de développer des systèmes de détection hors de la gamme. C'est la course classique entre l'arme et la cuirasse.

Aujourd'hui, l'avantage est à l'arme : il existe des avions américains très discrets et il existera demain d'autres avions très discrets dans une gamme suffisamment large pour que les radars de l'an 2000 ne puissent pas les détecter. En 2030, les radars auront évolué, mais les avions et les missiles également et il n'est pas interdit de penser que l'avantage sera toujours aux avions et surtout aux missiles dont les dimensions sont plus faibles.

La limite dans cette course technologique est économique : les avions et les missiles discrets coûtent plus cher que les avions et missiles de la génération précédente. Les radars opérant dans des gammes de fréquences moins favorables doivent surmonter des difficultés technologiques, au prix de développements onéreux. L'avantage acquis, soit dans le domaine des avions et missiles discrets, soit dans celui des radars capables de détecter tous les hostiles, est essentiel et se révélera fondamental pour porter le danger chez l'adversaire ou pour se protéger de ses attaques.

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A ce stade, après ces quelques réflexions concernant ce qui peut être imaginé comme l'ossature de la défense de la France en 2030, il importe d'essayer de procéder de façon analytique afin de tenter de saisir toute l'originalité des techniques futures et leur impact sur l'arme de demain.

4 - QUELLES TECHNOLOGIES POUR 2030 ?

4.1 - *LE TRAITEMENT DE L'INFORMATION*

C'est probablement dans le domaine des systèmes informatisés de commandement que la révolution du calcul apportera le plus d'innovations.

Les Systèmes Informatisés de Commandement (SIC) ou C3I (Command, Control, Communications and Intelligence) seront les supports futurs de la gestion d'un théâtre d'opérations.

L'objectif essentiel de ces systèmes sera de fournir une assistance efficace au commandement. Pour cela un SIC doit :

- donner accès à toutes les informations pertinentes dont le décideur peut avoir besoin,
- opérer des pré-traitements intelligents pour synthétiser les informations nécessaires sur les données reçues,
- élaborer toutes les informations permettant de prendre la décision le plus rapidement possible, en ayant réduit au maximum les facteurs d'incertitudes.

Les systèmes actuels progressent de façon spectaculaire grâce à l'augmentation des performances des dispositifs électroniques. Ceci conduit donc à :

- augmenter les flux d'informations reçues pour améliorer la précision et l'efficacité des systèmes de détection,
- augmenter les capacités de traitement (la puissance d'un supercalculateur de 1985 peut aujourd'hui être embarquée à bord d'un engin),
- présenter des résultats dans des formalismes très explicites : dessin, graphiques, images, langage naturel ou voix synthétique.

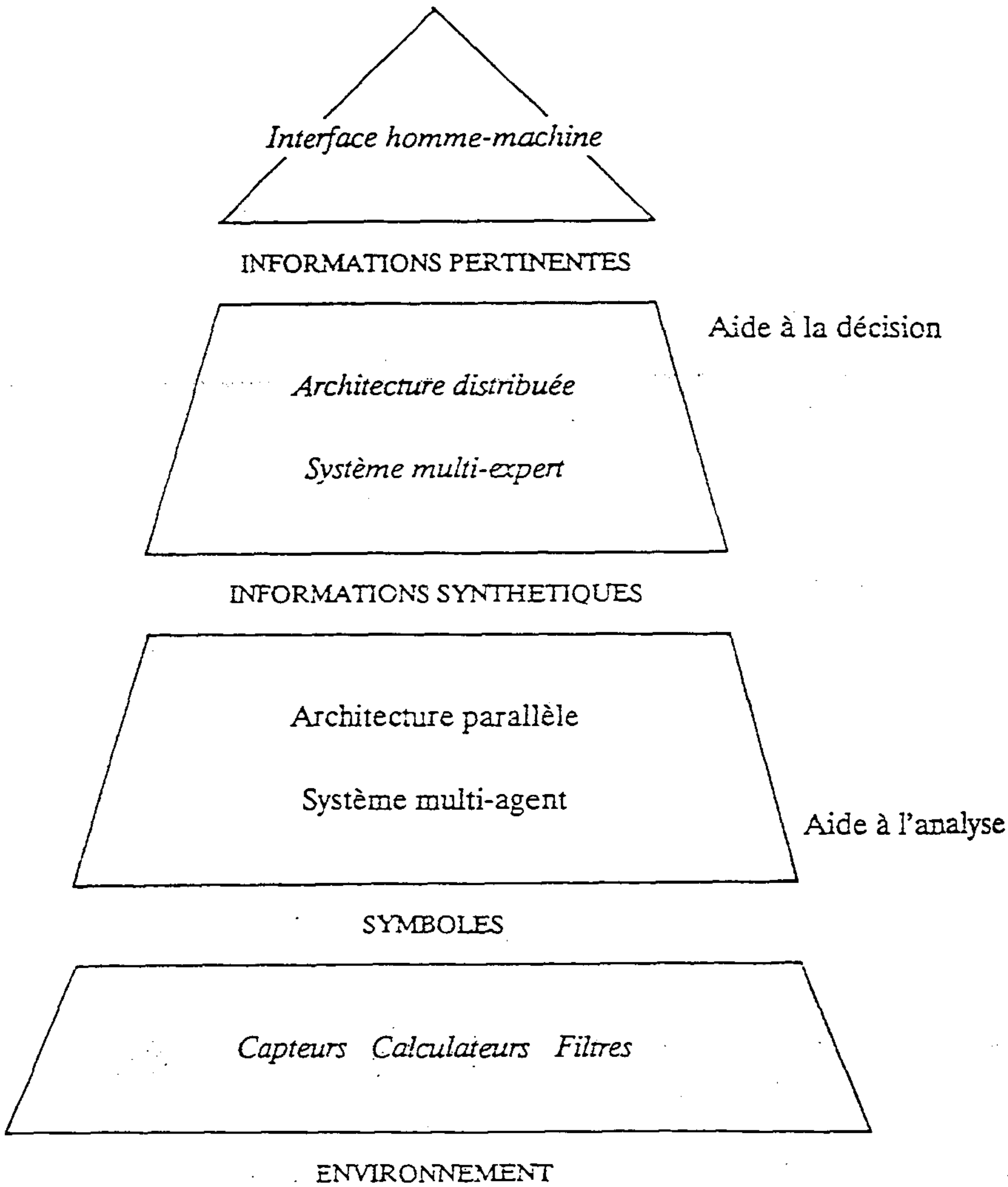
La méthodologie de définition des systèmes actuels est basée sur des spécifications précises devant fournir des informations certaines pour un système de commandement intégré et centralisé. Cette démarche va rapidement atteindre ses limites, compte tenu de l'évolution prévisible des capacités technologiques. Les SIC de cette génération ne savent donc pas :

- réguler les flux de données et acheminer le sous ensemble de l'information nécessaire à l'exercice du commandement ;
- gérer la pertinence et l'incertitude des données captées ;
- coopérer entre plusieurs systèmes pour exploiter des analyses et des déductions réalisées simultanément par plusieurs SIC.

La solution pour atteindre ces nouveaux objectifs passe par une méthodologie « *Intelligence Artificielle* », par opposition à la méthodologie actuelle que l'on pourrait qualifier de « *Traitement Automatisé* ».

Les Problèmes à résoudre

Les modèles conceptuels pour la mise en oeuvre de cette méthodologie font aujourd'hui défaut. Des recherches théoriques sont en cours, dont l'aboutissement sous forme de systèmes opérationnels concerne le long terme. Ces nouvelles voies de modélisation peuvent se représenter par le schéma ci-dessous (la forme pyramidale symbolisant des niveaux de présentation de l'information de plus en plus synthétiques).



La base est composée des équipements nécessaires à l'acquisition des données. Elle constitue l'interface entre le système et l'environnement. Elle est composée d'un ensemble multi-capteurs et des dispositifs d'accès fournis au décideur.

Ces données sont codées puis analysées pour en extraire des caractéristiques significatives. Ces traitements dits, de « bas niveau », construisent des informations symboliques qui seront analysées, enrichies et interprétées par les niveaux supérieurs : à partir de symboles plus ou moins précis à l'étage inférieur, le système commence à raisonner en incorporant des connaissances appropriées et contextuelles. Par exemple, des données issues de signaux radar peuvent être corrélées avec des bases de connaissances contenant la description des engins possibles sur un champ de bataille pour fournir une information qualitative et quantitative précise.

L'étage de décision permet de dégager les informations pertinentes et de gérer un certain degré d'incertitude. Des choix possibles et leurs conséquences sont alors présentés au décideur qui peut agir en fonction d'une stratégie dont il a la maîtrise.

Les problèmes à résoudre pour définir les concepts de cette approche concernent :

- la modélisation de la connaissance que l'on installe dans le système et qui permet d'opérer les choix initiaux ;
- l'introduction des contraintes temporelles dans les systèmes de déduction qui nécessitent d'adapter les stratégies de contrôle pour obtenir rapidement une information sommaire ou une information très précise mais en un temps imparti ;
- la gestion de larges bases de connaissances distribuées sur plusieurs sites ;
- la méthodologie de développement de Systèmes Experts pour atteindre une production industrielle de tels systèmes.

A ces problèmes méthodologiques s'ajoutent des problèmes d'architectures de calculateurs pour supporter de tels systèmes.

Architectures des calculateurs

De par la distribution des traitements, l'architecture de la machine informatique est décomposée en plusieurs sous-machines opérant simultanément et coopérant à la résolution du même problème.

Les modèles d'exécution des programmes sur les machines actuelles sont séquentiels. Les instructions s'exécutent les unes après les autres dans l'ordre défini par le programmeur. L'exécution de traitements, distribués sur plusieurs machines, sur plusieurs sites distants, impose de savoir gérer de nombreux flots d'instructions en simultanéité. Les modèles d'exécution des programmes sur des machines parallèles pour le traitement d'informations symboliques fait l'objet de recherches et ne pourra donner lieu à des systèmes opérationnels qu'à long terme.

Plusieurs raisons fondamentales incitent à concevoir de telles architectures :

Premièrement, de nombreux problèmes semblent pouvoir être traités en parallèle : soit que le problème se décompose en unités indépendantes synchronisées statiquement, soit que les algorithmes employés engendrent des exécutions simultanées par une parallélisation explicite ou implicite des opérations.

De plus, la complexité des problèmes à résoudre ne permet plus d'envisager une exécution séquentielle. En effet, la plupart des problèmes posés par le calcul symbolique ont une complexité exponentielle en temps d'exécution. Bien que le parallélisme ne permette pas de transformer un problème de complexité exponentielle en complexité polynominale, l'espace des solutions peut être examiné en simultanéité et une solution satisfaisante peut être trouvée sans attendre que tous les calculs soient terminés.

Pour ce qui est du traitement numérique, la voie du parallélisme est déjà expérimentée depuis longtemps, essentiellement sous la forme du parallélisme pipe-line ou SIMD (Single Instruction Multiple Data) ; un nouvel ordre de grandeur n'est envisageable qu'avec le développement de nouveaux modèles d'exécution basés sur un parallélisme MIMD (Multiple Instruction Multiple Data), réseau ou même neuro-mimétique.

Deuxièmement, la nature même d'une application contrainte par le temps est critique en terme de temps d'exécution et de ressources disponibles : pour un système temps réel, le temps pour effectuer un traitement doit être inférieur à l'intervalle de temps séparant l'activation du calcul de l'exploitation des résultats issus de ce traitement.

Cet intervalle est généralement inférieur à la seconde, souvent de l'ordre de la milliseconde ou de quelques dizaines de microsecondes. En ce qui concerne des applications symboliques, la détermination de cet intervalle reste à définir.

L'aspect temps-réel du système provoque de nombreuses contraintes. Le système doit notamment réagir à des conditions externes indéterminées au lieu d'exécuter un programme pré-enregistré dans lequel tous les états ont été prévus et dont les réponses possibles ont été programmées.

En définitive, la réalisation de tels systèmes nécessite de nouveaux concepts formels s'appuyant sur des théories qui sont à l'étude. Il s'agit essentiellement de nouvelles logiques permettant de modéliser l'incertain : logique modale, floue, temporelle, ou intuitionniste. Tant que ces théories ne seront pas complètement formalisées, on ne pourra raisonnablement envisager de systèmes fiables, produits industriellement, doués de « raisonnement ».

4.2 - *LA SIMULATION D'UNE GUERRE OU LES « WAR GAMES »*

Rien n'interdit d'imaginer qu'un jour, avant de déclencher un conflit en vraie grandeur, l'on puisse simuler les moyens de combat réellement existants chez l'un et l'autre adversaire, et faire déterminer le vainqueur par une simulation numérique.

Ce scénario se heurte à de nombreuses difficultés : il faut évidemment être à même d'obtenir le résultat en un temps raisonnable, c'est-à-dire disposer d'ordinateurs ultra-rapides (hypothèse : en 2020, la vitesse au niveau d'une puce sera multipliée par 5, la densité des composants par puce passera de 200 à 6000, c'est-à-dire de 1 milliard à 30 milliards de composants par puce). Il est également nécessaire d'écrire le logiciel correspondant, qui devrait être plus complexe que celui du programme SDI, estimé entre 13 000 et 81 000 années-hommes. Il est d'autre part plus que douteux que le perdant admette sans arrière-pensées la justesse du logiciel, or l'amélioration des méthodes de création de logiciel ne permettra certainement pas d'en affirmer l'exactitude, même en 2030.

Obtenir les données de base (performance des engins des pays combattants) pourrait être possible. Mais l'homme entre dans les chaînes de décision, et comment simuler la psychologie du décideur dans des conditions de stress jamais rencontrées ?

Comment aussi accepter que les scenari prévus par l'un et l'autre belligérant se déroulent conformément aux plans, particulièrement en matière de C3I ? Des études ont montré qu'une séquence réaliste de 8 décisions successives de prise de décision/transmission/réception-réalisation, chacune ayant une probabilité de déroulement non conforme de 0.10 par opération, rend probable (à 57 %)) une déviation majeure.... En tenir compte dans la simulation est possible. Mais dans ces conditions le vainqueur peut être le vaincu à la simulation suivante, avec les mêmes paramètres non probabilistes en entrée.

Pour ces raisons ainsi que d'autres, plus complexes, il semble bien que, même en 2030, cette façon de « faire la guerre en l'évitant » restera aléatoire.

4.3 - *LA GUERRE METEOROLOGIQUE*

Les exemples de batailles que les caprices de la météorologie ont influencées sont trop nombreux pour les rappeler tous. Citons seulement la bataille pour Bastogne en février 1945 où l'arrivée d'une période de beau temps a permis à l'aviation américaine de bombarder massivement les positions acquises par les Allemands et de stopper la contre-offensive de l'Armée allemande en Belgique.

La maîtrise de la météo peut se révéler une arme imparable pour dominer un adversaire :

- maîtrise partielle permettant de déclencher des orages dans des zones sensibles pour immobiliser le matériel ou rendre difficiles certaines opérations maritimes ou aériennes dans un conflit généralisé. On peut douter de son efficacité, compte tenu de la présence de missiles et d'avions capables d'opérer par tous temps ;
- maîtrise totale permettant de déclencher dans certaines zones des périodes de sécheresse graves ou au contraire des pluies torrentielles.

Le niveau actuel de la technique ne permet pas d'envisager à court terme une maîtrise de la météo car les énergies mises en jeu sont très élevées. Peut être en 2030 possédera-t-on suffisamment de moyens pour infléchir localement la météo. Même si cet infléchissement a une efficacité limitée dans un conflit d'ensemble entre grandes puissances, il pourrait se révéler redoutable dans un conflit localisé où le champ de bataille est plus restreint.

4.4 - *LA BIONIQUE*

La bionique est la branche de la technique fondée sur l'imitation de mécanismes biologiques naturels, qui présentent bien souvent des performances supérieures par rapport aux réalisations techniques assurant les mêmes fonctions.

A ce jour le recensement des mécanismes biologiques susceptibles d'être utilisés est limité.

Il s'agit essentiellement des mécanismes du domaine du comportement avec la chaîne du traitement biologique de l'information en passant par la réception, le traitement proprement dit et la réponse par les organes effecteurs.

Dans le domaine du traitement de l'information, l'être vivant manifeste une supériorité marquée sur la machine. Il capte, par ses organes sensoriels, les informations provenant tant de son environnement que de son milieu intérieur. Ces informations sont transmises par des voies nerveuses, sous forme de messages codés, jusqu'aux centres nerveux de projection ou « analyseurs » où se déroulent des opérations complexes d'intégration d'association et de rétroaction. Ces opérations traitent en un temps très court et avec une dépense d'énergie très faible le flux d'informations fourni à tout instant par les récepteurs. Ce flux est soit stocké dans une mémoire, soit transféré aux voies nerveuses qui conduisent les réponses jusqu'aux organes effecteurs. Ceux-ci comprennent essentiellement le système musculaire, qui oriente et adapte le comportement, et le système glandulaire, qui rétablit les équilibres végétatifs momentanément perturbés.

Les récepteurs sensoriels captent des signaux de nature variée (électromagnétique, mécanique, acoustique, dynamique,...), transforment l'énergie incidente en énergie électrique et projettent des messages codés vers les centres spécifiques.

Quelques-uns de ces récepteurs, qui possèdent une sensibilité et une sélectivité particulièrement remarquables, fournissent matière à la recherche des « bioniciens ».

Les mécanorécepteurs -la cochlée de l'homme et des mammifères qui convertit les ondes sonores en trains d'afflux nerveux, par exemple- représentent le dispositif le plus sensible.

Beaucoup d'animaux sont sensibles aux vibrations de fréquence plus basse que celles que perçoit l'être humain : cas des poissons, des larves aquatiques d'amphibiens, ou encore de la méduse reconnaissant le frottement des vagues sur l'air. Les soviétiques ont construit, sur ce modèle, une « oreille artificielle » qui permettrait de prévoir quinze heures à l'avance l'arrivée d'une tempête.

A l'opposé, de nombreuses espèces animales sont sensibles aux vibrations de haute fréquence, inaudibles pour l'homme : c'est le cas des chauves-souris et des dauphins qui peuvent émettre et recevoir des signaux acoustiques de fréquence supérieure à 150 KHZ.

Ce sonar naturel, efficace pour l'orientation et la détection à distance des proies, réalise des performances qui justifient la curiosité manifestée pour ces animaux. Les chauves-souris et les dauphins sont capables de repérer des barrières de fils métalliques fins, en dehors de toute possibilité de vision directe. Ils sont capables d'extraire des signaux d'intensité inférieure à celle du bruit ambiant. Le dauphin est capable de faire varier la vitesse et la fréquence de répétition de son sonar, qui peut ainsi fonctionner aussi bien à basse fréquence et à grande puissance pour la détection à longue distance, qu'à haute fréquence pour la reconnaissance rapprochée. De plus, il serait en mesure de déplacer sa source acoustique ce qui, par effet Doppler, lui permettrait de déterminer l'emplacement d'un câble.

Ces éléments montrent tout l'intérêt de l'étude de ce procédé naturel d'écholocation pour les spécialistes radar et sonar.

Les photorécepteurs

La photoréception est un sens presque universellement présent dans le monde animal. Les yeux des coléoptères et de la grenouille ont des rétines à facettes, qui, en intégrant les informations, permettent d'apprécier la vitesse et la direction des cibles visuelles. L'étude de fonctionnement a conduit des spécialistes du Max Plank Institut de Tübingen à réaliser un indicateur de vitesse destiné aux avions. L'oeil électronique pourrait fournir un outil utile dans les recherches ayant trait aux problèmes de *« reconnaissance de formes »*, devant conduire à la réalisation d'équipements pour la surveillance, la reconnaissance et le guidage des véhicules. Il convient de noter le formidable pouvoir d'intégration de toutes les données sensorielles qui confère à l'oeil humain sa supériorité.

Les chémorécepteurs

La perception et la reconnaissance de certaines substances chimiques sont très développées chez certaines espèces animales. C'est le cas des papillons et des saumons notamment. Il est donc intéressant, du point de vue bionique, de chercher à copier les chémorécepteurs naturels pour obtenir des nez *« synthétiques »* dont les applications seraient multiples.

Les thermorécepteurs

Les êtres vivants possèdent des récepteurs thermosensibles qu'ils utilisent en complément à la vue. Certains serpents, tels que le crotale détectent des variations thermiques très faibles (main humaine perçue à plusieurs dizaines de centimètres de la tête), l'étude de tel mécanisme est susceptible d'inspirer des solutions originales aux problèmes de la détection des radiations infra-rouges.

Les électrorécepteurs

Certains poissons sont capables de repérer des cibles par émission-réception de champs électriques faibles. L'étude de l'électrolocalisation pourrait contribuer à l'amélioration des systèmes de détection et de guidage.

Un autre domaine de recherche concerne l'orientation dans l'espace et le temps. Nos connaissances sont encore bien vagues en ce qui concerne l'orientation à longue distance de nombreux animaux migrateurs, qui met en jeu des mécanismes très complexes, voire des sens hypothétiques (sensibilité aux gradients du champ magnétique terrestre, aux variations des forces de Coriolis, aux ondes hertziennes). De plus, les rythmes auxquels sont asservis la physiologie et le comportement de multiples êtres vivants impliquent nécessairement l'existence d'« horloges biologiques », dont le réglage et le fonctionnement nous échappent.

Le domaine du traitement de l'information est le plus important à explorer, en raison des procédés globaux, synthétiques et agissant en parallèle qui sont mis en oeuvre. Les problèmes fondamentaux résolus par les différents types de systèmes nerveux sont de trois sortes :

- Reconnaissance des formes : dans ce domaine, il s'agit en particulier de ressemblances, en dépit des différences d'échelle et des différences de point de vue pour l'oeil. Cela paraît sous-entendre la reconnaissance de caractères invariants d'une forme. Si un tel mécanisme existe réellement, toutes les sciences bénéficieront de sa connaissance ;

- Mémoire et imagination : Il semble en réalité qu'une mémoire fidèle n'existe pas, mais que se conservent différents aspects élémentaires de chaque événement perçus, et que le cerveau reconstitue plus ou moins fidèlement la réalité au moment de l'apparition d'un souvenir. Cette faculté est de ce fait liée aux mécanismes de l'imagination et de l'abstraction, dont la connaissance pourrait faire faire une grand pas aux problèmes actuels de l'informatique ;
- Mécanismes d'apprentissage : dans un grand nombre de domaines très complexes, il serait utile de connaître les mécanismes que l'homme utilise pour des actions plus simples, lorsque, ignorant les lois qui régissent ces actions, il fait son apprentissage dans le domaine qui leur correspond.

Les organes effecteurs des systèmes naturels méritent également une attention particulière. Tout le système musculaire est un miracle de rendement thermodynamique ainsi que de contrôle de l'action. Pouvoir en reproduire les mécanismes serait extrêmement avantageux.

Enfin, les recherches à caractère bionique peuvent déboucher à plus ou moins long terme sur des applications. Parfois, l'homme devra se contenter d'exploiter directement les *« brevets »* inventés par la nature, en considérant l'organe intéressant ou l'organisme tout entier comme une « boîte noire ». Il pourra, par exemple, utiliser telles quelles les aptitudes particulières de certains êtres vivants, qu'il s'agisse de micro-organismes fournissant de l'énergie électrique bon marché, dans des piles « à bactéries » par exemple, ou bien d'animaux supérieurs tels que le dauphin.

Dans d'autres cas, seul l'organe intéressant sera incorporé dans un ensemble mécanique ou électronique, de façon à construire une machine mixte pourvue de composants biologiques hautement miniaturisés à bas prix de revient et à fonctionnement sûr (cellules nerveuses constituant des éléments de calculatrice, appareils de détection chimique utilisant des organes sensoriels d'insectes). Ces réalisations se heurtent encore à de nombreux problèmes.

On pourra enfin extraire, de certains tissus ou organes, un signal électrique et l'utiliser directement pour mettre en marche ou contrôler un moteur ou un dispositif électronique, comme par exemple la *« main articulée bio-électrique »* réalisée à Moscou.

On peut enfin copier très exactement des dispositifs biologiques. Dans cette entreprise, il convient de ne pas être trop ambitieux, car la plupart des modèles vivants mettent en jeu des mécanismes qui échappent à notre entendement et des matériaux que notre chimie ne sait pas encore synthétiser.

4.5 - *L'AMELIORATION DES CAPACITES HUMAINES*

Paradoxalement, face à une prodigieuse augmentation des capacités techniques des armes et systèmes présents sur le champ de bataille, on risque de trouver des hommes plus déphasés et dépendants de ces technologies sur les plans physique et intellectuel.

L'évolution prévisible des modes de vie mettra à la disposition du commandement une troupe (qu'elle soit nombreuse ou très réduite) moins résistante sur le plan physique qu'aujourd'hui, de la même façon que le fantassin de 1914 était plus robuste et dur à l'effort que l'appelé de 1990.

Au plan intellectuel, s'il est vraisemblable que le niveau général soit très sensiblement supérieur à ce qu'il est actuellement ce sera au prix d'une plus grande spécialisation. Le manque de compréhension entre spécialistes de disciplines différentes intégrées dans un même système pourrait être générateur d'inefficacité ou d'efficacité réduite. L'appréciation d'une situation dans sa globalité sera sans doute plus difficile pour un seul homme et le responsable devra s'en remettre davantage à une analyse automatisée. A contrario, au niveau de l'exécutant, cette évolution diminue le risque d'erreur humaine et contribue à la fiabilité de l'ensemble.

Il est tout à fait vraisemblable qu'encore plus qu'aujourd'hui, le facteur humain définira la limite d'utilisation d'un système choisi. Seul le pilote limite actuellement certaines formes d'emplois ou d'évolution des avions de chasse : il ne pourrait tolérer les contraintes physiques qu'elles impliquent.

Dans ces conditions, on imagine mal que ce décalage grandissant, physique et intellectuel, entre l'homme et la machine soit accepté. Seul le recours à la médecine, la biologie voire la génétique permettront de gommer partiellement ce déphasage.

Les résultats et performances nécessaires sur les plans de la résistance physique et des capacités mentales font appel à des techniques dont nous observons les balbutiements : médicaments permettant une meilleure concentration intellectuelle, plus longtemps, pilule anti-sommeil, alimentation concentrée. Mais il est probable que l'on atteindra très vite des limites qui risquent de paraître insuffisantes. Il faudra alors passer à des traitements médicaux plus poussés afin de pouvoir par exemple se passer de sommeil plus d'une semaine tout en restant parfaitement alerte. Selon la morale actuelle ces procédés appartiennent clairement au domaine du dopage et sont difficilement compatibles avec des conceptions non totalitaires de l'intérêt supérieur de la nation.

Il s'agit sans doute là d'une appréciation destinée à évoluer. En effet bien des thérapeutiques actuelles auraient été probablement considérées comme du dopage il y a quelques dizaines d'années.

Si des problèmes de morale se posent pour l'utilisation de certaines techniques médicales de prolongation de l'attention et de l'effort physique, ils sont incontournables en ce qui concerne la biologie et la génétique. Les scientifiques auront les moyens à l'horizon 2030 de « profiler » le patrimoine génétique d'enfants à naître ou à concevoir artificiellement ou non. Le but étant de produire des hommes plus forts et plus résistants, donc d'inverser la tendance décrite plus haut, tout en augmentant leur potentiel intellectuel et d'attention dans d'énormes proportions. En définitive, il s'agit là d'un problème fondamental de morale de société. On peut penser que des considérations morales ou religieuses limiteront ces manipulations bien en deçà de ce qui serait techniquement possible et que les « améliorations » à en attendre seront donc marginales.

L'homme sera malgré tout plus fiable et plus performant au niveau de l'exécution. Il est vraisemblable que les responsables appelés à juger des actions tactiques, ou stratégiques seront confrontés à des situations dont plus de paramètres leur échapperont qu'aujourd'hui. Paradoxalement, le jugement synthétique et global sera ainsi moins aisé et donc beaucoup plus dangereux.

4.6 - *LES FRAPPES CHIRURGICALES A GRANDE DISTANCE*

Le terme de chirurgical a été utilisé pour un missile (l'AS30 laser) voué à la destruction d'objectifs durcis (piles de ponts, abris bétonnés ...) en une seule frappe avec une charge classique. Le missile doit avoir une très grande précision malgré sa charge relativement lourde. Le missile réalise le compromis entre l'efficacité de la charge et la précision correspondant à ses objectifs. Sa portée (10 km) ne permet toutefois pas une opération à grande distance. En effet, l'objectif doit être « marqué » par une tâche laser et le pointage du laser nécessite l'observation de l'objectif et l'intelligence du pilote. La portée est ainsi limitée par la visibilité de la cible et le tir ne peut avoir lieu à une distance garantissant la sécurité du tireur.

Il est d'ores et déjà possible d'installer à bord d'un missile le senseur qui permettra une observation correcte de l'objectif. Il faut cependant y installer également une logique de reconnaissance sans aide extérieure, du point précis de l'objectif à frapper. On est donc conduit à développer des missiles intelligents qui apprennent à connaître puis à reconnaître les points de frappe de façon autonome.

Une telle évolution technique sera réalisable très probablement avant 2030, puisque déjà certains systèmes en développement l'appliqueront avec quelques limitations il est vrai (cible unique de la sous-munition guidée du MLRS (Multiple Launcher Rocket System : le char ; lourdeur de la préparation des données de mission du missile APACHE).

Les technologies qui interviennent au niveau de cette application sont particulièrement :

- les capteurs dans le visible et l'infrarouge (et particulièrement les matrices de détecteurs) ;
- les ondes millimétriques et sub-millimétriques (capteur combiné avec les premiers pour une observation dans un spectre très élargi) ;
- toutes les techniques de la furtivité (vol à basse altitude ; discrétion électromagnétique et infrarouge) ;
- les circuits intégrés à très grande vitesse qui permettront d'embarquer des capacités de calcul très importantes (avec l'ASGa, notamment, pour respecter les contraintes d'environnement contre les radiations) ;
- les logiciels d'élaboration à bord des informations pertinentes permettant la reconnaissance du point de frappe.

Aujourd'hui, pour une cible non identifiée, la préparation de l'opération est longue (image satellite ou autre image, élaboration au sol d'images de référence très dépendantes du capteur embarqué, chargement dans le missile). Cette phase devrait pouvoir être supprimée dès la prochaine génération (2010).

Libéré de toute contrainte de désignation d'objectifs, ce missile serait alors doté des portées et capacités d'emport autorisées par la limite de masse si cette dernière existe (cas des missiles aéroportés). Une frappe chirurgicale à grande distance sera donc tout à fait possible sur des objectifs fixes ou peu mobiles.

De tels moyens pourraient changer la nature des opérations tactiques dans l'avenir. Les frappes dans la profondeur sont aujourd'hui envisageables à moyenne portée (150 km) sur des objectifs précis. La frappe à 1000 km, quel que soit l'objectif, sans délai de préparation, et avec des charges classiques très lourdes est tout à fait réalisable dans la continuité des évolutions actuelles (l'utilisation de charges du type de celles évoquées au paragraphe suivant constituerait une rupture et serait également concevable). En généralisant l'emploi de telles armes cela conduirait à une modification importante de la nature des opérations militaires : nous assisterions à une succession d'opérations à distance, très efficaces et très brèves, ponctuelles, précises, conçues et exécutées en quelques heures. Réalisées sur un grand nombre d'objectifs dont le poids militaire ou économique est important, ces opérations devraient empêcher l'adversaire, privé de tout soutien, de poursuivre la guerre par une occupation physique au moyen de blindés par exemple. Dès lors, le conflit se réduirait à ce type d'opérations.

4.7 - *LES CHARGES EFFICACES ET PROPRES*

Le laser, de par sa précision et la mobilité possible de sa base de départ, est probablement une arme de base du XXI^ème^ siècle. D'une part, sa technologie est fort avancée et a déjà fait l'objet d'expérimentations, d'autre part, du fait de la *« légèreté »* des moyens à mettre en oeuvre il constitue une arme chirurgicale parfaitement adaptée aux missions stratégiques imaginables aujourd'hui.

Le canon électromagnétique peut également s'envisager, mais sa nécessité face aux objectifs stratégiques apparaît beaucoup plus incertaine.

Quant à la bombe à neutrons, aux effets destructeurs mal localisés, il faut tout d'abord souligner qu'elle trouve son origine dans la mise à niveau permanente de la technologie des armes nucléaires et que ces développements technologiques sont indispensables à toute politique de dissuasion nucléaire crédible.

Il semble à cet égard que les pays qui développent cette arme le font principalement dans cette optique, plutôt que celle d'un armement aux effets localisés. La bombe à neutrons, *« arme de terrain »*, serait d'ailleurs un bien mauvais exemple vis-à-vis des pays non liés par des accords de non prolifération nucléaire. Le risque paraît en effet considérable que ces pays accèdent à l'arme nucléaire, même rudimentaire. Cette bombe pourrait constituer un outil de terrorisme redoutable.

Dans un autre domaine les recherches actuellement en cours, sur les transuraniens ou le petit nucléaire, permettent d'envisager la mise à disposition des armées à l'horizon 2030 de charges nucléaires équivalentes à 1 T comblant l'intervalle énorme qui existe aujourd'hui entre les armes classiques et les armes nucléaires. Ces charges seront aptes à concurrencer la frappe chirurgicale, leur effet ajusté compensant les défauts éventuels de précision du vecteur.

4.8 - *LA LUTTE ANTI-TERRORISME*

Les progrès de la technologie dans le domaine du terrorisme apparaissent ainsi potentiellement formidables. Les problèmes qu'ils posent sont à la dimension de la menace.

Il s'agit, tout d'abord, d'une question où le militaire, une fois évacué le problème de la frappe par une arme chirurgicale, se confond avec le civil.

La détection des explosifs, celle des substances radioactives ou chimiques toxiques va faire assurément l'objet d'investissements majeurs dans la décennie à venir. C'est néanmoins une technologie qui concerne la protection civile plutôt que les armes. Même si la méthodologie ne semble pas actuellement entièrement au point, le problème évidemment posé est celui du nombre de points mesurés. C'est donc une question essentiellement politique. De même, la lutte anti-terroriste passe par la collecte du renseignement. La puissance informatique, la méthodologie du tri du renseignement par l'informatique sont disponibles. Il s'agit simplement de déterminer à partir de quel stade, cette collecte et ce traitement sont susceptibles de réagir sur les libertés individuelles.

5 - CONCLUSION

En définitive, les batailles de l'an 2030 se présenteront sans aucun doute sous des aspects différents de ceux que nous avons coutume d'imaginer aujourd'hui, du moins dans le cas de conflits entre grandes puissances.

L'importance des informations que le décideur sera capable de traiter simultanément le conduira à éviter un combat douteux ou à déclencher ponctuellement des opérations de courte durée et d'une grande efficacité. Le combat rapproché ne paraît pas s'inscrire naturellement dans cette perspective.

Une telle évolution résultera très probablement des progrès réalisés dans le domaine de la maîtrise de l'information. Le traitement de l'information est en effet la clé de tous les systèmes intelligents, que ce soit les systèmes de connaissance du champ de bataille, les systèmes de prise de décision, les systèmes de transmission ou encore les systèmes de simulation.

L'accroissement des capacités de calcul des machines informatiques, spécialisées ou non, la mise au point de capteurs performants conduiront à des révolutions.

Les armes actuelles prendront également en compte ces éléments, ce qui amélioreront leurs capacités dans les domaines les plus divers, la précision et la furtivité notamment.

La puissance militaire restera très probablement fondée sur la discrétion des sous-marins nucléaires, des avions et des missiles, hors d'atteinte des armes adverses. Des armes de longues portées et de grandes précisions dont la technologie existe déjà aujourd'hui seront produites industriellement.

Cependant, rien n'exclut qu'à l'horizon 2030 apparaissent d'autres systèmes d'armes résultant de l'application de technologies nouvelles et de la découverte de phénomènes physiques peu connus ou aux conséquences encore mal perçues.

Dans cette optique, il convient d'être très attentif aux progrès scientifiques dans des domaines tels que la bionique et la maîtrise de la matière (trans-uraniens) ainsi qu'aux études visant à découvrir des voies d'action à distance sur le cerveau humain.

La méthodologie permettant d'identifier à l'avance les techniques émergentes suppose une vision globale du panorama technologique, car les techniques ne sont pas indépendantes.

Cela nécessite une veille s'appuyant sur des catégories d'ingénieurs à la culture scientifique étendue. Ceux-ci, en permanence à l'affût de la moindre innovation, auront en charge de maintenir des contacts intenses avec les milieux de la recherche de l'université et de l'industrie.

C'est le prix à payer pour garantir l'efficacité de la Défense Française de demain.

ANNEXE 2

THE DEFENSE CRITICAL TECHNOLOGIES PLAN OF 1991
(extraits)

AD-A234 900

THE DEPARTMENT OF DEFENSE

CRITICAL TECHNOLOGIES PLAN

FOR THE
COMMITTEES ON ARMED SERVICES
UNITED STATES CONGRESS

1 MAY 1991

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THE DEFENSE CRITICAL TECHNOLOGIES PLAN OF 1991

1 MAY 1991

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I. SUMMARY

The purpose of the Department of Defense Critical Technologies Plan (DCTP) is to describe 21 technologies considered essential for maintaining the qualitative superiority of U.S. weapon systems and to outline an investment strategy to manage and promote the development of these technologies. The Defense Critical Technologies are the leading edge of the DoD Science and Technology (S&T) program. While all S&T efforts are fundamental to achieving continued improvement in military capabilities, the Defense Critical Technologies represent those technologies that are likely to set the pace of innovation in the development of advanced weapon capabilities and the evolutionary modernization of today's systems.

This third annual plan is more comprehensive than earlier editions. A new section has been added to document funding levels for individual Defense Critical Technologies for the relevant S&T Program Elements (PEs) (Annex A); moreover, the individual detailed technology plans (Annex B) provide greater detail on specific milestones and technology objectives, as well as a more comprehensive discussion of related private sector and non-DoD government programs. The plans also include assessments of international technology developments and trends.

The 1991 plan reflects a substantially increased level of participation from the Services, industry and interested Federal agencies, particularly in the generation of the detailed technology plans. The contributions of the Aerospace Industries Association, the Electronic Industries Association, and the National Security Industrial Association were particularly valuable. The Department of Energy, the National Aeronautics and Space Administration, the National Institute of Standards and Technology (Department of Commerce), and the National Science Foundation provided extensive information regarding relevant non-DoD programs and helpful comments on specific technology plans. In addition, the 1990 Defense Science Board (DSB) summer study provided a solid basis and framework for this DCTP. A wide range of DoD organizations were also integral to the preparation of this plan, particularly the Joint Staff and the DSB. The contributions of all are acknowledged.

The Secretary of Defense stated his top priorities on several occasions. These priorities not only recognize the complexities of national security and future uncertainties in the world, but also provide objectives for research and development in DoD. These priorities are:

- Quality Personnel
- Technological Superiority
- Efficient Acquisition
- Robust Nuclear Posture and Strategic Defense
- Versatile, Ready, Deployable, Sustainable Force
- Continued Maritime Superiority
- Reserve Forces and Mobilization
- Special Operations Forces

The DDR&E has established three streams that seek to:

1.) Provide for the orderly, evolutionary improvements in weapon systems, their subsystems, and support systems, such as the training, logistics, and defense industrial base infrastructure. These improvements must be responsive to future security threats and environments. The Services are the primary agents for these evolutionary technology changes.

2.) Generate innovative, highly leveraged breakthrough technology and insert this technology efficiently into our military capability. Here the Defense Advanced Research Projects Agency (DARPA) plays a major role, as does the Strategic Defense Initiative (SDI) program, the Balanced Technology Initiative, and the research organizations of the military departments.

3.) Seek technology trump cards (to be played every 5 to 10 years) to sustain long-term dominance in the technological arms race. Recent examples of such trump cards are stealth aircraft; older examples include the atomic bomb and the Polaris System. Trump cards bring about major shifts in how we think about and conduct war.

The S&T program is the principal vehicle for implementing these three streams. The Critical Technologies program focuses primarily on stream two, and contributes to streams one and three. The Critical Technologies program consists of 21 Defense Critical Technologies. They are listed in Table 1.

This year's planning process confirms the priority placed on these technologies by DoD in the 1990 Critical Technologies Plan. These technologies were originally selected on the basis of their contributions to maintaining the superiority of U.S. military weapon systems, primarily through their leverage on key subsystems. (The Defense Critical Technologies are discussed further in Chapter II. Brief technology plan summaries are presented in Chapter III, and the full technology plans are presented in Annex B.)

Tables 2A and 2B below show planned spending levels for the Defense Critical Technologies in FY 1991 as well as annual budget totals for FY 1992-97. These figures incorporate relevant funding from the DoD S&T program, including the Strategic Defense Initiative Organization (SDIO), which is a strong contributor to many of the Defense Critical Technologies. (Defense Critical Technologies funding is summarized further in Chapter IV and detailed at Annex A.)

The overall funding levels and objectives for development of the Defense Critical Technologies reflect the FY 1992 President's Budget. Recent management attention, including the 1990 Defense Management Review (DMR) initiated actions, has resulted in a strong emphasis on support for the Defense Critical Technologies, an emphasis that is reflected in these funding levels. Despite the fact that budget constraints will cause overall DoD RDT&E spending to decline over the coming years, funding levels for the Defense Critical Technologies have significantly increased in FY 1992 from the FY 1991 budgeted request and will remain stable or increase slightly. DoD's commitment to the Defense Critical Technologies will remain strong. The Defense Critical Technologies already represent a substantial focus within the combined S&T/SDIO technology development budgets, accounting for approximately 35 percent of projected FY 1992 spending. This share is projected to increase to approximately 40 percent of the total S&T/SDIO technology development budget by FY 1997. Without SDIO, the percent of critical technologies for FY92 is approximately 52%, a significant increase over the FY91 requirement.

DoD recognizes the need to ensure that its S&T resources — and particularly its Defense Critical Technologies budgets — are focused on high-payoff technologies that meet the most pressing current and emerging military needs. DoD is conducting an ongoing appraisal of the Defense Critical Technologies programs to ensure that the Services and Defense Agencies maintain proper emphasis on developing these technologies and to ensure that the goals of these programs remain consistent with DoD's overall S&T needs.

Table 1 Defense Critical Technologies

1	Semiconductor Materials & Microelectronic Circuits	The production and development of ultra-small integrated electronic devices for high-speed computers, sensitive receivers, automatic control, etc.
2	Software Engineering	The generation, maintenance, and enhancement of affordable and reliable software in a timely fashion.
3	High Performance Computing	High performance computing systems having 10^3 fold improvements in computation capability and 10^2 fold improvements in communication capability by 1996.
4	Machine Intelligence & Robotics	Incorporation of aspects of human "intelligence" into computational devices which enable intelligent function of mechanical devices.
5	Simulation & Modeling	Visualization of complex processes and the testing of concepts and designs without building physical replicas.
6	Photonics	Includes ultra-low-loss fibers and optical components such as switches, couplers, and multiplexers for communications, navigation, etc.
7	Sensitive Radar	Radar sensors capable of detecting low-observable targets, or capable of non-cooperative target classification, recognition, and/or identification.
8	Passive Sensors	Sensors not needing to emit signals to detect targets, monitor the environment, or determine the status or condition of equipment.
9	Signal & Image Processing	Combination of computer architecture, algorithms, and microelectronic signal processing devices for near real-time automation of detection, classification, and tracking of targets.
10	Signature Control	The ability to control the target signature (radar, acoustic, optical, or other) and thereby enhance the survivability of vehicles and weapon systems.
11	Weapon System Environment	A detailed understanding of the natural environment (both data and models) and its influence on weapons system design and performance.
12	Data Fusion	The machine integration and/or interpretation of data and its presentation in convenient form to the human operator.
13	Computational Fluid Dynamics	The modeling of complex fluid flow to make dependable predictions by computing, thus saving time and money previously required for expensive facilities and experiments.
14	Air Breathing Propulsion	Light-weight, fuel efficient engines using atmospheric oxygen to support combustion.
15	Pulsed Power	The generation of repetitive, short-duration, high-peak power pulses with relatively light-weight, low-volume devices for weapons and sensors.
16	Hypervelocity Projectiles & Propulsion	The ability to propel projectiles to greater-than conventional velocities (over 2.0 km/sec), as well as understanding the behavior of projectiles and targets at such velocities.
17	High Energy Density Materials	Compositions of high-energy ingredients used as explosives, propellants, or pyrotechnics.
18	Composite Materials	Two or more constituent materials that are combined together in such a manner to produce a substance possessing selected properties superior to those of its individual components.
19	Superconductivity	Makes use of the zero resistance property and other unique and remarkable properties of superconductors for creation of high-performance sensors, electronic devices and subsystems, and supermagnet based systems.
20	Biotechnology	The systematic application of biology for an end use in military engineering or medicine.
21	Flexible Manufacturing	The integration of production process elements aimed at efficient, low cost operation for small, as well as high, volume part number variations, with rapidly changing requirements for end product attributes.

Table 2.A. Funding for Critical Technologies (With SDIO) (Millions Then Year Dollars)

Technology	FY 1987-91 ACTUAL	FY 1991 REQ	FY 1991 ACT	FY 1992 REQ	FY 1993 REQ	FY 1994 REQ	FY 1995 REQ	FY 1996 REQ	FY 1997 REQ
1 Semiconductor Materials & Microelectronic Circuits	1,955	370	534	479	481	487	488	490	510
2 Software Engineering	384	115	133	149	148	153	155	156	157
3 High Performance Computing	414	80	106	172	219	273	301	349	350
4 Machine Intelligence & Robotics	551	116	162	146	142	145	144	144	143
5 Simulation & Modeling	1,230	202	300	334	343	340	335	344	344
6 Photonics	710	75	167	186	190	180	179	190	173
7 Sensitive Radars	669	110	169	196	201	192	188	191	192
8 Passive Sensors	2,065	480	428	530	554	523	512	514	509
9 Signal & Image Processing	753	130	221	235	230	232	234	240	219
10 Signature Control	*572	*120	*120	*109	*102	*89	*87	*86	*88
11 Weapon System Environment	929	180	213	232	238	248	249	252	260
12 Data Fusion	288	50	96	106	109	108	98	98	93
13 Computational Fluid Dynamics	428	55	118	94	95	99	101	105	108
14 Air Breathing Propulsion	968	180	227	224	211	185	190	193	201
15 Pulsed Power	541	95	95	76	76	81	80	80	82
16 Hypervelocity Projectiles & Propulsion	710	120	153	183	205	201	200	197	196
17 High Energy Density Materials	409	76	82	84	86	95	93	96	98
18 Composite Materials	1,089	170	204	193	197	211	218	224	229
19 Superconductivity	345	88	58	56	51	54	54	55	57
20 Biotechnology	79	100	69	65	66	68	69	71	72
21 Flexible Manufacturing	105	17	27	25	28	29	31	32	31
Planned Total Funding for Defense Critical Technologies – S&T with SDIO	15194**	2909**	3684**	3874**	3972**	3991**	4006**	4107**	4112**
Projected Total Funding for all Technology Development Activities – S&T with SDIO	NA	9784	9048	11095	11413	11749	11501	10895	10542

Table 2.B. Funding for Critical Technologies (Without SDIO) (Millions Then Year Dollars)

Technology	FY 1987-91 ACTUAL	FY 1991 REQ	FY 1991 ACT	FY 1992 REQ	FY 1993 REQ	FY 1994 REQ	FY 1995 REQ	FY 1996 REQ	FY 1997 REQ
Planned Total Funding for Defense Critical Technologies – S&T without SDIO	10944**	1989**	3081**	3144**	3179**	3200**	3211**	3308**	3309**
Projected Total Funding for all Technology Development Activities – S&T without SDIO	NA	5324	6186	6015	6223	6339	6489	6770	6886

* Funding for this Critical Technology are unclassified totals only.

**Totals do not include funding for classified Signature Control efforts.

ACT – Actual Budget

REQ – Budget Request

II. TECHNOLOGY INVESTMENT PLANNING

Emerging Security Environment Challenges to DoD

In a major address on national security at the Aspen Institute in August 1990, President Bush underscored the importance of defense R&D: "To cope with the full range of challenges we may confront, we must focus on readiness and rapid response. And to prepare to meet the challenges we may face in the future, we must focus on research — an active and inventive program of defense R&D."

Based on this mandate and in concert with global political events and military trends, DoD developed the Critical Technologies Plan provided here.

The following threats still challenge us:

a) The dissolution of the Warsaw Pact as a military organization is changing the U.S. national security problem; but the Soviet Union continues to be a potential threat to the U.S. While our national defense strategy no longer focuses primarily on Europe and the possibility of Soviet aggression there, we must not discount that nation as a formidable military force.

b) Second, we must deal with the rapid diffusion of advanced weapon technologies to regional powers, including potentially unpredictable and ruthless regimes.

c) Growing, too, is the potential for smaller conflicts, ranging from violence spawned by narcotics trafficking, to terrorism, and to insurgencies.

In tandem with this emerging security environment, the United States is likely to face new resource constraints. DoD plans a 25 percent reduction in active forces in the next five years, and procurement outlays are programmed to fall from $79.1 billion in FY 1991 to $71 billion in FY 1996.

All of these factors point to the importance of a strong and stable research and development posture that is tied directly to our defense strategy, funded appropriately, and managed effectively.

DoD Science and Technology Strategy — Responding to the Challenges

Our strategic vision for defense technology takes a twenty-year view as it looks at three streams of technology:

1) Putting in place a process that provides orderly, <u>evolutionary</u> improvements in weapon systems, their subsystems, and support systems, such as the training, logistics, and defense industrial base infrastructure. These improvements must be responsive to future security threats and environments. The Services are the primary agents for these evolutionary technology changes.

2) Generating innovative, highly leveraged <u>breakthrough</u> technology and inserting this technology efficiently into our military capability. Here the Defense Advanced Research Projects Agency (DARPA) plays a major role, as does the Strategic Defense Initiative (SDI) program, the Balanced Technology Initiative, and the Services.

3) Seeking <u>technology trump cards</u> (to be played every 5 to 10 years) to sustain long-term dominance in the technological arms race. Recent examples of such trump cards

To do this we have taken the list of 21 technologies and placed them in five clusters (see Figure 1). The clusters are a manageable way of looking at the vast array of opportunities available to us. They are a plausible way of organizing for action, a convenient way to illustrate broad themes. Our clusters also demonstrate the high degree of interdependence among these technologies in spite of their diversity. The clusters and their associated technologies are not unique, but they are useful in providing broad objectives.

Figure 1 Defense Critical Technologies Clusters

Critical Technologies	Computing/ Information	Sensing	Materials & Manufacturing	Energy & Material Flow Management	Infra-structure
1 Semiconductor Materials & Microelectronic Circuits	●	●	●		
2 Software Engineering	●		●	●	●
3 High Performance Computing	●	●	●	●	●
4 Machine Intelligence & Robotics	●		●	●	●
5 Simulation & Modeling	●			●	●
6 Photonics	●	●			
7 Sensitive Radars	●	●			
8 Passive Sensors		●	●		
9 Signal & Image Processing	●	●			
10 Signature Control		●	●		
11 Weapon System Environment		●			●
12 Data Fusion	●				
13 Computational Fluid Dynamics	●		●	●	
14 Air Breathing Propulsion			●	●	
15 Pulsed Power			●	●	
16 Hypervelocity Projectiles & Propulsion	●		●	●	
17 High Energy Density Materials			●	●	
18 Composite Materials			●	●	
19 Superconductivity		●	●	●	
20 Biotechnology			●		
21 Flexible Manufacturing			●		●

Table A-1. FY91 Critical Technology Funding by Program Elements (Cont'd-1)
($ in Millions)

CRITICAL TECHNOLOGIES \ PROGRAM ELEMENTS[a]	602622A. Chemical, Smoke, and Equipment Defeating Technology	602624A. Weapons and Munitions Technology	602705A. Electronics & Electronic Devices	602709A. Night Vision Technology	602716A. Human Factors Engineering	602720A. Environmental Quality Technology	602727A. Non-System Training Device Technology	602782A. Command, Control, & Comm. Technology	602783A. Computer & Software Technology
1. Semiconductor Materials and Microelectronic Circuits			6						
2. Software Engineering									6
3. High Performance Computing									
4. Machine Intelligence and Robotics					1				
5. Simulation and Modeling	2						3		
6. Photonics				2				1	
7. Sensitive Radars			3					3	
8. Passive Sensors		1		4				4	
9. Signal and Image Processing		1	3	1				3	
10. Signature Control				1					
11. Weapon System Environment	4								
12. Data Fusion				5					
13. Computational Fluid Dynamics									
14. Air-Breathing Propulsion									
15. Pulsed Power			1						
16. Hypervelocity Projectiles & Propulsion		9							
17. High Energy Density Materials	1	4							
18. Composite Materials		2							
19. Superconductivity									
20. Biotechnology	3					3			
21. Flexible Manufacturing									
CRITICAL TECHNOLOGIES TOTAL[b]	9	18	13	13	1	3	3	11	6

(Continued)

[a] PE letter designations: A=Army, N=Navy, M=US Marine Corps, F=Air Force, E=DARPA, H=DNA, C=SDIO.
[b] Sum for critical technologies portion in program element (may not add because of roundoff).

DOD Funding of the Critical Technologies

Table I.1: Science and Technology and IR&D/B&P Funding of the Critical Technologies

This report includes:

Dollars in millions

Critical technologies	Science and technology funds invested in critical technologies		IR&D/B&P funds invested in critical technologies	
Semiconductors materials	$533	14.0%	$340	11.9%
Passive sensors	420	11.1	272	9.5
Air breathing propulsion	374	9.9	516	18.1
Simulation and modeling	297	7.8	51	1.8
Weapon system environment	294	7.7	243	8.5
Signal processing	228	6.0	273	9.5
Composite materials	204	5.4	199	7.0
Sensitive radars	169	4.5	149	5.2
Photonics	166	4.4	117	4.1
Machine intelligence/robotics	154	4.0	83	2.9
Hypervelocity projectiles	143	3.8	40	1.4
Signature control	123	3.2	N/A[a]	N/A[a]
Computational fluid dynamics	120	3.2	104	3.6
Software producibility	111	2.9	141	4.9
Parallel computer architecture	108	2.8	150	5.2
Data fusion	88	2.3	102	3.6
Pulsed power	84	2.2	17	0.6
High energy density materials	82	2.2	39	1.4
Superconductivity	55	1.5	13	0.4
Biotechnology	42	1.1	9	0.3
Total	**$3,795**	**100.0%**	**$2,858**	**100.0%**

[a]Not available (N/A).

Source: Data on science and technology funding is based on fiscal year 1991 information provided by the military services and defense agencies to the Office of the Secretary of Defense. Data on IR&D/B&P funding is based on the results of 92 defense contractors responding to our questionnaire.

Technology Objectives — Semiconductor Materials and Microelectronic Circuits

Technical Area	By 1996	By 2001	BY 2006
Electronic circuits, including VHSIC, providing highly reliable and radiation-hardened technology	• 0.5 micron low-volume production available in digital silicon devices • Improved bulk and SOI technologies	• 0.2 micron low-volume production of digital silicon devices/SOI	• Less than 0.1 micron production of low-volume digital silicon devices
Millimeter and microwave integrated circuits providing reliable analog capabilities for system front-ends	• Continuous increases in single function (amplifiers, oscillators, mixers, switches) chips available in 1 to 20 GHz range	• Integrated multiple function chips available over entire 1 to 100 GHz range • CAD/production facilities available to meet large range of system requirements • Heterojunction MIMIC	• Microwave/digital integrated circuits • Microwave/optical integrated circuits
Computer-aided design tools	• Continued test/ reliability/process design on advanced parallel computers • Fast prototyping of continued circuits	• Testable, complex designs generated by scalable design tools • Rapid prototyping to second-level packaging	• Fail-safe, fault-tolerant, self-repairing adaptivity inherent in microelectronic subsystems
Manufacturing	• Expanded qualification procedures for gate array microcircuits	• National quality procedures for micro-electronics available • MMST	• Wafer scale integration for high-volume production
Fabrication of compound semiconductors	• Mass production of 4-inch diameter, 25 kg boules for GaAs substrates • Continued progress on improvement of MOMBE and MOCVD single wafer deposition equipment • Development of reliable sources of InP wafers	• Production of 5-inch diameter GaAs substrates • Production of high quality, 3-inch diameter InP substrates	• Production of 6-inch diameter boules for GaAs substrates
III-V integrated circuits (e.g., GaAs)	• Complementary logic • Improved medium-scale integration gate arrays	• Large-scale integration complementary logic circuits in production	• III-V integrated circuits fully compatible with silicon-based circuits
Materials Development	• SOI for 0.35 μm ICs • SiC • Diamond on Si	• SOI for 0.2 μm ICs, 3-D structures • SiC manufacturing • Diamond ICs in labs • InP manufacturing	• SOI in <0.1 μm ICs • SiC ICs • Diamond ICs • InP ICs

2. Technology Objectives

Technology Objectives — Software Engineering

Technical Area	By 1996	By 2001	By 2006
Software and system engineering process and environments	• Open architecture SEE framework with commercial acceptance and CASE interoperability • Iterative process models • Domain-specific prototyping capabilities for components • Robust design recovery tools	• Open architecture SEE with direct process support • Integrated project design information record • Process metrics supporting continuous risk, cost, schedule assessment • Initial process programmed software environment	• Hypermedia design information management across full life-cycle • Acquisition associate system supporting continuous process optimization • Machine intelligence assisted requirements elicitation • Pro-active knowledge based support in environments
Real-time and fault-tolerant software	• Operating systems interface standards supporting real-time • Real-time scheduling algorithms for mixed workload real-time tasks on uniprocessor	• Tool support for specification and formal analysis of small-scale real-time systems • Commercial operating systems kernels supporting real-time	• Synthesis of hard real-time schedulers for parallel processors • Automatic allocation of resources to processes for real-time systems • Hardware-independent models for distributed/ parallel real-time environments
Reuse and re-engineering	• Machine independent reuse of systems software components • Repository technology deployed, including national file system with access control	• Domain specific architectures and interfaces • Cost/benefit data collection for reuse and re-engineering • Distributed secure repository	• Precise codification and conformance testing for domain specifications • Reverse engineering tools supporting design recovery for fielded systems integrated into SEE frameworks
Software for parallel and distributed heterogeneous systems	• Heterogeneous distributed operating system supporting parallelism • Wide-area distributed file system with access control and limited replication	• Distributed reliable object management support with search and access control • Very high level languages for distributed object computation	• Adaptive, dynamic resource allocation for very large scale distributed computing • Databases with suport for advanced inference, full multi-media, and adaptive replication
High assurance software	• Confidentiality proofs for simple operating system kernels • High assurance system software products including operating system components and network gateways	• Iterative process models in use for development of high assurance software • Formal specification and analysis tools incorporated into software engineering environments • Environment support for high assurance Ada software components	• Integrity proofs • Software environment supporting design, development, and adaptation of highly assured software • High assurance distributed database management systems

3. Resources

Software has become a pivotal technology for a wide range of defense systems, and software capability continues to increase. Requirements placed on software elements of systems are increasing much more rapidly, particularly with the changes in the DoD environment towards more unpredictable threats, more rapidly changing interoperabilty requirements, more rapid mobilization and deployment, greater requirements for force multipliers, and the increasing need for high assurance as computer communications become requirements such as embedded computing, application specific accelerators, distributed systems, and heterogeneous systems that are fault tolerant and survivable.

2. Technology Objectives

Technology Objectives — High Performance Computing

Technical Area	By 1996	By 2001	BY 2006
High performance computing systems	• Teraops systems (Tera = 10^{12}) • Multi chip modules package • Heterogenous systems • Multi teraop designs	• 100 Teraops systems • Optical interconnect • Petaops designs	• 10 Petaops systems (Peta = 10^{15})
Advanced software technology and algorithms	• Scalable libraries • Design tools • Support for heterogeneous computing	• Deployed scalable programming environments with integrated software engineering	
High performance networking	• Gigabit networks available for deployment • Multi-gigabit designs	• 100 Gigabit available for deployment • Terabit designs with all optical data paths	• Terabit deployable
Defense specific technologies	• Embedded systems with Teraop components	• Embedded systems with 100 Teraop components	• Embedded systems with PETAOPS components

Technology Objectives – Machine Intelligence and Robotics

Technical Area	By 1996	By 2001	By 2006
Unmanned ground vehicle	• One operator controls two RCVs	• Robotic combat vehicle (one operator controls five RCVs) • Robot vehicle networking and interfacing family of RCVs	• Substantially expanded autonomous operation of unmanned ground vehicles
Robotic manipulator	• Field demonstration of tank loading	• Light-weight robotic vehicle	• Widespread use of robotics throughout weapon systems
Data rate reduction	• Telerobotic vehicle • Automatic planning and control of assembly from CAD models	• Robotic security patrol with remote display and control • Autonomous capability to reason and react	• Continuing reduction in size and increase in power of data reduction capabilities

3. Resources

Total S&T funding for this critical technology is shown in the following table.

Funding—Machine Intelligence and Robotics ($M)

FY87-91	FY92	FY93	FY94	FY95	FY96	FY97
551	146	142	145	144	144	143

4. Utilizing the Technology

Some of the DoD's most critical problems exist in logistics; current projects focus on efficient and intelligent resource allocation in military transportation and sustainment planning. Additionally, the DoD is investing in the development of robotic material handling systems for logistic applications (such as acquiring replacement parts). Nonlogistics applications also have achieved success to date. For example, the use of fiber optic-guided missiles (FOG-M) offers promise regarding the potential for future tele-operated systems. Tele-operated systems may be used as a force multiplier in which one manned vehicle could control a fleet of tele-operated companion vehicles. Today, DoD has efforts to develop a tele-operated mobile platform (TMP) that can serve as an unmanned reconnaissance platform. Another important application of a tele-operated robot will be the development of Caleb, a small vehicle capable of reconnaissance, surveillance, and target acquisition operations for the infantry. Further research will be directed at improving the man-machine interface for Caleb and developing autonomous capabilities for robots such as Caleb.

The application of expert systems is accelerating due to the commercial availability of shells, software tools to assist in the capture and representation of relevant knowledge and to facilitate the selection of appropriate reasoning mechanisms. This has had the secondary benefit of increasing the in-house technical understanding of machine intelligence concepts; for example, in extensive employee training programs that use expert systems on a daily basis. Over the next decade, the product of DoD's basic research and exploratory development efforts can be expected to affect weapon systems and related command and control. Many of these products are likely to lead to machine intelligence components embedded in larger conventional software systems.

2. Technology Objectives

Technology Objectives — Simulation and Modeling

Technical Area	By 1996	By 2001	By 2006
Complex battle management	• Integration of battlefield simulation into a battle management test bed, to have a test and evaluation approach for new planning and decision aids, pinpointing deficiencies in existing aids as the threat changes, and evaluating the effect of changes in our own doctrine, tactics, weapons, etc.	• Application of knowledge-based techniques for design of complex systems including large software systems and battle management simulations • Demonstration of C^3I workstation • Use of actual world technologies, selection, and training	• Substantially improved battle management, decision aids, human factors design, and cost-reduction techniques
Training in complex military environments	• Increased use of AI and knowledge-based systems in display generation	• Order of magnitude cost reduction for training and human factors design • Fully integrated real-time simulations with man-in-the-loop capability	• On-line diagnostics and "what-if" capabilities
Industrial design and production	• Modeling performance of hypothetical designs to help make trade-off decisions for optimal design	• Diagnostics and prognostics by modeling alternative situations	• Substantially improved cost effectiveness, planning, and design

3. Resources

Total S&T funding is shown in the table below.

Funding Simulation and Modeling ($M)

FY87-91	FY92	FY93	FY94	FY95	FY96	FY97
1230	334	343	340	335	344	344

[5]Funding is derived from programs in the DoD budget. Most programs involve several technologies. It therefore becomes a matter of judgment how many dollars to count toward which technology. The funding presented here and throughout this report for each critical technology, is of the right order of magnitude but is not to be construed as a precise budgetary quantity.

Goals and Payoffs – Photonics

Application	Goal	Payoff
Electronic Warfare	• 100X increase in processing rate • 10X fewer physical hook-ups • Distributed architecture • Reduced EMI susceptibility	• Greatly improved ECCM capability for all types of sensors (IR, radar, EW, acoustic, etc.) • Enable processing of data from high density (> 10^6 element) focal plane arrays, very large phased arrays, and collection systems
Command, Control, and Communications (C^3I)	• Transoceanic repeaterless cabling • Satellite-to-submarine communication • Fly-by-light • Satellite-to-satellite crosslinks	• Large distributed ASW systems with lower costs and higher reliability • Improved tactical and strategic connectivity • Reduced weight/volume and lower EMI/ECM susceptibility

The superiority of fiber optics over copper-based systems can be measured by information carrying capacity (which is 10,000 times greater for optical systems), energy loss in signal transmission (100 times lower), error rate (10 times lower), greatly reduced size and weight, and by its resistance to electromagnetic interference, and other harsh environments. Future developments in semiconductor lasers promise improvements in diode-pumped lasers as well as fast, efficient, high-brightness sources for memory, display, and materials processing technologies. Modulators promise still greater improvements in data rate capacity and link margin.

Ultra low-loss fiber optics is of particular importance to DoD in a number of critical military capabilities:

- Wide-area communications
- Wide-area surveillance
- Undersea and tactical missile guidance (low-cost, target and aimpoint selection)
- Remote surveillance and tele-operated weapon platforms (removing the requirement for personnel to enter high-threat areas).

Developing technologies such as zirconium fluoride (ZrF) glasses will enable such systems as large aperture, high-gain, acoustic arrays (thousands of acoustic sensors interconnected over tens of kilometers), and long-range command-guided anti-ship missiles. Important elements of this technology are continuous integration of electronic processors and controllers with fiber-optical devices; nuclear hardening; improved interconnects; switches and multiplexers; higher power; frequency tunable optical sources; and high bandwidth sensitive detectors.

Goals and Payoffs — Sensitive Radars

Sensor Type	Goal	Payoff
Advanced Monostatic Radar System Component Technology	• Counter 1,000-fold reduction in threat observability • Increase RF system robustness • Provide surveillance • Allow passive weapon systems to engage threat illuminated by remote source	• Provide capability to detect, track, and engage advanced threats including stealthy cruise missiles and aircraft. • Improve operational performance in severe environments • Improve resistance to countermeasures • Target does not know that it is under attack • Continuous theater MTI to keep track of all vehicles
Multistatic Radar	• Improve resistance to countermeasures • Allow passive weapon systems to engage threat illuminated by remote source • Counter 1000-fold reduction in monostatic radar cross section	• Provide capability to detect, track, and engage advanced threats including stealthy cruise missiles and aircraft • Improve operational performance in severe environments • Improve survivability
Radars for NCTR and ATR (MMW Radar, UHRR, and SAR/ISAR)	• Provide real-time positive hostile identification • Detect and identify camouflaged or foliage-concealed targets • Identify strategic relocatable targets • Discriminate against countermeasures	• Reduce Fratricide • Enable development and employment of smart, beyond-visual-range weapons • Improve battle management capability and employ weapons more effectively
Phased Array Radar	• Active conformal arrays embedded on structures • High power, narrow beam active apertures • Light, small, power efficient radars • Combine transmit, receive, illuminate and communications function	• Provide capability to detect, track, and engage advanced threats including stealthy cruise missiles and aircraft • Improve operational performance in severe environments • Improve survivability and reliability • Reduce own platform radar cross section • Deployment of radars on light satellites, RPVs, etc.
Laser Radar (Ladar and Lidar)	• Accurate target tracking, identification, and weapon guidance • Detect and identify camouflaged or foliage-concealed targets • Rapid minefiled mapping • Real-time environmental monitoring	• Provide capability to detect, track, and engage advanced threats including stealthy cruise missiles and aircraft • Improve survivability • Enhance weapon lethality • Improve weather forecasting capabilities • Improve operational performance in severe environments • Provide remote, real-time detection of chemical agents.

2. Potential Benefits to Industrial Base

a. Manufacturing Infrastructure

Radars represent an industrial base in transition. Conventional radars are a well established commodity for military systems, while sensitive radar technologies are still in

Goals and Payoffs — Passive Sensors

Sensor Type	Goal	Payoff
EO/IR sensors (including focal plane arrays)	• 100x more detectors per focal plane • Much greater producibility • High resistance diode detector arrays for high sensitivity • Low-noise signal processing on detector chips • Nondestructive in-process testing for affordability	• Enable passive sensor operation with very high resolution and good ECCM capabilities (e.g., for use in ship air defense) • Crucial to overall U.S. edge in satellite surveillance (real-time, high-resolution capability) • Crucial to tactical surveillance and eapon systems
Compact antennas	• Enable small high gain antennas to operate at lower RF frequencies • Lower profile • Reduced size and weight	• RF missile guidance systems that are effective against stealthy targets • Greater mobility • Stealth
Superconducting sensors	• Low-noise magnetic sensor	• Expanded range for magnetic detection of submarines
Diffractive optics/ sensors	• Non-protruding, look-ahead sensor systems	• Reduce the shock plasma background signatures in passive missile sensors
Fiber optic sensors	• Ultra-sensitive acoustic, magnetic, chemical, temperature, and other sensors	• Extended detection range • Lower cost, light-weight, highly reliable sensors
Multispectral sensors	• Techniques and database to exploit signatures across spectrum	• Counter stealth and ECM • Exploit full range of target observables
Sensor fusion	• 10x improvement in tracking accuracy • Effective target identification	• Greatly improved capability to engage targets
Microwave radiometry	• Tactical images	• Enable passive sensor operation at moderate resolutions in poor weather
Diagnostic sensors	• 10x less downtime	• Improved weapon system availability

Passive sensors represent an enabling technology that facilitates improvements of maintenance design quality over weapon system life cycles. Without the integrated application of this technology in weapon systems, the maintenance quality improvement rapidly stagnates as design and development energies are focused on the next systems. Only major and obvious faults are detected and resolved. The much needed diagnostic history data must be measured, communicated between maintenance levels, and fed back to the design improvement process.

Goals and Payoffs — Signal and Image Processing

Targets	Current State of the Art	Long-Term Potential
Fixed high-value ground targets (bridges, hangars)	• Ready for engineering development (laser and IR techniques)	• More robust techniques, i.e., all weather, night
Ships and submarines at sea, or in harbors	• Technology available (SAR/ISAR) for advanced development	• Near automatic recognition capability
Moving targets in moderate/low clutter (aircraft against clear sky)	• Technology potentially available using noncooperative target recognition techniques (e.g., IR conventional or MMW radar)	• Move to more automation of recognition function
Advanced atmospheric target in high clutter and EW environment	• Limited capability exists	• Fusion of multispectrual sensors required with high-resolution processing
Unobscured fixed land targets in benign backgrounds (tank in desert)	• Within state of the art for cueing (IR) • Ready for advanced technology demonstration	• More robust cueing and eventually automatic recognition • Multisensor approaches and laser radar
Moving targets in cluttered background and under the influence of obscurrants, weather, and countermeasures	• Still a subject of research or early exploratory development at the testing and signature collection stage	• Not likely to achieve full automation • Pilot will remain in the loop • Improve robustness to environmental conditions
Fixed land targets in high cluttered backgrounds/partially obscured (tank in bushes or trees)	• Still a subject of research or early exploratory development	• Success uncertain • Technology will evolve with this as a future goal
Secure and survivable communication	• Modest individual standalone capabilities exist	• Robust survivable integrated networks
Strategic relocatable targets	• Promising techniques emerging (SAR/ISAR)	• Limited capability possible • Capability against obscured targets and countermeasures much less certain
Quiet submarines	• High-gain, volumetric arrays under evaluation • Full spectrum signal analysis	• Capability against quiet targets
Moving targets in space on earth clutter	• Detection with low-sensitivity sensors	• Automated detection, acquisition track, and kill assessment

Algorithm development for automatic target recognition (ATR) capabilities are being embedded into numerous systems. In reconnaissance and imaging systems, much progress has been made in the area of image segmentation, feature detection/extraction, and pattern recognition of static objects. This ATR ability significantly reduces operator and photo interpreter workload. Present ATR developmental efforts will lead to weapon systems with automated detection capabilities to counter concealed (e.g., camouflage, foliage) targets, and deception techniques (e.g., decoys). This development will improve fire-and-forget weapon lethality and will also reduce operator workload for EW, sonar, radar, SAR, battle management, reconnaissance, and intelligence systems.

2. Potential Benefits to Industrial Base

Signal processing technology is also applicable to the industrial base. Signal processors are being developed to recognize handwritten characters for automatic zip code recognition systems and for handwritten data entry to computer systems. This will allow entry of data and text to computer and word processing systems. Speaker-independent voice and speech recognition systems are being developed. These capabilities will allow vocal entry of

Goals and Payoffs — Weapon System Environment

Application	Goal	Payoff
Oceanography	• Predict global and mesoscale ocean circulation • Predict marginal ice zone movement, behavior, and boundaries • Understand dependence of small-scale oceanography on larger-scale properties	• Tactical support of employment of surveillance assets and weapons • Improved support to search, rescue, and salvage operations • Improve localization for weapon systems
Underwater acoustics	• Describe and predict acoustic propagation in shallow and deep water environments • Improve performance prediction of bottom-mounted sensors • Model under-ice acoustic interaction	• Passive range and depth localization combined with detection • Broadband acoustics signal processing to offset narrowband quieting • Improved localization of under-ice targets • Reduced false targets
Meteorology	• Accurately forecast global, regional, and local weather (7 to 10 days, 3 to 5 days, and 24 hours, respectively) • Describe and predict atmospheric boundary layer (surface to 1,000 m) phenomena • Improve tropical cyclone forecasting • Understand and mitigate environmental effects on weapons systems	• Improved performance of surveillance and C3 systems (electro-magnetic and electro-optical) • Incorporation of real-time environmental effects into battle management and system operation • Tactical ship and aircraft routings, reduced damage to ships and cargo, fuel savings, covert movement of forces • More effective weapons systems development, deployment, and decision aids for the operational commander
Remote sensing	• Provide real-time quantitative data worldwide • Supplement observing networks in data-sparse and data-denied areas • Provide boundary data on marginal ice zone • Locate and identify major ocean features and weather systems • Develop sensing techniques extending environmental parameter coverage	• Rapid mapping of regions of interest • Improved initialization of prediction models for forecasting • Sensing capability over remote areas • Tactical support to battle management and weapons employment • Enhancement of weapon system design and testing
Ionosphere	• Describe and predict ionospheric disturbances and hazards • Develop modification techniques	• Protection of space assets • Enhance performance of over-the-horizon radar • Enhance communications

2. Technology Objectives

Technology Objectives — Data Fusion

Technical Area	By 1997	By 2002	By 2007
Theoretical Foundations	• Functional decomposition • Unified model: matching of solutions to problems	• Conditional event algebra	• Advanced algorithm research — neural — biological
Algorithm and Model Development	• Real-time fusion of track, ID, and weapon control • Real-time fusion of distributed surveillance sensors • Multi-national data fusion demonstration	• Automated sensor management • Real-time distributed fusion for track and ID surveillance • Resource allocation to counter low observables and jamming • Multi-spectral/multi-mode sensor • Integrated signal detection, processing, and control	• Automated sensor parameter control • Situation assessment supported by track and ID fusion using organic and non-organic sensors
Data and Knowledge Bases	• Spatial/temporal DBMS • Multi-sensor surveillance data -- selected applications	• Distributed asset - oriented DBMs • Domain knowledge for platform-based expert systems	• Advanced storage media — 3D holographic memory — other optical — multi-media
Reasoning Systems	• Real-time advisory system using multiple sensors • Automated message filtering • Automated template authoring system	• Plan recognition capability using mulitple sources • Spatial/temporal reasoning systems	• Plan prediction capability • Plan supervision and replanning support • Automated situation and threat assessment

Technology ObjectivesComputational Fluid Dynamics

Technical Area	By 1996	By 2001	BY 2006
Computational techniques	• Moving grid solver • Hypersonic weapon separation codes • CFD vehicle structure codes • Use of massively parallel architectures	• Real gas/ionization effects • Inverse methods that design rather than evaluate configuration	• Interdisciplinary inverse design methods
Hypersonic vehicles	• NASP • Hypersonic air-breathing missiles	• Hypersonic interceptors • Highly maneuverable reentry vehicles	• Low IR signatures • Hypersonic missiles • NASP-derived vehicles
Ocean vehicles	• 3-D Navier-Stokes for submarine applications	• Navier-Stokes for hydro-acoustic design of propulsors	• Inverse design with Navier-Stokes
Low Reynolds-number vehicles (low speed flight)	• VSTOL	• Complete demonstration vehicles	• Submarine-launched targeting and surveillance vehicle • Ship-launched decoy and jamming vehicles • Ship-launched high-altitude long-range reconnaissance vehicle
High-performance rotorcraft	• Validated Navier-Stokes computations of advanced rotor systems	• CFD simulations of new rotocraft concepts	• Highly maneuverable high-speed rotorcraft
High-performance parachutes	• Complete vortex panel models for predicting parachute flow fields • Develop and validate semi-empirical parachute infaltion codes • Extend decelerator technology into the hypersonic regime	• Place in operation an unsteady aerodynamic ground test facility for simulating parachute aerodynamics • Crew escape and paratrooper parachute systems configurations with greater reliability, and lower cost	• Complete development and validation of a full three-dimensional Navier-Stokes computer simulation of parachute inflation
High performance, large caliber guns	• Develop and validate end-to-end interior ballistics models for hybrid plasma/liquid propellant guns	• Simulate new gun concepts that permit the firing of smart projectiles	• Develop new electro-thermal-chemical weapons for shipboard and land-based use
Improved armor and anti-armor weapons	• Develop and incorporate materials strength models in two and three dimensions	• Accurate warhead of penetration models	

2. Technology Objectives

3. Resources

A summary of total S&T funding is shown in the table below.

Technology Objectives — Pulsed Power

Technical Area	By 1996	By 2001	By 2006
Energy Storage Inductive Capacitive Explosive generators Rotating machines	•10^4 J/kg at 1 Hz, 10^4 shots •25 J/kg at 100 Hz and 10^8 shots •10^6 J/kg (explosive generator •80 J/kg pulse (rotating mach)	•$2x10^4$ J/kg at 1 Hz and 10^8 shots •100 J/kg at 100 Hz and 10^8 shots •$3x10^5$ J/kg (explosive generator) •80 J/kg pulse (rotating mach)	•$3x10^4$ J/kg at 100 Hz and 10^9 shots •1 kJ/kg at 100 Hz and 10^9 shots
Power Switching Open Closed Rep rated Gaseous Solid State	•100 kV at 10 kHz •0.3 nsec risetime at 10 Hz •10^{14} A/sec single shot •1 µs conduction: 10 ns open	•10^{14} A/sec at 10 Hz •3 µs conduction; 2 ns open	•10x improvement in average power capability •10 µs conduction: 2 ns open
Conditioning Circuits Peak power Rep rate Alternators/inverters Voltage converters	•100/500 kg/MW alternators/inverters •1000 kg/MW voltage converters	•20/300 kg/MW alternators/inverters •300 Kg/MW voltage converters	•100 kg/MW voltage converters
Power Sources Batteries Fuel cells Power generators Compact accelerators	•20 MeV at 10 kA single shot (compact acc.) •700 g/kW fuel cells •16 watt-hr/kg battery	•500 MeV at 10kA and 10 Hz (compact acc.) •250 g/kW fuel cells •100 watt-hr/kg battery	
High Power Microwave Relativistic Solid State Wideband	•1 kJ/pulse per 10 pulse burst at 1 kHz rate (HPM) •10 GW (relativistic)	•10 kJ/pulse per 10 pulse burst at 1 kHz rate (HPM) •50 GW (relativistic)	•100 kJ/pulse (HPM) •100 GW (relativistic)

Funding — Pulsed Power ($M)

FY87-91	FY92	FY93	FY94	FY95	FY96	FY97
541	76	76	81	80	80	82

4. Utilizing the Technology

The Joint Directors of Laboratories (JDL) recognized the importance of pulsed-power components and subsystems to critical DoD weapons, radars, and electronic warfare (EW) systems was recognized by by establishing a tri-Service pulsed-power team to assess US resources to high-energy, high-power programs for future military system requirements. A combined 6.1 and 6.2 level program in pulsed power technology development that also provides the technology-based teams among university, national laboratory, and private industry participants, would enable specific applications to be defined and funded by mission agencies within DoD and DoE. Some of these missions can be enabled

(2) **Development Milestones**

- Programs to develop basic understanding of projectiles–target interactions are designed to directly support the tests of various projectile and propulsion developments, many of which occur in the FY 1994/95 timeframe.

2. Technology Objectives

Technology Objectives — Hypervelocity Projectiles and Propulsion

Technical Area	By 1997	By 2002	By 2007
Projectile Design • Inbore "G" and EM – Sabots – Armatures – Projectiles – Guidance components – Maneuver components	**Demo Only** • Composite structure-based push projectile and armament • 50 kilo "G" components	**FSED** • Mid-riding, integrated sabot/armature • Mach 10 launch • 100 kilo "G" components	**Deployed Systems** • Guided anti-tank round Mach 6–10; long range MMW seeker • Segmented high density penetrator
• Hypervelocity Flight – Nose and heat shield – Airframe dynamics and materials – Stability, control, maneuver – Lateral propulsion	• Mach 6.0 guided projectile • 6–10 "G" lateral maneuver	• Mach 10 maneuver • 10–30 "G" lateral • < 1.0 millisecond response	
• Guidance – Sensors, seekers – Processors – Algorithms; recognition – Acquisition and tracking	• 94 GHz seeker, processor, and algorithms	• Micro IMU • Miniature processor electronics • Demonstrated target recognition	• Demonstrated target recognition • Antiair/ATBM Mach 10, 15 km MMW seeker
Projectile Propulsion • Antiarmor System • Artillery System • Air Defense System • Strategic Defense System	• Complete 20 MJ EMORETC ATTD • Complete ETC ATTD	• Complete FSD of integrated propulsion/projectile system	• Technology for advanced smart projectiles
Projectile Design • Interaction	• Mach 6.0 long rod, K.E. • Mach 6.0 extension of segmented penetrator • Area target HE warhead	• Microsecond fusing • ATBM intercept demo • Mach 10 high density segmented penetrator	

2. Potential Benefits to Domestic Industrial Base

While there is a significant industrial base providing HEDM, nearly all of the product is for the DoD, DoE, and NASA. Most non-military applications are NASA and communication satellite launch related. Other non-military applications (such as blasting agents) are not likely to be affected by the type of HEDM produced in this critical technology effort.

The US chemical industry forms a vital part of the industrial infrastructure for HEDM. Most forms of HEDM contain binders and energetic materials which greatly affect their working characteristics. Binders, which bond fuels and oxidizers together, alter the characteristics of HEDM in areas such as processing, curing, energy, energy release rate, and sensitivity. The properties of the binder generally determine the processing conditions that can be used to manufacture an energetic material.

Goals and Payoffs — High energy Density Materials

Application	Goal	Payoff
Propulsion		
Minimal-signature tactical missile propulsion	•Increase delivered performance over current observable motors •No visible or contrail signature •1,000% reduction in infrared signature •Radar cross section less than launch platform •No increase in hazards •No combustion instability •Tailorable burn rate	•Increased range (200 nm increases for anti-air, 500 nm for anti-surface), velocity (Mach 2 increase), and payload •Increased element of surprise and greater lethality •Reduced trackability and vulnerability •Reduced obscuration of own missile without increasing hazards or decreasing reliability
Boost propulsion for submarine-launched cruise missile	•Exceed current booster performance by 50% •Increased launch depth •Low signature plume	•17% increase in delivered boost performance yields 50% increase in range over existing Tomahawk cruise missile •Allow launch from greater submerged depth •Decrease ability to detect launch
Boost propulsion for strategic missiles	•Retain or exceed performance of current high signature metallized propellants •No primary or secondary plume signature	•Increased range, velocity, and payload •Increased amount of ocean to conceal submarine •Decreased risk of launch detection •Decreased risk to launch platform
High-energy gun propulsion	•Increased delivered performance over current gun propellant formulation •More than 50% increase in mass impetus •Greatly increased burn rates	•Increased range (stand off increase of 2 km) and velocity (200 m/s increase) without increasing hazards or decreasing reliability •Reduced vulnerability
Nonpolluting booster propulsion	•Exceed current performance by 100% •Clean propellant •Stable combustion	•Single stage to orbit •50% increase in payload •Affordable, on-demand launch system •No launch-site contaminations •Reduced atmospheric pollutants

Goals and Payoffs — High energy Density Materials (Continued)

Application	Goal	Payoff
Orbit transfer vehicle propulsion	•Exceed current performance by 100% •Clean propellant •Stable combustion	•100% increase in payload •50% reduction in launch costs •No vehicle contamination
Explosives		
High-energy explosives for shaped charge application	•Increase penetration depth in steel armor plate -- 50% increase from the current formulations -- Meet insensitive munition requirements	•Increased armor penetration against thick armor increases vulnerable area of enemy tank •Increased safety, enhanced survivability
Bomb fill (blast/frag)	•Exceed performance of current fill •Meet IM requirements and/or 1.6 hazard classification •Affordable, producible materials and processes	•More munitions allowed in ready storage area, increasing number of sorties •Increased safety, survivability •No sacrifice in performance •Low cost
Underwater explosive technology	•100% increase in shock and bubble energy •Meet IM requirements	•Improved kill of current and future submarine and large surface vessels •Enhanced survivability
Booster technology	•Insensitive/high output booster explosives/devices for igniting insensitive explosives with large critical diameter	•Improved reliability in initiating insensitive HE materials (New devices increase reliability)
Follow-through and penetration warheads	•Survive hard-target penetration •50% increase in performance •Meet IM requirements	•In many cases provides difference from current no kill against hardened submarine, land, or ship targets
High-energy insensitive explosives for nuclear weapons application	•100% increase in performance •Reactive case •Meet IM requirements	•50% increase in missile range (smaller warhead) •Increased safety
Internal blast	•100% increase in performance •Reactive case •Meet IM requirements	•Kill ship and land targets •Increased missile range due to lighter warhead
Explosively formed projectiles	•50% increase in penetration •Meet IM requirements	•Effective against current and future armor threat •Increase safety, greatly enhanced survivability
Enhanced blast	•900% increase in blast energy over HE •Meet IM requirements	•500% increase in effectiveness against shielded targets •Low cost •Increased safety, enhanced survivability
Pyrotechnics		
	•High output pyrotechnics with fast and tailorable burn rates •Ballotechnics	

(2) **Development Milestones**

To achieve these objectives, the following milestones are needed:

- Initiate a design data base for hybrid composites (FY 1992).
- Characterize complex constituent interfaces (FY 1993).
- Generate thermo–structural analysis methods for complex hybrid systems (FY 1994).
- Develop joining technology for complex systems (FY 1995).
- Identify quality assurance criteria (FY 1996).
- Generate standardized inspection techniques (FY 1997).
- Initiate production scale–up (FY 1997).

2. Technology Objectives

Technology Objectives — Composite Materials

By 1996	By 2001	By 2006
• Development of high-temperature metal, ceramic, and carbon composite engine components • Pervasive application of composite materials in aerospace vehicles and advanced ship/submarine hulls and land vehicles	• Qualification of composite materials for thermal management and weight reduction in electronic devices and space vehicles • 25 to 50% weight reduction in airframes, land vehicles, and space vehicles • Significant reduction in radar and infrared signatures • Thrust-to-weight ratio for gas turbine engines increased to 17:1	• Widespread use of advanced composite materials in US weapons systems and platforms • Thrust-to-weight ratio for gas turbines achieves 20:1 • Composite fabrication conducted in space

3. Resources

Army, Navy, Air Force, and DARPA are the principal performers in this critical technology. Each Service focuses its development programs on those composites critical to meeting system performance requirements.

A summary of total S&T funding[17] for this critical category is given in the following table.

[17]Funding is derived from programs in the DoD budget. Most programs involve several technologies. It therefore becomes a matter of judgment how many dollars to count toward which technology. The funding presented here and throughout this report, for each critical technology, is of the right order of magnitude but is not to be construed as a precise budgetary quantity. Here the NASP is not included.

2. Technology Objectives

Technology Objectives — Superconductivity

Technical Area	By 1996	By 2001	BY 2006
Materials and processing	• Higher transition temperature HTS materials • Quality HTS tunnel junction arrays • Higher critical current densities in ceramic materials • Long HTS wires; prototype conductors • Large-area HTS films for shielding and cavity resonators	• Higher transition temperature HTS materials • Quality HTS tunnel junctions in large arrays • HTS conductors suitable for supermagnets • Theoretical undersanding of HTS	• Codified manufacturing processes for materials production and fabrication
Sensors	• LTS IR focal plane arrays • HTS sensors, DC to IR • LTS inertial and gyro sensors	• LTS MAD ASW systems • HTS IR focal plane arrays • HTS inertial and gyro sensors	• Widespread use in a variety of sensor platforms
Superconducting electronics	• LTS analog communications and surveillance systems • HTS analog communications and surveillance components • HTS A/D converters • LTS Nb/NbN digital chip-level technology • HTS interconnects for semiconductor circuits • HTS digital electronics array technology	• HTS analog communications and surveillance systems • LTS Nb/NbN digital signal processor and memory • HTS digital chip-level technology • HTS satellite system	• Widespread use of superconducting electronics
Supermagnetic-based applications	• Prototype LTS magnetic gun • Test of LTS MHD ship propulsion systems • Modest-performance HTS supermagnets	• Engineering of operational LTS rotating electrical machines • Engineering of operational LTS magnetic energy storage system • Engineering of operational magnetic gun • Engineering of operational MHD ship propulsion system • High-performance HTS supermagnets	• Widespread use of superconducting magnets in industry, academia, and defense
Particle accelerators	• Low-loss HTS cavity resonators	• Prototype HTS cavity resonator particle accelerator	• Widespread use in academia and defense research

Specific Goals and Payoffs — Biotechnology

Goals	Payoffs
Biosensors	
• Receptor-based sensors	• Identification of organisms
• Immuno sensors	• Improved real-time detection and identification of chemicals, pathogens, toxins, explosives, and drugs
• Nucleic-acid based biosensors	• Improved non-acoustic undersea surveillance
• Optical-based microsensors	• Detection of pollutants at low levels
• Molecular channels	
Bioprocesses	
• Biological crystal growth	• Tailored inorganic crystal sizes and shapes for ceramics and electronics
• Waste site bioremediation	• Low-cost, permanent solution for persistent toxic substances
• Bio-paintstripping	• Elimination of hazardous solvents for removal of paint from aircraft
• Enzyme decontamination and surfactants	• Selective decontamination and cleaning agents
• Synthesis of energetic compounds	• Lower cost and improved safety for high-energy materials
• Bio-degradation of energetic compounds	• Low-cost, environmentally safe disposal
Biomaterials	
• Understanding natural designs, enzymes, and pigments	• Optical integration of sensing, decisionmaking, functional capability, and mechanical properties in "smart" structures
• Recombinant-derived fibers	• Improved light-weight, high-strength materials
• Biosynthetic polymers	• Low-cost, low-weight, high-strength organic matrix composites for aircraft
• Catalytic polymers	• Self-decontaminating materials for individual and collective protection
• Bioelastomers	• Seals, gaskets, coatings with better chemical and mechanical properties
• New antifoulants	• Environmentally safe coatings for ships, buildings, and bulkheads with improved performance
• Bioadhesives	• Low-cost, high-performance lubricants
• Biosynthesized lubricants	• Improved manufacturing and processing of ceramic composites and powders
• Bioceramics	• Photoresponsive materials and coatings for signature reduction
• Immobilized protein-pigment complexes	• Improved ballistic and camouflage protection
• Self-assembling protein arrays	• Laser protection
• Biomolecules with nonlinear optical properties	• Light-based computers
	• Low-cost microcircuit manufacturing
• Thin-film, self-assembling molecular arrays	• Increased circuit density and speed with decreased size; three-dimensional logic capability
• Improved metallized biotubule fabrication	• High-power microwave and energy storage devices

2. Technical Objectives

Technology Objectives -- Flexible Manufacturing

Technical Area	By 1996	By 2001	BY 2006
Product Data Definitions for Automated Life Cycle Support	• Continue development of product definitions • Test and validate methodology and begin implementation	• Design all new weapons systems in standard product format • Continue development of more productive and automated tools for transitioning from legacy data to new product moels • Implement data definition at parts level and extend to systems level • Integrate into CAE structure	• Standard product data in wide use nationally, for all product designs • Fully implement at all levels of design and manufacture
CAD/CAM/CAE/CAPP	• Identify existing design tools • Develop an integrated design tool (architecture, mechanical, hydraulics, electrical, and software design, manufacturing and support) • Develop new design tools and algorithms • Develop architecture for universal controller • Improve man-machine interfaces (sensory controls)	• Develop voice interactive man-machine interface protocols • Develop the capability to capture and re-use design components • Develop the capability for collaborative design • Develop knowledge base concepts for engineering design and manufacturing • Implement design tools on new weapon system designs • Implement next generation controllers • Implement sensory controls	• Apply integrated design architecture and product data to shop floor control
Database and Database Management	• Define database models to support design, analysis, simulation, production, life cycle support, and enterprise planning, financial and administrative functions • Define generic database of integrated enterprise • Demonstrate effectiveness of database as a management tool	• Demonstrate consensusderived industry standard distributed, object-oriented databases • Demonstrate effectiveness of enterprise integration and value to production of weapon systems • Transition selected weapon systems to full support in new database model	• Establish full integrated weapons database to facilitate design, procurement, manufacturing, training, repair and overhaul, and administrative functions • Integrate concept into subcontract and supplier base

Technology ObjectivesFlexible Manufacturing (Continued)

Technical Area	By 1996	By 2001	BY 2006
Communications and Networking	• Develop concept of fully distributed scalable communication networks serving manufacturing enterprise needs based on intelligent software interfaces • Demonstrate robust integrated manufacturing planning, material procurement and subcontracting, production control, and shop floor routing through linkage to knowledge-based planning tools for timely delivery to assembly stations	• Implement pilot programs of robust integrated networks • Develop network prototocols to transfer data between government and contractors and suppliers	• Implement seamless networking in defense and industrial base
Enterprise Integration	• Develop object-oriented databases, intelligent controllers, and adaptive manipulation of objects	• Continue development of controllers • Apply database concepts and adaptive manipulation	• Promote integration concept across an entire industry sector
Intelligent Software Interfaces	• Improve methods, software, and hardware for improved object recognition in terms of product definition data	• Apply to parts recognition and manipulation, and the assembly of parts	• Implement in the base

3. Resources

Funded programs in this area are to be found in RAMP, CALS, and DARPA. A summary of funding for flexible manufacturing relative to the above functions is given in the following table.

Funding — Flexible Manufacturing ($M)

FY87-91	FY92	FY93	FY94	FY95	FY96	FY97
105	25	28	29	31	32	31

4. Utilizing the Technology

Defense industries and depots have begun to employ elements of flexible manufacturing. Through the decade of the 1980s many companies installed computerized production equipment of various kinds, e.g., composites tape laying equipment, four- and five-axis numerical control machines, robots, and wire harness fabrication machines.

The capability and flexibility of individual computerized design, finance, and manufacturing systems has also steadily increased. Computer-aided design (CAD) system

ANNEXE 3

LES PROGRAMMES DE RECHERCHE AMONT DES ETATS-UNIS (Introduction)

MINISTÈRE DE LA DÉFENSE

LES PROGRAMMES DE RECHERCHE AMONT DES ÉTATS-UNIS

•

UNE IMAGE

•

VOLUME 1

ÉDOUARD VALENSI

(Janvier 1995)

Dossier n° 0105/95

DGA

DIRECTION DE LA RECHERCHE ET DE LA TECHNOLOGIE

CENTRE DE DOCUMENTATION DE L'ARMEMENT

TABLE DES MATIERES

8 - ARMEMENT TERRESTRE

- 8.1. Véhicules terrestres mobilité
- 8.2. Armes à feu
- 8.3. Munitions et mines
- 8.4. Génie

9 - MISSILES (espace)

10 - CONSTRUCTIONS AERONAUTIQUES

- 10.1. Technologies aéronautiques
- 10.2. Propulseurs
- 10.3. Avionique systèmes d'armes

11 - CONSTRUCTIONS ET ARMES NAVALES

- 11.1. Technologies sous-marines
- 11.2. Lutte ASM, guerre des mines
- 11.3. Navires de surface
- 11.4. Combat naval, autodéfense
- 11.5. Technologies diverses

12 - FORCES SPECIALES

13 - TECHNOLOGIES ET SERVICES

- 13.1. Logistique
- 13.2.Techniques diverses
- 13.3.Technologies industrielles
- 13.4. Démilitarisation environnement

La recherche amont aux Etats-Unis : une source de réflexion pour la Défense française

Ce dossier a été réalisé à partir des fiches du "Defense Program Service" publiées par la Carroll Publishing Company, complété par l'analyse du Defense & Economy World Report. Les programmes étudiés correspondent approximativement à la notion française de programmes de recherche amont, sans que les concepts français et américains puissent exactement coexister. Au demeurant, à la notion de recherche se substitue celle de stratégie scientifique et technologique

Aucun caractère d'exhaustivité ne peut être recherché puisque les études les plus importantes, classifiées, ne figurent pas dans ce catalogue et qu'un programme de plus de cent millions de dollars peut se trouver résumé en une page; les études citées étant d'importance très variables, pouvant ne pas dépasser le million de dollars, une très grande variété de sujets, même très aléatoires étant cités. Les budgets sont un repère capital auquel il convient d'être très attentif.

Ce dossier appelle une lecture diversifiée dont l'objet pourrait être une réflexion sur les différences d'approches américaines et françaises s'agissant des politiques de recherches de Défense, se traduisant par une certaine antinomie dans les choix. Y a-t-il deux vérités de part et d'autre de l'Atlantique, ou bien sur tel ou tel sujet ne doit on pas donner raison à l'un ou à l'autre ?

Comme le souligne le Defense & Economy World Report, les programmes de recherche américains ont été redessinés pour tenir compte de risques nouveaux :

- les menaces potentielles générées par des conflits locaux,
- la prolifération d'armes de destruction massive,
- la multiplication des actions du maintien de la paix.

A partir de quoi le *Joint Staff* et le *Joint Requirements Oversight Council* ont déterminé cinq *Future Warfighting Capabilities :*

1. Disposer d'une connaissance temps réel, quasi parfaite de l'ennemi et d'une capacité d'information de toutes les forces proches du temps réel,

2. Engager des forces régionales rapidement, pour un combat décisif global,

3. Mettre en oeuvre un ensemble de moyens permettant d'actionner jusqu'au plus bas niveau, des opérations militaires qui permettront d'aboutir aux objectifs militaires avec un minimum de pertes et de dommages collatéraux (c'est à dire, civils)

4. Maîtriser l'usage de l'espace,

5. Contrer la menace des armes de destruction massive sur le territoire des Etats-Unis et les espaces de déploiement des forces.

En parallèle, des efforts particuliers de gestion ont été engagés. Ils s'appuient sur cinq principes :

1. Adapter les technologies aux exigences du combat,

2. Réduire les coûts par le recours à des sources commerciales, le développement de la simulation, l'accroissement de la productivité industrielle,

3. Renforcer les bases industrielles duales,

4. Promouvoir la recherche de base,

5. Préférer la qualité à la quantité.

Les efforts de recherche des Etats-Unis qui ont été regroupés par grands thèmes, indépendamment des organismes qui les financent permettent d'aboutir aux pourcentages indicatifs suivants :

Coopérations universitaires	513 M$	6,1 %
Informatique, matériels et logiciels	2.049 M$	24,2 %
Total électronique de défense	1.321 M$	15,6 %
Mécanique	371 M$	4,4 %
Océanographie, Géophysique	347 M$	4,1 %
Support du combattant	781 M$	9,2 %
Armement terrestre	476 M$	5,6 %
Missiles (espace)	624 M$	7,4 %
Constructions et armes navales	1.166 M$	13,4 %
Forces spéciales	78 M$	0,9 %
Total Technologies et services	649 M$	7,7 %

Total recherches amont (répertoriées) 8.475 M$

Quelques observations sur les programmes:

1. Les Etats-Unis décomposent leurs programmes de manière un peu différente dans les domaines technologiques suivants :

Une image des programmes de recherche amont aux Etats-Unis

Coopérations universitaires	513 M$
Matériaux et composants électroniques	671 M$
Calculateurs hautes performances	530 M$
Technologie des logiciels	267 M$
Simulation systèmes d'entraînement	156 M$
Systèmes de communication et de com.	423 M$
Total Informatique	2.049 M$
Radars	222 M$
Guerre électronique	391 M$
Optronique Infrarouge	502 M$
Laser	196 M$
Total électronique de défense	1.321 M
Aérodynamique hypersonique	107 M$
Energétique	139 M$
Matériaux	125 M$
Total Mécanique	371 M$
Océanographie, Géophysique	347 M$
Technologies médicales	445 M$
Facteurs humains ergonomie	184 M$
Défense NBC	152 M$
Total support du combattant	781 M$

Véhicules terrestres mobilité	175 M$
Armes à feu	47 M$
Munitions et mines	232 M$
Génie	22 M$
Armement terrestre	476 M$
Missiles (espace)	624 M$
Technologies aéronautiques	192 M$
Propulseurs	85 M$
Avionique systèmes d'armes	281 M$
Total constructions aéronautiques	558 M$
Technologies sous-marines	187 M$
Lutte ASM, guerre des mines	312 M$
Navires de surface	194 M$
Combat naval, autodéfense	451 M$
Technologies diverses	152 M$
Total constructions et armes navales	1.166 M$
Forces spéciales	78 M$
Logistique	99 M$
Techniques diverses	
Technologies industrielles	162 M$
Démilitarisation environnement	270 M$
Etudes et technologies diverses	118 M$
Total Technologies et services	649 M$

- *Propulsion et énergie aérospatiale*
- *Milieux du combat*
- *Biomédical*
- *Défense chimique et biologique*
- *Habillement textile et nourriture*
- *C3*
- *Logiciels et informatique*
- *Armements conventionnels*
- *Electronique*
- *Guerre électronique*
- *Armes à faisceaux dirigés*
- *Qualité de l'environnement et génie*
- *Interface homme-machine*
- *Ressources humaines et entraînement*
- *Construction navale et terrestre, matériaux*
- *Capteurs*
- *Techniques manufacturières et technologie.*
- *Simulation et modélisation.*

2. Cette décomposition traduit le point de vue des états-majors qui est omniprésent et marque fortement chacune des opérations. Au niveau des fiches, les finalités opérationnelles servent de critère de classement principal, au détriment d'une bonne économie scientifique et technique.

3. L'aspect "système" est très privilégié, parfois trop puisqu'il fait l'objet de développement avant même que des composants critiques soient disponibles. De fait les présentations françaises et américaines des programmes d'études sont complémentaires.

4. Au niveau des programmes :

- L'informatique et l'électronique sous toutes leurs formes occupent la place principale Des programmes majeurs ont été lancés, dans un contexte de dualité prononcé, pour donner le premier rang aux Etats-Unis et une prééminence internationale incontestable. Les programmes répertoriés se montent à 1,2 milliards de dollars..

De nombreux groupes d'études naguère éparpillés se trouvent regroupés en concepts cohérents : la guerre électronique sur laquelle les crédits de recherche amont engagés se montent à 390 millions de dollars, simulation sur laquelle 156 millions de dollars sont regroupés, la notion de système étant omniprésente.

- Les hommes sont placés au premier plan et bénéficient d'une beaucoup plus grande attention qu'ils n'en trouvent en France. Technologies médicales et facteurs humains constituent deux grands domaines d'efforts, 630 millions de dollars leur sont affectés.

Des activités ont perdu beaucoup de leur importance :

- l'ensemble des études relatives à la mécanique, aux matériaux structuraux,
- les recherches touchant au domaine stratégique (à l'exception de l'électronique et de l'optronique)

Des activités nouvelles font l'objet de développements organisés :

- l'organisation du combat en profondeur, qu'il s'agisse de définir des moyens d'observation, de frappe ou de simulation du combat.
- la logistique. Les récents engagements des forces de maintien de la paix en ayant démontré l'importance,
- l'environnement et la décontamination,

Ces activités ne pourraient-elles pas retenir l'attention de centres de recherche de Défense français ?

5. De la lecture des fiches, on retiendra la très grande souplesse du processus de programmation de la recherche aux Etats-Unis. Cette souplesse est démontrée par l'apparition de programmes nouveaux, le réordonnancement sous des éclairages nouveaux d'opérations élémentaires antérieures, l'arrêt brutal de financement ou, au contraire, par l'apparition soudaine de programmes très richement dotés.

Peut-être trouve-t-on ici quelque précipitation, mais dans l'ensemble ,il y a là un défi que la France devrait pouvoir relever.

6. Les coopérations internationales sont marginales. Mais sans doute beaucoup d'entre elles sont jugées confidentielles ou n'apparaissent pas directement dans les fiches descriptives des programmes.

Au total, c'est à une réflexion de fond qu'invite la lecture des éléments de programme rassemblés :

1. Il semble que les Etats-Unis aient fait très rapidement évoluer leurs axes d'intérêt en trois temps :

- suite à la fin de la guerre froide,
- en fonction des enseignements de l'intervention dans le Golfe
- pour permettre la restructuration de l'industrie de Défense.

Et que les programmes de recherches en aient été très fortement affectés. Une évolution semblable s'observe-t-elle en France ? Serait-elle souhaitable ?

2. La dualité est un paramètre essentiel, et les programmes qu'il est possible de regrouper sur ce thème se chiffrent en milliard de dollars. Une telle évolution peut-elle être envisagée en France, compte tenu des structures et des choix industriels civils ? De l'Europe ?

3. L'équilibre entre opérations élémentaires de recherche et le développement cohérent de systèmes est il convenable en France ? Ne privilégions nous pas les opérations élémentaires, proposé des équipes de recherches, au détriment d'études plus organisées et plus ambitieuses d'un point de vue scientifique

4. L'effort d'adaptation des technologies émergentes aux besoins militaires nouveau est il suffisant ? N'y a t-il pas là une possibilité d'évolution des plans charge des établissements de recherche de défense ?

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U.S. DEFENSE SCIENCE AND TECHNOLOGY STRATEGY 1994

In September, the U.S. Department of Defense (DOD) approved a new Defense Science and Technology (S&T) Strategy. The plan is driven by the five Joint Staff Future Joint Warfighting Capabilities which establish the broad military requirements. The building blocks of the strategy are 19 technology areas. Central to the plan are investment priorities and new management guiding principles.

Strategy

The Director of Defense Research and Engineering (DDR&E) approved the Defense Science and Technology Strategy and Plan in September. The plan is a continuation of the 1992 strategy and of the annual Defense Critical Technologies Plan (DCTP) (Formerly, some technology areas were known as key technology areas and earlier as critical technologies).

The plan is rooted in the new defense strategy [D&E 1993, p. 997] and in the new approach to defense acquisition. It responds to the new demands of the post-Cold War era as well as to the shrinking resources for defense.

Military needs are driven by

- potential threats of regional and local ethnic conflicts;
- proliferation of weapons of mass destruction; and
- increased demand for peacekeeping and humanitarian missions.

But chief requirement is to develop superior technology for warfighting. The Joint Staff and the Joint Requirements Oversight Council have identified five *Future Warfighting Capabilities* most needed by U.S. combatant commands:

- 1. To maintain near perfect real-time knowledge of the enemy and communicate that to all forces in near-real time.
- 2. To engage regional forces promptly in decisive combat, on a global basis.
- 3. To employ a range of capabilities more suitable to actions at the lower end of the full range of military operations which allow achievement of military objectives with minimum casualties and collateral [i.e., civilian] damage.
- 4. To control the use of space.
- 5. To counter the threat of weapons of mass destruction and future ballistic and cruise missiles to the Continental United States and deployed forces.

S&T Priorities

Two generic priorities apply to all specific science and technology programs and are receiving top consideration:

Dual Use

Defense-unique industries cannot be sustained by current and future defense budgets, in general. Also, technologies critical to national security are being developed and matured commercially and internationally, notes the Defense Department. Therefore, in the future it must rely—to the extent possible—on the same industrial base that builds commercial products. Both reduced cost of product and technological sophistication will result. A common commercial and defense industrial base will serve defense needs better, says DOD, and it will strengthen American economic competitiveness.

Affordability

Decreases in resources compel the consideration of affordability as an integral part of the S&T program. Technology can and must ensure that the military can buy more for less. Materiel and systems must be developed at a lower cost, be longer-lived, and be incrementally enhanced in capability through planned upgrades, says DOD. The potential of technology to contribute is great, considering that

- simulation can improve training and readiness, thus enabling a smaller force to be more effective;
- technology can improve production process and reduce fabrication cost and elapsed time;
- sensors and materials that monitor wear, stress, and fatigue, can reduce the need for maintenance

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and maintenance personnel; and

- components and subsystems that improve performance also extend the useful operational lives of current systems.

Technology

Analysis of the future capabilities that the combatant commands most need and the scientific and technological opportunities that exist today leads to establishing several technology areas as requiring high priority investments:

- Information science and technology;
- Modeling and simulation; and
- Sensors.

Beyond these three high-priority, DOD-wide technologies, the S&T program will continue to be broad-based, says DOD, spanning all defense relevant sciences and defense-relevant technologies. The Military Services will continue to field robust programs in service-specific technologies: the Army will continue to invest in terrestrial science and armor materials, the Navy in ocean geophysics and acoustic signature analysis, and the Air Force in atmospheric physics and space launch.

S&T Program

Traditionally, the program is described as having three separate and identifiable elements: Basic Research, Exploratory Development, and Advanced Development. But these categories relate more to budgeting and accounting than to execution. The program and the advancement of technology is a continuum, not a discrete phase.

The objective of the Basic Research Program is to produce knowledge in a science or engineering area that is militarily relevant. It cannot be known whether a particular scientific result will lead to a military application. Basic research is inherently a long-term investment, yielding possible opportunities far into the future. Program investments are in 12 areas:

- Atmospheric and space sciences
- Biological and medical sciences
- Chemistry
- Cognitive and neural sciences
- Computer sciences
- Electronics
- Materials science
- Mathematics
- Mechanics
- Ocean sciences
- Physics, and
- Terrestrial sciences.

Exploratory Development and Advanced Development programs mature technologies. In some cases prototypes embodying a technology are built. Exploratory Development provides proof of concept experiments and evaluations built around models and laboratory experiments. The Advanced Technology Development program is structured to apply technological advances to provide military capability.

Rapid technology transition into the operational forces is crucial. To make this possible and to establish a sound basis for acquisition decisions, a new aspect of S&T has been defined: the Advanced Concept Technology Demonstration (ACTD). It is the successor to the broad S&T thrusts pursued over the past several years. Where the thrusts were broadly based, ACTDs are tightly focused on specific military concepts. The ACTD provides a mechanism for intense involvement of warfighters while incorporation of technology into a warfighting system is still at an informal stage. This allows iterative change of both the system construct and the user's concept of operations without the constraints and costs which are incurred when the discipline of formal acquisition is involved.

The ACTDs are user-oriented, even user-dominated. The ACTDs have three motivations: 1) to have the user gain an understanding of and to evaluate the military utility before committing to acquisition; 2) to develop corresponding concepts of operation and doctrine that make best use of the new capability; and 3) to provide residual; operational capability to the forces.

Requirements of the operational forces are generated during definition of an ACTD. The outcome of an ACTD is judged by the users. If a user is not prepared to initiate acquisition, the effort will terminate consistent with the user's reasons. If, on the other hand, the user determines that the demonstrated concept should be brought into the forces, there are two possible avenues. First, if large numbers are required, the system will enter the acquisition process at whatever stage good judgment dictates. Second, if only small numbers are required, it is preferable to modify the demonstration system appropriately and then to reproduce it as needed.

Management

The S&T program is planned, programmed and conducted by the Military Departments and the Defense Agencies. The Director of Defense Research and Engineering (DDR&E) is responsible for the direction, overall quality and content of the Department of Defense Science and Technology Program. DDR&E ensures that the program responds to the needs of the U.S. military and to the national goals embraced in the program's vision.

DDR&E, in collaboration with the Military Departments and Defense Agencies, has prepared a Technology Plan which documents the focus and content of the overall DOD technology effort. Goals, objectives, schedules, and funding are defined for each of the 19 technology areas. The plan also dicusses opportunities for transitioning technology rapidly into fielded systems, and projected operational payoffs. In each technology area, a detailed plan is maintained as a working document. Components executing programs and projects maintain the most detailed plans.

Five guiding management principles have been adopted by the Military Departments and Defense Agencies:

- 1. Convert technology to address warfighting needs. This requires work with the warfighters, rapid movement of promising concepts, insertion of technology into Service systems, and prevention of technological surprise.
- 2. Reduce cost through the use of the best commercial products, practices, and capabilities; the use of simulation; improvement of manufactuyring processes, considering environmental effects; establishment of Service affordability programs; and reduction of costs of ownership.
- 3. Strengthen the commercial-military industrial base. Use the same technology and the same industrial base, where appropriate, to build military and commercial products, strengthen technology transfer, and field selected initiatives to apply technology to societal needs.
- 4. Promote basic research. Quality must be supported, stable research funding sustained, future scientists and engineers educated, and teamwork and partnerships promoted.
- 5. Assure quality. Quality is more important than quantity in the execution of the S&T program, stresses DOD. To achieve this, a critical mass of internal expertise must be retained, innovation encouraged, Project *Reliance* strengthened, quality of staff and facilities improved, and international science efforts monitored and collaboration offered.

TECHNOLOGY AREA PLANS

AN OUTLINE

1. Aerospace Propulsion and Power

This technology area includes those efforts directed toward propulsion and power systems for aircraft, missiles, and space vehicles. There are four major sub-areas:

1.1 Integrated High Performance Turbine Engine Technology (IHPTET) program, focused on gas-turbine propulsion systems for aircraft and cruise missiles;

1.2 Integrated High Payoff Rocket Propulsion Technology (IHPRPT) program, focused on propulsion systems for space and missile systems;

1.3 High Speed Propulsion and Fuels, focused on ramjet, scramjet, combined-cycle propulsion systems for missiles and space-launch systems, and fuels;

1.4 Aerospace Power, focused on non-propulsive power generation systems for aircraft, missiles, and space vehicles.

Rationale for Investment: Aircraft, missiles, and space vehicles constitute a major portion of the force structure—total expenditures related to aircraft alone are about one-third of the Department of Defense budget. Increased cost-effectiveness of these system is essential to support all of the top five Joint Staff Future Joint Warfighting Capabilities. Since propulsion and power systems (including fuel) for these vehicles typically account for 50-90 percent of their overall weight and a significant fraction of their supportability requirements, increases in propulsion and power system performance—reductions in weight, volume, and fuel—and decreases in cost and supportability requirements will have a large impact on the affordability and capability of these vehicles.

Significant improvement in performance and cost of propulsion and power systems—e.g., a 100 percent increase in the thrust/weight ratio of fighter engines, a 100 percent increase in thrust/weight ratio and a 20 second increase in specific impulse of rocket engines, a 100 percent increase in effective impulse in a ducted rocket engine, and a 200 percent increase in the specific power of satellite power systems—are attainable through foreseeable technological advances in: aerothermodynamic design, lightweight/high-temperature materials, innovative structural arrangements, improved propellants and fuels, tribology, controls, and direct energy conversion phenomena. These improvements in propulsion and power system characteristics will have a large impact on reducing the cost and increasing the capability of aerospace vehicle systems.

Technology Sub-Areas

1.1 Integrated High Performance Turbine Engine Technology (IHPTET)

1.2 Integrated High Payoff Rocket Propulsion Technology (IHPRPT)

1.3 High Speed Propulsion and Fuels

1.4 Aerospace Power

2a Air Vehicles

Air vehicles, which provide affordable, global delivery of people, supplies, weapons and sensors, are divided into four major sub-areas:

2.1 Fixed Wing vehicles

2.2 Rotary Wing vehicles

2.3 Unmanned Air Vehicles (UAV), and

2.4 Systems Integration Technology, focused on the integration of air vehicle technologies with other technology areas, e.g. sensors, propulsion, weapons, and human systems, to provide improved or new operational capability.

Technology efforts are aeromechanics, flight controls, subsystem, air vehicle structures.

Rationale for Investment: Air vehicles form the backbone for both the national defense and power projection abroad--supporting four of five (not "Control Use of Space") of the Joint Staff Future Joint Warfighting Capabilities. Air vehicles are critical to air superiority, strike, military airlift, early warning, reconnaissance, command and control, ground attack, and sea control. Since one-third of the annual budget of the Department of Defense supports aircraft expenditures, improvements in air vehicle cost and capability offer significant potential for reducing defense expenditures.

Air vehicle technology advances in lift/control augmentation, fly-by-light controls, weapons/avionics/propulsion integration, and helicopter active control offer the opportunity by 2010 for major improvements in warfighting capability, including: a 100 percent increase in range/payload for fighter/attack aircraft; a 50 percent reduction in system acquisition cost for airlift/patrol/bomber aircraft; a 400 percent increase in global mission range, and a 50 percent reduction in global reaction time for high speed aircraft; a 50 percent increase in survivability for attack/reconnaissance/utility helicopters; and a 35 percent increase in payload/gross weight ratio for cargo helicopters.

Technology Sub-Areas

2.1 Fixed Wing

2.2 Rotary Wing

2.3 Unmanned Air Vehicle

2.4 Systems Integration Technologies

2b Space Vehicles

The technologies assembled under the Space Technology area are those oriented toward the spacecraft bus, as opposed to payload; technologies unique to space and the military; and their implementation through flight experiments. Space Technology encompasses eight sub-areas:

(1) propulsion focused on thrust producing engines and devices for space launch, orbit transfer, and maneuver (covered in 1. Aerospace Propulsion and Power area).

(2) power focused on the generation and distribution of electrical power on-board spacecraft (covered in 1. Aerospace Propulsion and Power area).

(3) Thermal Management focused on cyrocooler and heat transfer/dissipation technologies for all satellite applications.

(4) Structures focused on adapting advanced materials and structures produced in basic research for space applications.

(5) Survivability focused on two sub-areas, "environments," both natural and hostile; and "techniques," including active and passive approaches to survivability.

(6) Guidance, Navigation, and Control (GN&C) focuses on advanced science and technologies for the launch from earth, earth orbit and free space. GN&C encompasses both missile guidance to the unique gravity free and to the gravity controlled space environment. GN&C also involves the precise timing and time transfer technologies enabling the Global Positioning System (GPS), and advancing the technologies in GPS applications.

(7) Technology Integration (Astronics) focuses on adapting products of other technology areas to space systems.

(8) Flight Experiments which is the culmination of space related science and technology, focuses on space qualification and transfer of the technology to the military and civilian space communities. The flight experiments sub-area also caters to the science community and enables the scientific examination of the sun, the space environment, the earth's surface from space, as well as the earth's weather and atmosphere.

Rationale for Investment: If the fundamental goal of space related science and technology is to make future Department of Defense space systems more cost effective while retaining U.S. technological superiority, then there must be three thrusts. The first is to reduce the direct costs of space systems. Currently the total cost associated with a space system are 30 percent for the actual satellite, 20 percent for launch, 25 percent for ground control, and 25 percent for user equipment. Great savings can be achieved in the satellite and launcher through weight reduction and increased component life. Weight reduction in the satellite and booster reduced the size of the booster needed, the amount of fuel consumed, and the overall complexity of the effort. Advanced composite materials, smart structures, high temperature superconductivity, integrated structural and electrical systems all have great promise for weight reduction. New materials, durable coatings, radiation hard electronics promise increased component life if adapted to space systems. Increased component life also includes reusable components. Reusable, less complex boosters have great promise for cost reduction, single stage to orbit and recoverable boosters being examples. Not only can the cost of the booster be amortized over more usage but these less complex launchers will be cheaper to be built and require less infrastructure. The second thrust is a rapid insertion of new technologies into operational space systems. This means the application or adaptation of commercial off-the-shelf technology wherever possible and the demonstration and space qualification of new technologies through flight experiments. Selective use of small experimental satellites and technology test beds with operational capabilities can demonstrate that technology and operating concepts are mature enough for insertion directly in planned operational systems. The third thrust must be capabilities which push the edge of technology to ensure that the space systems available to U.S. forces are more advanced than those of any potential foe. In a global environment where high technology, low cost space systems are commercially available, technological surprise must be guarded against. These three thrusts can be described as cheaper, faster, better.

Technology Sub-Areas

2.1 Thermal Management

2.2 Structures

2.3 Survivability

2.4 Guidance, Navigation, and Control

2.5 Technology Integration (Astronics)

2.6 Flight Experiments.

3. Battlespace Environments

The Battlespace Environments Technology area encompasses the study, characterization, prediction, modeling, and simulation of the terrestrial, ocean, lower atmosphere, and space/upper atmosphere environments to understand their impact on personnel, platforms, sensors, and systems; enable the development of tactics and doctrine to exploit that understanding; and optimize the design of new systems.

Rationale for Investment: Commanders at all levels must know how the environment will impact their operations as well as the operations of their adversary and use this knowledge for military advantage. Sensor and weapon system developers must also understand the environment's effects on system performance to optimize design effectiveness. This investment will provide:

A 10 time improvement in providing digital topographic data needed by the commander for optimized deployment, mobility, planning, and logistics support.

High resolution weather and sea state forecasts for incisive decision making and enhanced operational capability in adverse weather with reduced weather related damage and fuel costs.

Realistic representation of dynamic environment and terrain in simulations to permit effective mission rehearsal and training, and more cost effective materiel acquisition.

Detection and precise location of nuclear weapons tests to support counterproliferation and treaty verification.

A 90-percent improvement in capability to predict magnetic storm induced outages of C3, surveillance, and navigation systems to maintain control of the battlespace.

Realistic portrayal of the effects of the battlespace environments to reduce operational costs and reduce casualties.

Technology Sub-Areas

3.1 Terrestrial Environment

3.2 Ocean Environment

3.3 Lower Atmosphere Environment

3.4 Space/Upper Atmosphere Environment

4. Biomedical

Biomedical Science Technology (BST) programs are focused to yield superior technology in support of the Defense mission to provide health support to U.S. military forces. Unlike non-defense medical science and technology investments, BST is concerned with preserving the combatant's optimal mission capabilities and health despite battle and non-battle threats rising from the distinctive nature of military operations. By international treaty and convention, military medical research programs must be conducted for the benefit of mankind. Also, many programmatic activities are regulated by the U.S. Food and Drug Administration.

Defense BST programs are coordinated through the Armed Services Biomedical Research, Evaluation and Management Committee with direction and oversight exercised through Joint Technology Evaluation Groups aligned to the following seven functional areas:

4.1 Infectious Diseases of Military Importance

4.2 Combat Casualty Care

4.3 Medical Biological Defense

4.4 Medical Chemical Defense

4.5 Military Operational Medicine

4.6 Military Dentistry, and

4.7 Ionizing Radiation Bioeffects.

Each area, except Combat Casualty Care, emphasizes prevention of injury or disease through the provision of medical materiel (e.g. vaccines, drugs, and applied medical systems) and biomedical information (e.g., health risk and performance criteria). Combat Casualty Care provides capabilities for resuscitation, stabilization, evacuation, and treatment of all casualties.

Rationale for Investment: Individual service men and women are the most important, yet most vulnerable, components of military systems and mission capabilities. Life-threatening or incapacitating regional disease epidemics both limit and constrain military deployment alternatives for conflict resolution and peacekeeping operations. The declining force structure—confronted by the potential for large-scale regional conflicts, proliferation of weapons of mass destruction, diverse and highly complex missions, the enduring threats of disease, harsh climates, operational stress and injury—mandates sustained, robust investment in BST programs.

Superior BST technologies contributed substantially to the Gulf War victory; e.g., forward diagnostic labs; protective vaccines, drugs and practices; and fluid intake discipline. This translated into reduced casualties and sustained military operational superiority despite the harsh environment and continuous high-tempo operations.

The Gulf War also emphasized the need for medical countermeasures to biological and chemical weapons, since demonstrably superior countermeasures deter and constrain proliferation and use of such weapons. Finally, the nation's concern about causes and treatment of the Gulf War Syndrome exemplifies the need of the Department of Defense for robust BST investment.

Technology Sub-Areas

4.1 Infectious Diseases of Military Importance

4.2 Combat Casualty Care

4.3 Medical Biological Defense

4.4 Medical Chemical Defense

4.5 Military Operational Medicine

4.6 Military Dentistry

4.7 Ionizing Radiation Bioeffects

5. Chemical and Biological Defense

The danger posed by the proliferation of weapons of mass destruction is highlighted by the Joint Staff as one of the top five Future Joint Warfighting Capabilities. U.S. forces must be prepared for conflict in a chemical and biological (CB) environment in a *Global Reach* concept. The CB defense technology area includes four major sub-areas:

5.1 Detection

5.2 Protection

5.3 Decontamination, and

5.4 Information Processing and Dissemination.

Rationale for Investment: The purpose of CB defense research is to develop equipment that will protect U.S. forces, sustain combat operations and maintain system effectiveness in a CB contaminated environment. The cornerstone of CB defense strategy is early detection and warning to provide situational awareness and permit forces to avoid the threat. Detection systems, including both point and standoff sensors, will enable commanders to detect CB warfare agents below incapacitating levels and immediately activate protective or avoidance measures.

The complement to detection is protection, both active and passive. The goal of active protection is to intercept and destroy CB warhead payloads. The goal of passive protection is to insulate forces from CB agents using clothing ensembles and respirators as well as collective filtration systems and shelters. Carefully balancing performance requirements with human physiological and psychological parameters, protection technologies will enable the forces to sustain their mission with minimal casualties when a CB threat is encountered.

When CB contamination cannot be avoided, decontamination systems quickly reconstitute personnel and equipment with minimal logistics burden and impact on mission effectiveness. Decontamination technologies will be used during operations or in preparation for return to the Continental U.S.

Finally, information processing and dissemination technologies, including modeling and simulation, will aid in the assessment of Joint Service doctrine, training and materiel for operating in a CB environment, provide equipment design parameters, and enable field commanders to integrate and interpret real-time data.

Technology Sub-Areas

5.1 Detection

5.2 Protection

5.3 Decontamination

5.4 Information Processing and Dissemination.

6. Clothing, Textiles and Food

The Clothing, Textiles and Food Technology area focuses on protecting and sustaining soldiers, sailors, airmen, and marines, individually and collectively. Food, clothing, and shelter are essential to performance, survival, enhancing quality of life, boosting morale, and maintaining readiness. At first glance, providing for the basic needs (food and clothing) for service personnel appears to be deceptively simple. In truth, it is a highly complex challenge—protecting and sustaining hundreds of thousands of military personnel for every operational mission in every environment at any time presents a unique spectrum of challenges for which there is no civilian comparison.

This technology area is comprised of two sub-areas:

6.1 Clothing and Textiles, and

6.2 Food.

The clothing and textiles sub-area includes all textile-related polymer, fiber, yarn, fabric, film, dye, pigment, coating, and clothing systems and their packaging that enhance survivability, performance, and mobility—both on the battlefield and in operations other than war. These efforts provide technology advancements in the areas of individual ballistic protection, percutaneous chemical or biological protection, countermeasures to sensors, integrated protection (to include flame or incendiary protection and anthropometric or biomechanical concepts for clothing design), and bioengineered materials for protection. This sub-area also includes textile-based technologies for items such as tentage and parachutes.

The food sub-area includes science and technological efforts to sustain warriors and enhance their mental and physical acuity and performance on the battlefield. These efforts include nutritional performance enhancement, food preservation, food packaging, consumer acceptance, and equipment and energy technologies. They support the unique feeding requirements of the Military Services ranging from general purpose individual and group ration systems to rations designed for special operations or for extreme or remote environments, as well as the development of field food service equipment and systems essential for individual and group feeding during ground, air, and shipboard operations. The need to "fuel the fighter"—to deliver the right nutrients at the right levels at the right time in the right combination—requires breakthroughs in food related technologies, especially to meet the additional and unique demands that the "information/electronics age" will bring to bear on military personnel.

Rationale for Investment: Individual protection, sustainment, and mobility are critically required military capabilities. The clothing, textiles, and food area is structured to develop the technologies necessary to provide these capabilities. Military personnel are the essence of our ability to achieve our national military strategy and are the primary means through which successful mission accomplishment is assured. The specialized abilities of troops have been vital, nationally and internationally, not only for operational contingencies, but also for operations other than war (e.g., humanitarian, peacekeeping). Protection and sustainment of soldiers is a must when the public demands few casualties, especially in operations other than-war.

Through years of traditional approaches to clothing and textile-based protective materials, the military has fielded hundreds of high performance protective items. Now the military is at a juncture where the traditional approach is no longer sufficient to defeat the complex and ever-increasing battle theater challenges. An integrated approach to designing systems of protection and modular suites of components is more effective and affordable in providing new levels of protection to the individuals. This new approach allows incorporation of suites of modular chemical protective components, modular small arms bullet protection, and modular load carriage equipment.

Further, in the increasingly sophisticated battlefield of the future, it is the warfighter who assures mission success. Sustaining that fighter, the "man in the loop" in most weapons platforms, in peak condition is critical to that goal. Subsistence research efforts encompass support to ground combat, special operations, air and shipboard operations, and other specialized operations with emphasis on the standardization of rations, and of field feeding, equipment, and procedures among the Services while also providing cutting-edge solutions for sophisticated and unique military activities. The food provided to the fighter before and during his mission can provide the performance edge that makes him a true force multiplier.

Foreseeable advances in clothing and textile technology include: development of next generation high performance fibers, membranes, and fabrics for multiple threat protection textile-based systems; dyes and textile materials to prevent detection by multi-spectral sensor devices; increased understanding of chemical penetration mechanisms; and textile systems for clothing and soft shelters that provide thermal and environmental protection with minimum bulk and weight.

Foreseeable advances in food science and technology include: use of natural ingredients with glucose-modulating and neuroactive potential to enhance mental and physical performance; use of lipsomal vesicles of surviving digestive stress and delivering special nutrients and bioactive constituents to specific physiological sites; use of edible plasticizers and antiplasticizers to manipulate food structure and viscosity to minimize deteriorative physical and chemical reactions during high temperature storage; development of aseptically and ohmically processed particulate foods with optimal textural properties that would enhance soldier acceptance; use of intrinsic chemical markers to validate sterility of thermally processed foods to avoid overprocessing and quality degradation; use of integral-chemical heaters in self-activating package configurations to ensure hot meals "on-the-move"; use of predictive equations and time-temperature indicating labels for assessing remaining shelf life of foods stored in uncontrolled environments; development of integrated thermoelectric power generators to simplify food preparation equipment; development of non-powered refrigeration for storing perishables in the field; and development of nonpowered water heaters for remote site applications.

Payoffs are demonstrated in terms of greater system capability and reduced costs. These systems are: multifunctional combat uniforms, integrated protective equipment, lightweight airbeam-supported soft shelters, air deployment of personnel and large equipment and cargo, rations, efficient, modular, highly mobile field feeding systems. As compared to other major Department of Defense systems, a relatively small investment in clothing, textiles, and food science and technology significantly impacts the survivability, sustainability, effectiveness, performance, readiness, and morale of every Department of Defense service member.

Although the Department of Defense investment in clothing, textiles, and food technology is focused on military unique applications, many of the basic clothing and food technologies are inherently dual use. This results in decreased cost to the Department of Defense where industry is willing to invest its own resources, and creates are more stable manufacturing base for surge production during times of mobilization. It also plays a strong role in strengthening the commercial-military industrial base, allows Department of Defense to exploit cutting-edge technologies, and results in faster development, transition, and insertion of superior technologies. Developing technological advancements that address advanced clothing and textiles and optimal foods or rations and the purchasing of these items through the use of best commercial practices and processes, results in a larger and more reliable manufacturing base and a more affordable means of fielding advanced technology. Investment in manufacturing science and technology is one way to ensure improved, cost effective production and manufacturing processes.

Technology Sub-Areas

6.1 Clothing and Textiles

6.2 Food.

7. Command, Control and Communications (C3)

This science and technology area encompasses C3 systems of all types data processing hardware and software dedicated to operational planning, monitoring or assessment (including information fusion), distributed processing, distributed data storage, and distributed data management. Not included within C3 are those science and technology efforts directed at general purpose computer hardware and high performance computers, general purpose software, languages, software engineering, environments, and communications and processing elements considered subsystems in vehicles.

Effective Command, Control and Communications is recognized as a pivotal element in modern warfighting, providing the means for accurate decision making and information distribution to permit the successful employment of weapons systems. The Joint Staff list of top five Future Joint Warfighting Capabilities all require significant advances in C3 to be achieved. The number one capability, "To maintain near perfect real-time knowledge of the enemy and communicate that to all forces in near real-time" is a canonical C3 goal. Achieving this capability will require significant effort and technological advances in a number of areas.

Rationale for Investment: The means for implementing C3 are advancing at a rapid pace. In no other technical area is the means of implementation decreasing in cost while rapidly increasing in performance. Many of these advances are being driven by commercial developments and products. The results can be brought to bear on Department of Defense problems through cooperative efforts and participation in standards-setting and policy-making bodies rather than through costly Department of Defense-specific development. There are aspects of C3 that must be strongly influenced or directly supported by the Department of Defense. In particular, communications to and among numerous, widely dispersed mobile sites, operation in actively hostile environments, identification of friend and foe, aspects of information security, and military-unique processing and decision support systems will not be developed without Department of Defense support. The C3 technology strategy is necessarily a pragmatic one: identify the pivotal issues, capitalize on commercial development whenever feasible, leverage development in areas with special military aspects, and sponsor programs in technologies with unique Department of Defense interest that would otherwise not be available to meet Department of Defense needs.

Technology Sub-Areas

7.1 Seamless Communications

7.2 Information Management and Distribution

7.3 Decision Making

8. Computing and Software

The Computing and Software Technology area, by pushing the frontiers of advanced information technology beyond that normally achieved by the commercial sector alone, enables the creation of a broad range of advanced information processing systems of critical value in support of the missions of the Department of Defense. The Computing and Software area can be broadly grouped into six major sub-areas:

8.1 System Software

8.2 Software and Systems Development

8.3 Intelligent Systems

8.4 User Interface

8.5 Computing Systems and Architecture; and

8.6 Networking.

Rationale for Investment: Access to and exploitation of timely information is a key element of America's future warfighting and crisis management capabilities, as well as its national competitiveness. Joint and Allied forces need timely access to the most complete and accurate information, together with the ability to rapidly process and exploit it, to facilitate swift command and control decisions based on accurate, comprehensive knowledge of the current situation. Such capability, while greatly enhancing the autonomy and survivability of individual units, will quickly seize the advantage in any conflict, permitting early, decisive victory with minimal cost in assets and human life. Advanced computer software, computing systems, and communications technology is essential to supporting the top five Joint Staff Future Joint Warfighting Capabilities.

This technology area enables a wide range of defense-critical applications, such as new methods for design enabled by computational models in many science and engineering disciplines, advanced simulations for optimization and verification of weapons designs, and authentic, real-time engagement scenarios to be used in training at all levels. These have the potential to dramatically reduce cost while increasing quality. For example, the capabilities for high-performance computing combined with advanced simulation and modeling techniques make possible the more effective investigation of diverse problems, including computational fluid dynamics (CFD) for modeling hypersonic flight or weather forecasting, technology computer-aided design (TCAD) for advanced microelectronics process development, and computational electromagnetics for improved stealth technologies.

Technology Sub-Areas

8.1 System Software

8.2 Software and Systems Development

8.3 Intelligent Systems

8.4 User Interface

8.5 Computing Systems and Architecture

8.6 Networking.

9. Conventional Weapons

This area develops conventional armaments technologies for all new and upgraded non-nuclear weapons. It includes efforts directed specifically toward non-nuclear munitions, their components, and launching systems, guns, bombs, guided missiles, projectiles, special warfare munitions, explosive ordnance disposal (EOD) devices, mortars, mines, countermine systems, torpedoes, and underwater weapons and their associated combat control. There are six major sub-areas:

9.1 Fuzing/Safe and Arm

9.2 Guidance and Control

9.3 Guns (Conventional and Electric)

9.4 Countermine/Mines

9.5 Warheads and Explosives; and

9.6 Weapon Lethality/Vulnerability.

Rationale for Investment: The Conventional Weapons Technology areas strongly support needs of the Services in both tactical and strategic mission areas. It responds to the services' operational needs for cost-effective system upgrades and next generation systems in support of the top five Joint Staff Future Joint Warfighting Capabilities. Performance objectives focus on projecting lethal force precisely against an enemy with minimal friendly casualties and collateral damage. Objectives address the need for affordable all-weather, day-night precision strike against projected critical mobile and foxed targets; all-weather defense against very low observable cruise missiles, aircraft, and ballistic missiles; undersea superiority through highly lethal underwater attack capabilities against anti-submarine warfare and airborne anti-surface warfare platforms at long range, in shallow water, increased speed, and with reduced weight and acoustic signature; an effective mine detection and neutralization capability to permit movement of forces ashore during amphibious assaults and during movement on land; gun and missile systems to support the development of advanced, lighter weight air and land combat vehicles; ship and vehicle self-defense systems; and lightweight high-performance gun systems for artillery applications and naval surface fire support missions.

Technology Sub-Areas

9.1 Fuzing/Safe and Arm

9.2 Guidance and Control

9.3 Guns (Conventional and Electric)

9.4 Countermine/Mines

9.5 Warheads and Explosives

9.6 Weapon Lethality/Vulnerability.

10. Electronics

The Electronics Technology area extends from basic research to applications at the subsystem level. Electronics includes the research, development, design, fabrication, and testing of electronic materials; electronic devices, including digital, analog, microwave, optoelectronic, vacuum and integrated circuits (IC); and electronic modules, assemblies, and subsystems. The Electronic Technology area is organized into five major sub-areas:

10.1 Radio Frequency (RF) Components

10.2 Electro-Optics Technology

10.3 Microelectronics Technology

10.4 Electronic Materials; and

10.5 Electronic Modules and Subsystems.

Rationale for Investment: Military Capabilities Addressed– An adaptive, and innovative program in electronics science and technology is essential to implement the U.S. military strategy of (1) electronic force multiplication with a minimum number of platforms and personnel, and (2) avoidance of technological surprise on the battlefield. Electronic device technologies enable all five of the Joint Staff Future Joint Warfighting Capabilities and support seven of the other key technology areas. The requirements of military systems such as electronic warfare (EW), radar and command, control, communications, computer, and intelligence (C4I) translate into component requirements, which include performance, weight, size, radiation hardness, reliability interoperability, and maintainability. Furthermore, electronics represents over 40 percent of the procurement cost of many military and commercial systems. The ability to field weapons systems that meet requirements, that can be upgraded to meet future operational requirements, and that have affordable life-cycle costs, depends on our ability to adapt or exploit commercial electronic devices or develop new technologies.

Technical Forecast–Electronics has been, and continues to be, one of the fastest moving technology areas relevant to modern warfighting and conflict prevention. The present 30 percent per year increase in electronic subsystem performance can be expected to continue well into the next century as silicon-based integrated circuits with feature sizes to 0.18 micrometer come into production. Impressive advances in fabrication, design technologies, and associated tools will be coupled with new electronic material systems to produce entirely new generations of sensors, sources, actuators, and display technologies that provide unprecedented capabilities in land-sea-air warfare.

Advanced computational tools, using advances in electronic hardware, will enable the rapid simulation and design of affordable future weapons systems with first-pass hardware success assured. The development of ultracompact, highly efficient microwave and millimeter-wave power modules will enable new concepts in unmanned airborne vehicle radars, electronic decoys, and phased-array systems. Advances in millimeter waves will dramatically improve our ability to defend against stealth platforms, provide platform self-protection, and improve weapon accuracy in land, sea, and air encounters. Developments in electro-optics will significantly increase the speed with which information can be accessed and transmitted, thereby greatly enhancing the seamless communication required for information management and distribution.

Potential Payoffs–U.S. forces will have all-weather day and night precision weapons, the information and control to deliver payloads effectively with low collateral damage, and superior real-time knowledge of our adversaries' capabilities and intentions while denying them this intelligence about our own. Advanced information electronics capabilities will also increase dramatically and shift to forward-deployed units. This will permit the rapid collection, analysis, and dissemination of strategic, tactical, and logistical information, providing commanders with a common view of the tactical situation and increasing the tempo and synchronization of joint warfighting operations. It will also reduce personnel requirements for staffs and noncombat forces. Advanced electronics technologies will also reduce operating and support costs by a factor of 10 and extend the life and interoperability of existing fielded systems. Modernization of the force over the next decade will occur primarily through low-cost system upgrades, resulting in revolutionary performance improvements and capabilities.

Technology Sub-Areas

10.1 Radio Frequency (RF) Components

10.2 Electro-Optics Technology

10.3 Microelectronics Technology

10.4 Electronic Materials

10.5 Electronic Modules and Subsystems.

11a. Electronic Warfare (EW)

The science and technology program in the Electronic Warfare (EW) area develops technology for the offensive and defense application of electronic warfare. It includes efforts to intercept, counter, and exploit the complex threat weapons spanning the entire electromagnetic spectrum, including radio frequency (RF), infrared (IR), electro-optic (EO), ultraviolet (UV), and multispectral and multimode sensors. These technologies are applied within three sub-areas:

11.1 Force Protection

11.2 Offensive EW Applications; and

11.3 Electronic Warfare (EW) Support Functions.

Rationale for Investment: The Electronic Warfare technology area is responsive to the Services' needs and directly supports the Joint Staff Future Joint Warfighting Capabilities. Flexible, robust sensor systems have significantly increased the Services' overall warfighting capability and have become a true force multiplier. Performance objectives for electronic warfare focus on developing the capability to counter the extensive RF missile threat; to detect, identify, and jam modern-threat radar systems to defend against advanced IR missiles using imaging and pseudo-imaging seekers; to counter the coherent and millimeter wave fire control and surveillance sensors. The science and technology program in electronic warfare makes extensive use of electronic countermeasures (ECM) effectiveness assessments, and simulation and modeling.

Over 90 percent of recent aircraft losses have been due to IR surface-to-air missiles. Additionally, anti-ship cruise missiles are being developed with pseudo-imaging and imaging seekers which are immune to the current inventory of flares and jammers used for self-protection. The threat to ground vehicles from top-attack munitions using IR sensor technology is increasing. Significant improvements can be made in providing IR countermeasures for ships, air and ground platforms with the development of advanced threat warning, recognition expendables and on-board systems. In the near term, program efforts will concentrate on sensor and countermeasures technology for the detection and jamming of top attack munitions and air defense missiles as well as laser designated/beam riding missiles. This technology supports the Hit Avoidance Advanced Technology Demonstration (ATD) and the multi-spectral countermeasures technology demonstrations with improved infrared flares and distributed decoy concepts. A series of field tests and demonstrations in the near and far term will demonstrate technology solutions to the IR missiles threat. These tests will include laser and high power microwave technologies as an alternative to current techniques.

Advances in microwave technology allow smaller, more effective, and less expensive receiver systems, which can be used in ground, air, and naval applications. As threat sensors and weapons become more diverse and sophisticated, there is a corresponding need for radar warning receivers, electronic support measures, and countermeasures systems that can perform their function without detailed a priori information on the signals that they must recognize and act upon. Processing techniques are being developed to recognize and analyze certain signals in dense environments and generate articulate jamming waveforms. Knowledge-based systems using artificial intelligence and adaptive parallel distributed processing can provide "smart" software control to optimize performance in a dense, complex signal environment. Specific emitter identification, unintentional modulation on pulse processing, and monolithic microwave integrated circuits are being incorporated in small, lightweight, affordable receivers with 28,000-percent reduction in weight and a 3,600-percent reduction in cost.

The inventory of self-protection jammer systems for aircraft has been ungraded through the insertion of advanced jamming techniques. Progress in digital RF memory (DRFM) technology (DRFM on a chip) is the basis for advanced, low cost, channelized ECM exciter subsystems. Improvements in expendables technology resulted in flares which respond to IR missile seekers employing discrimination logic processing and other infrared counter countermeasures capability. Although dual use opportunities are limited within the electronic warfare technology area, small, light weight and affordable analog and digital receivers can be developed for general purpose, home entertainment, and satellite use. Wideband IR fiber optic cable used for laser-based countermeasures has medical and surgical applications; brushless, electronically controlled direct current motors used for decoys can be used in home appliances and automotive devices .

Technology Sub-Areas

11.1 Force Protection

11.2 Offensive Electronic Warfare Applications

11.3 Electronic Warfare Support Functions.

11b. Directed Energy Weapons

Directed Energy Weapon (DEW) technologies are those that relate to the production and projection of a beam of concentrated electromagnetic energy or atomic/subatomic particles. Directed energy weapons and devices generate energy that travels at or near the speed of light from a beam source directly to the target. The DEW technology area is divided into three sub-areas:

11.1 Laser weapons are devices which destroy or negate targets using beams of electromagnetic radiation with wavelengths less than 1 mm.

11.2 Radio frequency (RF) weapons are devices which destroy or negate targets by radiating electromagnetic energy in the RF spectrum; i.e., with wavelengths greater than 1 mm (frequencies less than 300 GHz).

11.3 Particle beam weapons are devices which destroy or negate targets by projecting either energetic uncharged (neutral) atomic particles, usually hydrogen, deuterium, or tritium (Neutral Particle Beams or NPM); or energetic charged atomic or sub-atomic particles. usually electrons (Charged Particle Beams or CPB).

Rationale for Investment: DE weapons cause structural or material damage, disruption and disturbance of electronics, and non-lethal to lethal biological effects. Because the timeline of DEW target engagement is of the order of a few seconds or less and because the beam can be repointed very rapidly, many targets can be negated in a short period of time over a wide field-of-view.

DEW systems have the potential to address all of the Joint Staff Future Joint Warfighting Capabilities. High energy lasers used to achieve early boost phase destruction of ballistic missiles at long range offer a potential counter to these threats, especially important when their warheads contain weapons of mass destruction. All three DEW sub-areas are developing technologies to negate ballistic missiles and cruise missiles in various phases of missile flight. All sub-areas also offer the potential of space control through satellite negation. DEWs may also contribute heavily to establishing air supremacy. Beams from directed energy weapons offer surgical strike capability (at the speed of light) to defeat specific subsystems or systems, thereby minimizing collateral damage. Non-lethal to total destruction capability is available within a single DE system by adjusting power levels. Space-based lasers or neutral particle beams have the potential for instantaneous global response. Mobile systems under development could provide flexible response options. Passive or active imaging, either as a stand-alone system or inherent in all high power laser systems, provides high resolution images of enemy systems.

Because DEW is an emerging technology, transition opportunities usually involve deployment of new systems rather than upgrades or product improvements on existing systems. DEW systems are under development in each of the following application areas: Theater missile defense, cruise missile defense, national/ global missile defense, anti-satellite/space control, high resolution imaging, air defense, active denial, ship defense, ground combat/close support, and aircraft self-protection.

Technology Sub-Areas

11.1 Laser Weapons

11.2 Radio Frequency (RF) Weapons

11.3 Particle Beam Weapons.

12a. Environmental Quality

The Environmental Quality technology area provides technologies to reduce the costs of Department of Defense operations while ensuring mission accomplishment is not jeopardized by adverse environmental impacts. There are four tri-Service sub-areas:

12.1 Cleanup of sites contaminated with hazardous materials resulting from Department of Defense operations.

12.2 Compliance with all laws concerning the treatment and disposal of Department of Defense's hazardous waste products.

12.3 Pollution Prevention to minimize Department of Defense's use and generation of hazardous wastes; and

12.4 Conservation of natural and cultural resources under Department of Defense's stewardship.

The Strategic Environmental Research and Development Program (SERDP) technology thrust areas include the above four areas plus

12.5 Global Environmental Change; and

12.6 Energy Conservation/Renewable Resources.

Rationale for Investment: National and international laws demand the mitigation of environmental impacts resulting from the normal operations and maintenance of the Departments of Defense and Energy activities. Base realignment and closure actions place an added urgency on bringing the sites into compliance. Reduced budgets and increased regulatory requirements dictate the need for new or improved technologies that 1) reduce the costs of contaminant cleanup, treatment and disposal, and 2) reduce the generation of hazardous materials while maintaining stewardship of resources.

Based upon modest assumption that new technologies will reduce cleanup costs by 25 percent, the immediate return on science and technology investment is over 5,000 percent. The payoff for investments in Compliance, Pollution Prevention Global Environment Change, Energy Conservation and Natural/Cultural Resources Conservation is also realized by maintaining mission readiness without shutdown of assets, expenditure of limited manpower, and penalty costs resulting from environmental violations.

Technology Sub-Areas

12.1 Cleanup

12.2 Compliance

12.3 Pollution Prevention

12.4 Conservation

12.5 Global Environmental Change

12.6 Energy Conservation/Renewable Resources.

12b Civil Engineering

Science and technology efforts solve critical Department of Defense civil engineering problems related to training, mobilizing, deploying, and employing a force at any location at any time. Science and technology areas include

12.1 Conventional Facilities

12.2 Airfields and Pavements

12.3 Survivability & Protective Structures

12.4 Sustainment Engineering

12.5 Fire Fighting

12.6 Ocean & Waterfront Facilities and Operations; and

12.7 Critical Airbase Facilities and Recovery.

Rationale for Investment: The payoff will be enhanced fighting readiness that allows true global reach and power projection with minimal friendly force risk. The implications to national security interests of this (0.00005 percent of the annual total Department of Defense budget) research budget make the return on this investment large. Unique Department of Defense civil engineering needs arise from the characteristics of the weapons and transportation systems. The requirement to counter the effects of advanced conventional weapons and sabotage threats is not found in the private sector and, accordingly, there is no robust civilian research and development effect. The need to rapidly establish, maintain, and upgrade or retrofit facilities and transportation infrastructure within a theater of operation is unique; the private sector has no like requirement and no significant research and development investment. The aging infrastructure in the Continental United States (45 percent of all military facilities are over 35 years old) requires modernization on a scale not seen elsewhere. Mobilization, deployment, force reception within theater, and mission execution of the force are directly dependent upon efficient operation, maintenance, and upgrading or retrofit of facilities.

Technology Sub-Areas

12.1 Conventional Facilities

12.2 Airfields and Pavements

12.3 Survivability and Protective Structures

12.4 Sustainment Engineering

12.5 Fire Fighting

12.6 Ocean & Waterfront Facilities and Operations

12.7 Critical Airbase Facilities and Recovery.

13. Human Systems Interface

Human Systems Interface (HSI) technology fully leverages and extends the capabilities of warfighters and maintainers to ensure that fielded systems will exploit the fullest potential of the warfighting team, irrespective of gender, mission or environment. It is organized into four areas:

13.1 Crew Systems Integration and Protection integrates the human with weapon system hardware and software to maximize the safety and effectiveness.

13.2 Performance Aiding produces technologies to minimize human error, overcome sensory and physical limitations, and improve mission performance.

13.3 Information Management and Display develops methods and media to deliver task-critical information to individuals, teams and organizations.

13.4 Performance Assessment and Design Methodologies develops specialized databases, metrics, software tools and models of human system performance, and incorporates them into engineering design processes.

Rationale for Investment: Human system interfaces, ranging from the individual soldier's weapon to complex team-operated systems, are essential to joint warfighting capabilities. Quick-reaction, information-intensive operational environments pose an increasing challenge to achieve the Joint Staff Future Joint Warfighting Capabilities. The human has become, simultaneously, the critical component and the limiting factor in military operations. Major gains in system performance and affordability will be realized through technology advances from Department of Defense's HSI program, enabling 50 percent reductions in crew size, 25 percent reductions in workload, a doubling of critical decisionmaking accuracy and reliability, a quadrupling of crewmember situation awareness, an 80 percent reduction in fatalities and injuries from aircrew escape, and a conservative 50 percent reduction in costs through common displays.

These improvements will have far-reaching impact on the operability, effectiveness and affordability for a variety of military systems. Typical examples include a doubling of first pass target kills, a 50 percent reduction in maintenance troubleshooting time, a tenfold reduction in the re-engineering of crew systems, and reduced vehicle size, weight and training costs through crew size reductions.

Complex technologies are pervasive in tasks, jobs, and processes from the factory floor to the family living room. Linking humans effectively with these technologies is the key to affordability and international economic competitiveness. The unique research and development assets within the Department of Defense are a national center of excellence and lead the nation's HSI efforts. Products from the Department of Defense investment in HSI have been extensively and successfully used by commercial industry, academia, local government and other federal agencies. New administration initiatives such as the National Information Infrastructure are aggressively capitalizing on enabling technologies developed under the HSI research and development area. Multi-use applications have been achieved or are planned in medical instrumentation and techniques, automotive interior packaging and assembly, industrial safety and job design, job performance aiding, commercial aviation safety and air traffic control, product producibility and manufacturing, computer-aided human engineering, and entertainment.

Technology Sub-Areas

13.1 Crew Systems Integration and Protection

13.2 Performance Aiding

13.3 Information Management and Display

13.4 Performance Assessment and Design Methodologies.

14. Manpower, Personnel, and Training

The Defense Manpower, Personnel, and Training science and technology program seeks to maximize human military performance and is organized in these sub-areas:

14.1 Manpower and Personnel technology directly affect the Department's single highest system cost—the personnel system. This technology area addresses the recruitment, selection, classification, and assignment of people to military jobs. It seeks to reduce the attrition of high-quality personnel and helps the senior department leadership to predict and measure the consequences of policy decisions.

14.2 Training Systems technology improves the effectiveness of the Department's annual training investment in individual (and many times this amount in team, crew, unit, and joint training) instruction, improves the efficiency of student flow through the training pipeline, enhances military training systems, provides opportunities for skill practice and mission rehearsal, and lowers life-cycle costs of training systems and combat systems.

Rationale for Investment: The Defense Science and Technology Strategy revolves around the five highest priority Joint Staff Future Joint Warfighting Capabilities. The manpower, personnel, and training science and technology program directly contributes to all of those necessary capabilities by optimizing the use of the Department of Defense's most critical resource—its people—in achieving those capabilities.

The guiding principles for defense science and technology management include 1) reducing weapon and support system life-cycle cost, 2) strengthening the commercial-military industrial base, and 3) developing, transitioning, and inserting technologies to improve the capabilities of new and existing systems. The defense manpower, personnel, and training science and technology program directly aligns with these guiding principles. Over a system's life-cycle the cost of the people to operate and maintain the system is significantly higher than the cost of the system itself. Reducing that cost is the over-riding objective of this technology area. In addition, virtually all these technologies are dual-use technologies that can be directly applied to strengthen the civilian economy. Finally, manpower, personnel, and training technologies provide efficiencies in the operation and maintenance of both current and future systems.

The potential payoffs from success in the manpower, personnel, and training science and technology area are immense. Supporting the active-duty force costs in excess of $7 billion annually. In addition, the Department of Defense spends over $19 billion annually in individual training costs. This number increases dramatically when the costs of crew, unit, and joint training exercises are added. Even very small efficiencies from this technology area result in significant cost and risk reductions for the Department, resulting in increased readiness for warfighting forces.

Technology Sub-Areas

14.1 Manpower and Personnel

14.2 Training Systems.

15. Materials, Processes, and Structures

Materials, Processes, and Structures (MP&S) technologies produce an enabling array of capabilities for every Department of Defense system that flies in air or space, navigates on land or over and under the sea, and fires or is fired upon. MP&S technologies are equally critical in maintaining the Department of Defense infrastructure, from military piers and trucks to sophisticated sensors and optical systems, and in reducing the impact of defense systems on the environment. MP&S spans all material categories--metal and intermetallic alloys; ceramics; polymers; composites of all types; semiconductors; superconductors; optical, ferroelectric, and magnetic materials; and materials for power sources.

MP&S technologies are divided into four sub-areas:

15.1 M&P for Survivability, Situational Awareness, Weapons Delivery

15.2 Life Extension, Reliability, and Affordable Processing

15.3 Military Structural and Propulsion Materials; and

15.4 Weapons Systems Structures Science and Technology.

Rationale for Investment: All military hardware relies on MP&SD for its performance and, indeed, its very existence. Continued progress in MP&S is essential to increased affordability, performance, and longevity in Department of Defense hardware and, therefore, crucial in meeting all the Joint Staff Future Joint Warfighting Capabilities. MP&S supports not only prime development programs, e.g., composite materials and armor for lightweight, rapidly mobile fighting vehicles and aircraft, but also operational needs, such as corrosion control, life management and extension of aging military assets, and, not least, materials to protect eyes and sensors against future agile (tunable) lasers.

The evidence of advances in MP&S surrounds us in both civilian and military life and is so widespread and deep that space permits few examples. The future will bring artificial diamond fore 200-400 percent harder sensor windows, intelligence processing using embedded sensors for control to eliminate scrap loss, polymer composites for 30-50 percent structural weight reduction, adaptive structures that respond and tailor themselves to environments--allowing rock-solid space platforms and aircraft wings that shape themselves to flight requirements and report their structural health as well, and advanced ship hull steels, which have saved the Navy millions of dollar so far and have many commercial possibilities beyond ships, e.g., bridges.

All upgrades and new military systems provide transition opportunities. Lightweight combat vehicles, low observable aircraft and ships, advanced propulsion systems of all types, high temperature microcircuits, and comfortable chemical and biological suits and body armor for the individual warfighter, and many more are dependent critically on MP&S. Furthermore, the government technical personnel who produce and procure these science and technology products form a crucial cadre that guarantees that the Department of Defense remains technically current.

Although driven by defense needs in terms of performance, protection, and life-cycle costs, MP&S technologies are inherently dual-use and many have been exploited by the commercial sector to enhance the economic position and security of the United States in products ranging from aircraft engines to high temperature circuits and sensors in automobiles and steel production. Concomitantly and symbiotically, often a commercial technology is exploited by tailoring or further development to meet Department of Defense needs. Since the majority of MP&S Program is performed by U.S. industry and universities; it bolsters the academic and industrial infrastructure and promotes linkage among them.

Technology Sub-Areas

15.1 M&P for Survivability, Situational Awareness, and Weapons Delivery

15.2 Life Extension, Reliability, and Affordable Processing

15.3 Military Structural and Propulsion Materials

15.4 Weapons Systems Structures Science and Technology

16. Sensors

This area develops technologies in five major sub-areas:

16.1 Radar Sensors

16.2 Electro-Optic Sensors

16.3 Acoustic Sensors

16.4 Automatic Target Recognition and

16.5 Integrated Platform Electronics and Sensors.

Applications include strategic and tactical surveillance, identification and targeting of threats from all military platforms, including satellites, aircraft, helicopters, ships, submarines, ground vehicles, and sites, unmanned air vehicles, unattended ground sensors and the individual soldier.

Rationale for Investment: Sensors are pervasive... the eyes and ears for nearly all U.S. tactical and strategic weapon systems as well as the intelligence community and represent an increasingly high percentage of total weapon system cost. The planned Department of Defense science and technology investment in sensors will significantly reduce future sensor costs and provide technologies crucial to meeting the top five Joint Staff Future Joint Warfighting Capabilities, including: all-weather, all-night surveillance, precision targeting and damage assessment; detection and tracking of difficult targets, such as cruise missiles, anti-ship missiles, ballistic missiles, and quiet submarines; and positive combat identification.

Significant improvements in performance and cost of sensors—e.g., 50 percent reduction in cost of imaging radars and infrared search track sensors, 10:1 improvement in thermal sensitivity of infrared sensors, and a 100:1 improvement in false alarm rate and search rate of automatic target recognizers are attainable through foreseeable advances in: affordable microwave integrated circuits, ultra-large and multi-color infrared focal plane arrays, low noise fiber optic sonar arrays, very high speed signal processors, common modules, shared aperture and adaptive processing. Illustrative payoffs include: Cost-effective imaging radars for unmanned aerial vehicles, 5:1 improvement in reentry vehicle/decoy discrimination, 2:1 improvement in detection range of submarine, and 2:1 increase in non-cooperative identification and weapon engagement ranges against tactical targets.

Because of their pervasiveness, potential for cost-effective system upgrades, and potential for revolutionary next generation systems, sensor technologies have a myriad of transition opportunities. Examples include: Ground based radar, fighter, electronic warfare, and surveillance aircraft, all tanks, all submarines, all anti-submarine warfare aircraft, and unattended ground sensors. Dual-use applications include: environmental sensing, air traffic control, Global Positioning System navigation equipment, airline landing systems, and medical; imaging equipment.

Technology Sub-Areas

16.1 Radar Sensors

16.2 Electro-Optic Sensors

16.3 Acoustic Sensors

16.4 Automatic Target Recognition (ATR)

16.5 Integrated Platform Electronics and Sensors.

17a. Surface/Under Surface Vehicles--Ships and Watercraft

The Ships and Watercraft Technology area provides the technology for improved combat efficiency, survivability, and stealth of

17.1 Surface Ships

17.2 Submarines; and

17.3 Unmanned Undersea Vehicles.

Rationale for Investment: The potential for large-scale regional conflicts, the proliferation of weapons of mass destruction, and the proliferation of conventional weapon and information technologies are major threats to the security of the United States. Ships and watercraft play a critical role in countering these threats, particularly in the joint mission and support areas of strike, littoral warfare, strategic deterrence, surveillance, strategic sealift, forward presence, and readiness. The vehicles addressed by this technology area provide the essential means by which personnel, weapons, and sensing devices are delivered and positioned in remote global areas to effectively prosecute both military and non-military objectives.

Technology Sub-Areas

17.1 Surface Ships

17.2 Submarines

17.3 Unmanned Undersea Vehicles.

17b. Ground Vehicles

This technology area incorporates technologies to support the basic Army and Marine Corps land combat functions: shoot, move, communicate, survive and sustain. Covered here are propulsion and power, track and suspension, vehicle subsystems, hydrodynamics, signature reduction, fuels and lubricants, and integration technologies related to land combat vehicles, including amphibious vehicles with a ground combat role. The area is divided into seven sub-areas:

17.1 Vehicle Chassis

17.2 Non-Traditional Survivability

17.3 Crewman's Associate

17.4 Mobility

17.5 Amphibious Operations

17.6 Robotics; and

17.7 Future Vehicle Integration.

Rationale for Investment: The ground forces' most critical deficiency in the post-Cold War era is the rapid deployment of forces for worldwide contingency missions. Current heavy forces are capable but take too long to be deployed, have a large logistics tail, and have problems with the Third World infrastructure. A lighter "heavy" force is required that can be sea-deployable in half the time with half the ships, and be lethal, survivable and affordable. Such forces would be particularly well suited to actions at the lower end of the full range of military operations. Rapid and decisive response of amphibious forces is critical to power projection of U.S. interests abroad. Marines are most vulnerable during movement from ship to shore. Exposure time to enemy fire will be reduced by a factor of four. Current combat vehicles rely on traditional materials for construction, manual operation of subsystems, passive armor to defeat threat armament and conventional mobility. The result is large, expensive and vulnerable to an increasing number of threat weapons. The strategy is to:

Reduce size and weight by 40-50 percent through application of advanced lightweight materials; task automation to reduce number of crew; develop compact mobility components; develop new survivability techniques.

Reduce cost by 35-45 percent through application of integrated product and process development; application of virtual prototyping; sharing of electronic subsystems between vehicles.

Reduce vulnerability by 20-100 percent (scenario dependent) through application of countermeasures, signature management and high mass efficiency; increased engagement ranges; target size reduction; exposure time reduction; blast/energy management.

Technology Sub-Areas

17.1 Vehicle Chassis

17.2 Non-Traditional Survivability

17.3 Crewman's Associate

17.4 Mobility

17.5 Amphibious Operations

17.6 Robotics

17.7 Future Vehicle Integration.

18. Manufacturing Science & Technology

Affordability is a key concern in every technology area. The Manufacturing Science & Technology area is focused on cross-cutting engineering and manufacturing process technologies beyond those developed in conjunction with new product technologies in the other technology areas. The area includes programs of the

Advanced Research Projects Agency (ARPA) for manufacturing applications, Service/Defense Logistics Agency Manufacturing Technology (ManTech) programs, advanced technology demonstrations got affordability, and advanced industrial practices to demonstrate the combination of improved process technology and improved business practices. These programs encompass process technologies at all manufacturing levels (enterprise/ factory/cell/machine/unit process).

Rationale for Investment: Advanced manufacturing technologies are vital to affordable defense systems and economic security. The Department of Defense needs access to manufacturing capabilities that meet world class benchmarks for cost, cycle time, and quality. Compared to current defense manufacturing this means, for selected products, a 30 to 50 percent reduction in development and production costs, commensurate in cycle times, near-perfect quality even for selected products, a 30 to 50 percent reduction in development and production costs, commensurate reductions in cycle times, near-perfect quality even for items produced in small lots, and designed-in life cycle supportability.

The maturity level of processes employed to produce defense weapon systems has a telling effect on the ability of those systems to meet schedule and cost targets as they transition through development and into production. Immature manufacturing processes represent a major source of risk and uncertainty that is often translated into system cost growth and schedule slippage. Science and technology work in maturing factory processes as well as promoting effective Integrated Product and Process development are critical elements in understanding and resolving risk early.

Strategy is to target defense-driven process technologies with the greatest leverage on costs, and to accelerate progress toward commercial viability where feasible. Life cycle costs are determined to a large extent by early design decisions, so design is one important leverage point.

Technology Sub-Areas

18.1 Manufacturing Processing & Fabrication (Factory Floor)

18.2 Manufacturing Processing & Fabrication (Above Shop Floor)

19. Modeling and Simulation

This technology area includes development, integration, and implementation of tools and applications to apply Modeling and Simulation more broadly and with greater validity across the Department of Defense. Efforts are directly dependent on enabling technologies such as high speed computing, communications and networking, human systems technologies such as high speed computing, communications and networking, human system interfaces, and software. Major sub-areas are:

19.1 Architectures (software, data and database methodologies, and interfaces with communications and networks);

19.2 Environmental Representation (terrain, weather, atmosphere, space, oceans, and others); and

19.3 Computer Generated Forces (systems representations, human behaviors, and their interactions).

Modeling and Simulation efforts include those focused on advancing the state-of-the-art in modeling and simulation and that exhibit features such as scalability, variable resolution, interactive use, and interoperability with diverse models. While significant Department of Defense investments in Modeling and Simulation are embedded in other technology areas (C3, human-system interfaces, battlespace environments, and manpower, personnel, and training), those applications support a particular scientific or engineering problem area and are often not applicable for advanced distributed simulations. Hence, these classes of models and simulations are not included in this plan.

Rationale for Investment: The nation's long term security is largely dependent on the Department of Defense's ability to place the right equipment in the hands of warfighters, train them to use that equipment, and develop commanders who understand mission requirements in a changing geopolitical environment. Maintaining readiness in the face of evolving missions, rapidly developing technology, instantaneous global communications and the information it carries, and compounded by budgetary constraints is a daunting problem. Effective use of Modeling and Simulation from acquisition through training, development of doctrine and tactics, and mission rehearsal offers the best possibility for improving readiness at lower cost. In fact, Modeling and Simulation is often the only way to address Department of Defense's increasingly complex problem sets.

Simulators are very cost effective to train warfighters to use their equipment. Where operations are too dangerous for peacetime training or where live operations pose ecological hazards, simulation is the only reasonable means of effective training and mission rehearsal. Focused investment in the emerging technology base can substantially improve the quality of synthetic environments and the ability to create large, complex simulations from repositories of models, data, and databases. Investments must produce better environmental models, more intelligent autonomous components, more realistic live participation, and the architectural structure for linking components reliably.

As warfighters require training with new or improved equipment, commanders must train for a wider variet of missions, many of which are not rooted in prior operational experience. Engagement simulations in whic tactics and warfighting doctrine can be explored will allow commanders to master today's doctrine and evolv tactics for new types of engagements. Simulations will be viable to the extent that the entities on the battlefiel are accurately modeled in synthetic environments that reflect realistic operational conditions.

Modeling and Simulation can provide repeatable, iterative experiments, with appropriate fidelity, from whic data can be extracted and analyzed as a quantitative means of assessing capability and determining effectiv ness. Such analyses are needed to assess the impact of new systems and direct the acquisition process to inve in those systems that can provide the most significant payoff. Modeling and Simulation also has the potenti to allow force structure analysis at the Joint Task Force, Service, Component, and Department levels.

In an era of rapidly evolving technology, the ability to move through the acquisition process in a timely ar cost effective fashion is essential to maintaining the materiel readiness of the armed forces. Using Modeling ar Simulation as a predictive tool and to focus test planning can have a significant impact on both the time requir and the validity of operational testing. To do this, constructive simulations using high fidelity engineeri models must be combined with live and virtual simulations in synthetic environments in a consistent fashi from design through test. To accomplish this objective, the architecture must support the interoperability engineering models through analysis models to constructive and live models in the same environment.

Technology Sub-Areas

19.1 Architectures

19.2 Environmental Representation

19.3 Computer Generated Forces.

Source: U.S. Defense Department.

Information cutoff: Completed in September 1994.

(Last report no. 683, 23 September 1992.)

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ANNEXE 4

DOD DEFENSE CRITICAL TECHNOLOGIES PLAN

Appendix IV - DoD Defense Critical Technologies Plan

DOD DEFENSE CRITICAL TECHNOLOGIES PLAN/

DOD DEFENSE KEY TECHNOLOGIES PLAN

DOD DEFENSE CRITICAL TECHNOLOGIES PLAN

The Defense Critical Technologies Plan came in response to Public Law 101-189 (November 29, 1989), which mandated the Secretary of Defense to submit to the Armed Services Committees of the House of Representatives and Senate an annual plan for developing those technologies considered by the Secretaries of Defense and Energy to be the most critical for ensuring the long-term qualitative superiority of US weapon systems. Twenty technologies were selected, with the total raised to 21 technologies in the 1991 version. Electronics is a very significant emphasis, if not the predominant one. The selected technologies are:

- Air-breathing propulsion - lightweight, fuel efficient engines using atmospheric oxygen to support combustion
- Biotechnology - the systematic application of biology for an end use in military engineering or medicine
- Composite materials - two or more constituent materials that are combined together in such a manner to produce a substance possessing selected properties superior to those of its individual components
- Computational fluid dynamics - the modeling of complex fluid flow to make dependable predictions by computing, thus saving time and money previously required for expensive facilities and experiments
- Data fusion - the machine integration and/or interpretation of data and its presentation in convenient form to the human operator
- Flexible manufacturing - the integration of production process elements aimed at efficient, low cost operation for small, as well as high, volume part number variations, with rapidly changing requirements for end product attributes
- High energy density materials - compositions of high-energy ingredients used as explosives, propellants, or pyrotechnics

- High performance computing - high performance computing systems having 103 fold improvements in computation capability and 102 fold improvements in communications capability by 1996
- Hypervelocity projectiles and propulsion - the ability to propel projectiles to greater than conventional velocities (over 2 km/sec), as well as understanding the behavior of projectiles and targets at such velocities
- Machine intelligence and robotics - incorporation of aspects of human "intelligence" into computational devices which enable intelligent function of mechanical devices
- Passive sensors - sensors not needing to emit signals to detect targets, monitor the environment, or determine the status or condition of equipment
- Photonics - includes ultra-low-loss fibers and optical components

such as switches, couplers, and multiplexers for communications, navigation, etc

- Pulsed power - the generation of repetitive, short-duration, high-peak power pulses with relatively light-weight, low-volume devices for weapons and sensors
- Semiconductor materials and microelectronic circuits - the production and development of ultra-small integrated electronic devices for high-speed computers, sensitive receivers, automatic control, etc
- Sensitive radars - radar sensors capable of detecting low-observable targets, or capable of non-cooperative target classification, recognition, and/or identification
- Signal and image processing - combination of computer architecture, algorithms, and microelectronic signal processing devices for near real-time automation of detection, classification, and tracking of targets
- Signature control - the ability to control the target signature (radar, acoustic, optical, or other) and thereby enhance the survivability of vehicles and weapon systems
- Simulation and modeling - visualization of complex processes and the testing of concepts and designs without building physical replicas
- Software engineering - the generation, maintenance, and enhancement of affordable and reliable software in a timely fashion

- Superconductivity - makes use of the zero resistance property and other unique and remarkable properties of superconductors for creation of high-performance sensors, electronic devices and subsystems, and supermagnet-based systems
- Weapon system environment - a detailed understanding of the natural environment (both data and models) and its influence on weapon system design and performance

Since not all of these elements are specifically concerned with electronics, we are providing excerpts only on those elements that we feel are apropos for users of this binder product.

Data Fusion

This technology incorporates machine integration and/or interpretation of data and its presentation in convenient form to the human operator. The principal component fields are: theoretical foundations, algorithm and model development, data and knowledge base for fusion processing, and development of reasoning systems.

With the increasing speed and complexity of battle, the DoD has recognized the need to integrate data obtained from disparate sensors to yield information about the location, movement and types of targets. Data fusion technology includes data processing techniques for a wide range of military applications from sensor cueing to cockpit display integration to battle management. This technology will be part of military systems from simple weapons to large-scale information processing applications.

As US operational doctrine evolved to stress deep attack and interdiction capabilities, a concurrent demand was created for information describing the location, movements, and intentions of targets beyond the performance of conventional sensors. Programs will be initiated by the DoD to meet this demand. To more fully meet the data needs of modern battle management, the DoD will demonstrate at-sea fusion of land-based and ship-borne sensor data by 1995. The most complex aspect of fusion technology is dealing with uncertainties associated with data. The evolution of automated correlation and reasoning systems dealing with data and contextual information opens new possibilities for partitioning functions between human and machine, resulting in demonstration of multi-hypothesis reasoning in 1994. DoD research in data fusion will result in improvements to C3I systems by providing the basis for information processing and sensor management which is critical to surveillance activities, advanced "smart" weapon systems, and the design of advanced computer-supported command centers. High-speed, low-cost reliable techniques for data fusion are of growing importance to automated manufacturing in the defense and non-defense sectors. Real-time process control, sensor-directed cells and workstations, and robot and effector manipulation are three examples of DoD data fusion initiatives aimed at manufacturing products faster and with higher quality.

High Performance Computing

Rapid improvements in the performance and cost effectiveness of computer hardware, enabled by integrated microelectronics technologies, have spread computing into all areas of military and civilian life. Performance is expected to exceed one trillion operations per second (teraops) by the mid-1990s as a result of the Presidential Initiative in High Performance Computing and Communications described in a supplement of the President's FY92 budget submission. Teraops computing systems will require billion bit per second (gigabit) networks. The DoD is fully supporting this initiative in the DARPA HPC program.

The major technology areas are: high performance computer systems, advanced software technology and algorithms, high performance networking, basic research and human resources, and defense specific technologies. High performance computer systems development are in four main areas: research for future generations of computing systems, system design tools, advanced prototype systems, and the evaluation of early systems. Systems capable of sustaining 0.1 teraops for large problems will be available for deployment by late 1993, and the teraops systems will be available by 1996. Advanced software technology and algorithms will cover scalable libraries, programming languages, and analysis tools for scalable parallel systems in a workstation/server configuration. High performance networking technologies will be produced to satisfy the needs for gigabit networks. These involve interface, protocol, security and multiple types of services over a wide range of performance characteristics. Basic research and human resources will address long-term national needs for more skilled personnel, enhancement of education, training, materials and curriculum development in the high performance computing science and engineering areas.

Defense specific technologies will focus on special needs for embedded systems such as high density packaging, special accelerators, and real-time fault-tolerant systems. These will provide a critical edge in performance for broad classes of weapons, command and control systems, and multilayer distributed battle management systems and simulations such as smart weapons with integrated C3I systems, platforms, or elements of strategic defense systems.

Machine Intelligence and Robotics

This technology area incorporates aspects of human intelligence into computational devices which enable intelligent function of mechanical devices. The principal component areas are: image understanding, autonomous planning, navigation, speech and text processing, "machine" learning, knowledge representation and acquisition, and adaptive manipulation and control.

These systems will help human operators by functioning as decision-making aids. In the fast-paced battlefield of the future, intelligent machines will fuse, process, and analyze data, and present the results almost immediately. By processing huge amounts of data, machine intelligence will provide more effective tools for effective military intelligence, data analysis, battle management, timely decision-making, and survivability through distribution of tasking, machines, and data repositories. A pilot's associate is being developed which will provide an artificial intelligence-based decision aid to significantly reduce the information load on military pilots by the turn of the century. In addition, machine intelligence and robotics applications will reduce the need for manpower while improving human response times.

Robotics technology involves controlling complex mechanical devices under the direction of computer software in response either to fixed assumptions, or dynamically changing requirements. One example of this type of application is an autonomous robotic ground vehicle or an unmanned aerial vehicle. The DoD will demonstrate artificial intelligence for autonomous vehicles by 2005. When combined with other rapidly advancing critical technologies, such as passive sensors or high performance computing, machine intelligence will provide automatic target recognition capabilities, allow truly effective diagnostic aids, and permit the development of robotic combat systems. First-generation machine intelligence systems already have proven their worth in both defense and commercial applications.

Passive Sensors

These type of sensors do not need to emit signals to detect targets, monitor the environment, or determine the status or condition of equipment. The principal component fields of this critical technology are: passive seekers, advanced thermal imagers/IR focal plane arrays, infrared search and track sensors (IRST), diffractive optics, sensors integration for target acquisition, advanced passive antennas, passive radio frequency surveillance, passive acoustic surveillance, fiber optic sensors for environmental and systems status monitoring and navigation, and superconducting sensors.

Passive threat warning technology provides strategic or tactical alert so that defensive measures can be taken. These systems include radar warning receivers, laser warning devices, space-based electro-optic systems, and warning of passive electro-optic/infrared (EO/IR) guided missiles. The latter is particularly challenging and crucial to maintaining US force survivability as heat-seeking missiles proliferate. IRST sensors scan wide areas in order to detect and track air or ground targets. An airborne IRST for use against ship targets will be demonstrated in FY93. Advanced acoustic sensors are needed to counter the threat posed by rapid progress in submarine quieting. Multi-band passive electro-optical sensors can reduce the sensitivity of existing sensors to environmental and target signature variations. Integrated sensor approaches will allow for multiple functions and collection of multiple target signatures. Anti-radiation seekers will counter hostile radars and increase the survivability of US forces by targeting enemy radars. A prototype advanced microscan receiver for detecting radiation sources will be constructed in FY92. Fiber-optic sensors embedded in structures will provide continuous coverage of critical internal variables (like stress and temperature) to evaluate structural performance. The availability of low cost, high-efficiency IR sensor technology would find wide application in in situ process monitoring and control.

Photonics

This technology involves the use of light (photons) for the representation, manipulation, and transmission of information, and includes ultra-low-loss fibers and optical components such as switches, couplers, and multiplexers for communications, navigation, and other information processing applications. The principal component fields of this critical technology are laser devices, fiber optics, optical signal processing, and integrated optics.

Photonics technology has long been used in important niches in both defense and commercial applications. But it has been only recently that photonics technology developed the necessary tools and capabilities to bring about revolutionary new applications. By combining fast, massively parallel techniques with devices possessing high spatial resolution, photonics can provide order-of-magnitude improvements over today's conventional electronic devices. Defense photonics will provide currently unavailable capabilities through faster, smaller, more reliable, and more survivable systems. The small size, light weight, and resistance to electromagnetic interference of optical fibers provide major advantages in avionics, microwave, and communications systems. The small size, light weight, and resistance to electromagnetic interference of optical fibers provide major advantages in avionics, microwave, and communications systems, and will see deployment in the defense sector over the next decade. As an example, the DoD will demonstrate optical signal processing at a rate of 500 million operations per second by 1996.

Over the next 20 years, photonic signal processing devices increasingly will be incorporated into defense sensor, communication, and information processing systems. Photonic processing offers the promise of order-of-magnitude improvements in processing speed resulting from the natural parallel architecture and high switching speeds of optical devices. By the turn of the century, the DoD will demonstrate a 10 gigabit per second local area network. Integrated optics will enhance weapons capabilities in the areas of automatic target recognition, state-of-health monitoring, and detection avoidance. Photonics R&D will significantly affect the high-speed computing defense industrial base through the development of components such as high-speed lasers, detectors, sensors, interconnect media, and signal routing and control elements.

Semiconductor Materials and Microelectronic Circuits

This technology area encompasses the production and development of ultra-small integrated electronic devices for high-speed computers, sensitive receivers, automatic control, etc. The principal components of this area are very large scale integrated circuits, CAD for complex circuits, high resolution lithography, analog/digital converters, power converters, micro- and millimeter wave sources and amplifiers, transmit/receive modules and arrays, signal control components, and radiation hard isolation technology.

The information processing capability provided by advanced microelectronic devices is truly pervasive in US weapon systems, and is likely to become even more so. The availability of microcircuit technology continues to have two major effects on the development of new systems. First, the technology makes it possible to extend the flight control envelope of aerodynamically unstable aircraft, and second, the technology allows the creation of radically new systems, like smart weapons. The systems made possible by this technology provide a qualitative advantage to US forces by increasing the soldier's ability to acquire and act upon information and to deliver weapons against the adversary.

"Ultra-small" circuits have allowed a shrinkage of the volume of computational capability required by smart weapons. As these devices have become smaller, the manufacturing technology required to fabricate them becomes more highly specialized and requires continued research and development into processes, equipment and materials. Much of the R&D thrust towards higher levels of miniaturization and increased performance is applicable to both the defense and commercial sectors; however, battlefield requirements for ruggedness, radiation-hardness, and extreme environments are unique to defense systems. Research in microelectronic circuits is aimed at achieving several major objectives for weapons systems. Central to DoD requirements is a need to perform signal processing at gigahertz speed levels and beyond. This will require components of advanced materials whose feature sizes are below one-quarter micron. In addition, the DoD is developing ever-increasing levels of integration with the objective of wafer-scale integration of logic and memory to further reduce system size and cost.

Sensitive Radars

This refers to those radar sensors capable of detecting low-observable targets, or capable of non-cooperative target classification, recognition, and/or identification. The principal component fields are advanced monostatic radar, multistatic radar, radars for non-cooperative target recognition and aided/automatic target recognition, active phased array radar, laser radar, and electronic counter countermeasures (ECCM).

Radars will continue as a primary sensor since they provide an all-weather capability and do not rely on threat emissions. Continued reduction in target observables will significantly reduce the effective range of existing US surveillance, tracking, target classification, and weapon guidance systems. Sensitive radars (such as large power aperture monostatic radar, synthetic aperture radar, bistatic radar, wideband radar, laser radar, and advanced over-the-horizon radar) will be required to handle future advanced low observable threats, and to provide needed ECCM capabilities.

Advances in radar system components are needed to implement projected sensitive radar improvements. To achieve this goal, by FY93 the DoD will demonstrate a 50-100 watt (peak), 10 GHz pulsed power transistor. Increasing radar sensitivity creates some significant technical challenges. First, increased sensitivity will require development of frequency generators with increased stability, systems with increased processing gain, and receivers and analog-to-digital converters with wider dynamic ranges. Second, increased sensitivity makes US systems more vulnerable to enemy exploitation, interference by unwanted objects such as birds, and natural phenomena.

By FY92, the DoD will demonstrate an 8-in active array missile seeker which integrates guidance and fuze radar functions. The DoD is developing laser radar systems for applications from target detection and tracking to navigation in order to exploit their inherent advantages, increased bandwidth, smaller size, and higher resolution. To demonstrate this technology, the DoD will prototype a laser radar for obstacle avoidance and target detection by 1996. Sensitive radar technology is a major factor in providing a technical edge to US forces by enhancing detection, localization, classification, identification, and tracking capabilities. Conventional radars are a well-established commodity for military systems, while sensitive radar technologies are still in development and there is only a limited industrial base. Both the conventional and sensitive radar markets are primarily driven by the DoD.

Signal and Image Processing

This technology area combines computer architecture, algorithms, and microelectronic signal processing devices for near real-time automation of detection, classification, and tracking of targets. The principal components are algorithm development, hybrid optical-digital techniques, control of phased arrays, and artificial neural networks.

Application of signal processing technology to weapon systems offers important advantages, such as reducing operator workload, improving system performance, and performing new functions, such as autonomous vehicle control. Perhaps the most immediate enhancements in signal processing and compression can be obtained through the use of new, very-high-performance algorithms, such as compactly-supported wavelet structures and the Gabor transform. Possibly the greatest challenge in signal processing technology is automatic target recognition (ATR), where the DoD has a major program under way in algorithm development. The development of advanced ATR capabilities will result in both reduced operator workload and improved system performance. ATR algorithms have been developed for IR search and track systems which scan for aircraft, and advanced algorithms using spatial temporal techniques will be demonstrated in FY92.

In reconnaissance and imaging systems, advanced computer architectures will demonstrate new capabilities in the areas of image segmentation, feature detection/extraction, and pattern recognition of static objects. Here, the ability of neural networks to perform pattern recognition is being investigated for synthetic aperture radar, EW, and ASW. Phased arrays of sensors are electronically controlled through individual activation rather than mechanical steering, while the next technical advance is a conformal array, where the phased array is applied directly to the surface of the vehicle. The demonstration of an airborne conformal array using digital beam steering control will occur in FY94.

The most important signal processing applications depend on advanced, high-speed, high-throughput processors. Acoustic-array and ASW signal processing share a common technology base and were originally derived from marine seismic techniques for the petroleum industry. The further development of this technology has significant applications to both the military and commercial industrial base, such as the ability to recognize handwritten characters for data entry into computer systems.

Signature Control

This technology area concerns the ability to control the target signature (radar, acoustic, optical, or other) and thereby enhance the survivability of platforms and weapon systems. The principal component fields are radar signature (radar cross section) reduction; infrared, visual, and ultraviolet signature reduction and management; acoustic quieting; low probability of intercept radars, communications, and navigation (electronic emission control); deceptive signature (emissions and decoys); magnetic signature control; and wake signature.

The reduction or control of platform signatures greatly improves survivability, resulting in improved weapons effectiveness, while in some cases, the objective is signature enhancement for deception against hostile sensors. This technology area includes the reduction of the wakes created by moving any vehicle through water or air, and by emissions, such as rocket plumes. The reduction of radar signatures is accomplished by vehicle shaping, the use of radar absorbing materials to reduce radar echoes, and passive or active cancellation techniques. For infrared signatures, the reduction is brought about by cooling and/or heating the vehicle or its emissions and by applying special material for background matching to reduce detection by passive systems.

In addition, there is a requirement to create low probability of intercept radars, communications, and navigation systems. These programs apply improved spectrum management capability, sensors, and navigation instruments to control sensor emissions to assure C3I and navigation, under low-observability operational constraints. Reduction of the signatures of weapon systems significantly affects their design, support, and effectiveness. Industrial process technologies which are critical to advanced signature control concepts include computer-aided design and computer-aided manufacturing, computer numerically-controlled machine tools, laser and optical hardware, and robotics. New and improved manufacturing capabilities will be required to transfer new signature control technology materials to system applications that emphasize producibility, cost and performance.

Simulation and Modeling

This computer-based technology allows the visualization of complex processes and the testing of concepts and designs without building physical replicas. The principal components are high-speed graphics, solution of non-linear equations, and simulation verification and validation.

Simulation and modeling technology has four major components: computers, networking, visualization, and software. The DoD continues to develop advanced capabilities to simulate weapon systems and the tactics which most effectively utilize them as computer capabilities continually increase. This technology can be applied to every major DoD weapon development pro-gram to reduce design and production cost, shorten development lead-times, improve performance, improve command and control, and assist in training. By 2001, the DoD will attain an order-of-magnitude cost reduction for training and human factor design. For example, training cost effectiveness can be increased by providing a realistic, interactive simulation involving tanks, aircraft, and ground personnel. The payoff for large-scale maneuver simulation, in terms of improved training at reduced cost, is enormous. For example, SIMNET provides a realistic interactive simulation of tanks, armored personnel carriers, fighter/attack aircraft, helicopters, and other systems. Additionally, in SIMNET newly proposed systems (such as vision devices, anti-tank weapons, and anti-helicopter weapons) can be simulated digitally so that the utility of given technical and human-centered parameter requirements can be assessed before hardware is built.

The use of simulation and modeling in the systems design process will enhance the operational suitability and effectiveness of virtually all human/machine systems, whether being initially procured or being modified. The DoD is also pursuing battle management simulation technology to evaluate sophisticated systems in hostile environments. Efforts include development of environmental and terrain space technology (including artificial intelligence links to environmental information), environmental data characterization, and target recognition based on the environment. During FY92, the capability to rehearse carrier-based weapon system missions will be demonstrated.

As the costs and complexity of hardware development increase, designers in all fields will begin to rely more heavily on modeling and simulation. Computer modeling has significantly affected R&D programs by providing researchers a stronger basis for weapon system design and effects (nuclear, conventional, chemical) and understanding interactions among low-observables, materials, and geometries with electromagnetic radiation.

Software Engineering

This technology area refers to the generation, maintenance, and enhancements of affordable and reliable software in a timely fashion. The principal component fields are software and system engineering processes and environments, real-time/fault-tolerant software, reuse and re-engineering, software for parallel and distributed heterogeneous systems, and high assurance software.

The "smarts" of major defense systems, including weapon systems, information systems, and scientific/engineering systems, are usually embodied in software. Indeed, software capability has become a principal determiner of overall weapon systems capability. In theory, software has enormous potential power and flexibility. In practice, software development and management is a complex, labor-intensive process, and the US software capability is bounded by the extent to which the complexities in this process can be managed through attention to process and use of tools. Automated tools, linked together in software and system engineering environments that coordinate and manage tool operation, can take over many of the details of software engineering activity, yielding more cost-effective processes and potentially larger and more powerful systems.

By 1993, the DoD will be making experimental use of software engineering environment frameworks supporting use of commercially compatible tools to manage large scale software developments. Design of embedded defense software usually involves management of "real-time" constraints and deadlines for processing of incoming sensor data and generation of outgoing control signals. In the presence of unreliable system components, the software must be designed in a fault-tolerant manner.

By 1995, the DoD will be demonstrating distributed operating systems supporting time-constraints and fault-tolerance. Much of the DoD software expenditure is in post-deployment activity or software logistics. Technology to facilitate management and re-engineering of existing assets can not only reduce post-deployment costs, but also greatly facilitate creation of reusable software assets such as simulation. The principal opportunity in reuse is megaprogramming, which is the development and management of DoD software applications on a component-by-component basis rather than instruction-by-instruction. Megaprogramming technology includes software component definition and composability technology, software tools and environments supporting component composition, software component libraries, associated capabilities for software electronic commerce, and software process models supporting reuse.

By 1998, the DoD will demonstrate the ability to develop domain-specific systems architectures and reusable components compliant with these specifications. High performance computing systems of all kinds, including scientific/engineering systems, embedded systems, and the leading edge information systems, employ parallel and distributed processing.

By 1994, the DoD will demonstrate systems software for survivable distributed and parallel computing. High assurance software technology is required in the design of safety-critical systems, including most weapon systems, and secure systems, in which confidentiality and integrity must be assured to a high level of confidence. By the mid-1990s, the DoD will demonstrate highly secure and reliable operating systems, database management systems, and other related components. In each of these software technology areas, the DoD must work to stimulate commercial development of off-the-shelf products that can be made to meet military needs.

Superconductivity

This technology makes use of the zero resistance property and other unique and remarkable properties of superconductors for creation of high-performance sensors, electronic devices and subsystems, and supermagnet based systems. The principal component fields are low temperature superconductors (LTS) and high temperature superconductors (HTS), both of which include supermagnets, sensors and electronics.

Introduction of superconducting devices offers the potential for reducing drastically the energy losses and cooling requirements, which in turn make for much improved processing speed and packaging density in digital microcircuitry. The frequency selectivity in analog filters using superconductor elements can not be approximated by other types of devices. The recently discovered high-temperature superconducting materials offer further increases in cooling requirements, promising the use of liquid nitrogen, rather than helium as a coolant, which makes potential applications much more practical. The challenge in the field is how to make the best possible (relatively near-term) use of the well established technology of low-temperature devices (working at less than 23oK) while resolving the serious problems associated with the use of high-temperature superconductors, which in the long-term may be more promising.

The DoD LTS program covers electric drive systems for ships, electric generators, magnetic energy storage systems, electromagnetic guns and catapults, microwave and millimeter wave generators, analog communications and surveillance system components, and digital electronic subsystems and systems, including analog-digital converters, cross-bar switch, cache-memories and digital signal processors. Many of these LTS developments will endure, but they will also serve as prototypes for later HTS applications which use transition temperatures as high as 125oK or possibly above. While the HTS devices impose lesser refrigeration penalties, problems of brittleness, crystalline anisotorphy, corrosion and bulk current density still require extensive development. The DoD plan for HTS materials aims at the fundamentals in the development of bulk conductors for magnets, thin-film sensors and electronics, together with the associated manufacturing processes.

Superconductor applications will result in higher performance sensors and electronics for the military and reduced weight, volume and power requirements. Electromagnetic propulsion of ships and projectiles may become practical through the introduction of HTS devices.

DOD DEFENSE KEY TECHNOLOGIES PLAN

The Defense Key Technologies Plan is centered on eleven key technologies considered crucial to achieving the goals of the Defense Science and Technology Strategy. The 21 Defense Critical Technologies identified in the May 1991 Defense Critical Technologies Plan were selected through a much less focused process. The shift in focus as represented in the Key Technologies Plan reflects the Department of Defense's reassessment of the geopolitical changes that have occurred throughout the world in the last year. This plan is also intended to fulfill the requirements of PL 101-189, National Defense Authorization Act for Fiscal Years 1990 and 1991, as amended by PL 101-510, and serve as the 1992 edition of the Defense Critical Technologies Plan.

The Key Technologies are as follows:

Computers - high performance hardware systems (and their software operating systems) for improved computational and communications capabilities

Software - the generation of enhanced programs for distributed systems, data bases, neural nets, and artificial intelligence

Sensors - active sensors (with emitters such as radar and sonar), passive ("silent") sensors (thermal imagers, low light level TV, and infrared search), and the associated signal and image processing

Communications Networking - the worldwide distribution of information in support of joint-Service mission planning, simulation, rehearsal, and execution

Electronic Devices - ultra-small (nano-scale) devices combined with packaging and photonics for high speed computers, data storage modules, communications systems, advanced sensors, signal processing, radar, imaging systems, and automatic control

Environmental Effects - the study of atmospheric, oceanic, terrestrial, and space environmental effects (natural and man-made) interacting with a weapons system on the battlefield

Materials and Processes - the development of man-made materials (composites, electronic, photonic, etc.) for improved structures, higher temperature engines, signature reduction, and electronics, including the synthesis and processing required for their application

Energy Storage - the safe, compact storage of electrical or chemical energy, including energetic materials for military systems

Propulsion and Energy Conversion - the efficient conversion of stored energy into usable forms such as those in efficient aircraft turbine engines and hypersonic systems

Design Automation - computer-aided design, concurrent engineering, simulation, and modeling to include the computational aspects of fluid dynamics, electromagnetics, advanced structures, structural dynamics, and other automated design processes

Human-System Interfaces - the machine integration, interpretation, and presentation of data in a form convenient to the human operator

Not all of these elements are specifically concerned with electronics, therefore only those elements appropriate for users of this binder are excerpted.

Computers

The field of computer technology includes developing, assessing, and transitioning into use digital high performance computing (HPC) processors, accelerators, and systems; specialized systems for harsh and unusual environments; generic signal processors; and associated peripheral equipment. The objective is to improve the state of the art and state of the practice of data, information, and general purpose signal processing for military missions and systems. While this area emphasizes high performance computers, it also includes other associated technologies such as HPC software, algorithms, and networking that are necessary to apply, evaluate, demonstrate, and transition them into productive HPC systems. These computer technology subareas include scalable parallel HPC systems, specialized computing and signal processing systems, and optical processing.

High performance computing and communications are essential base technologies that either drive or limit the scope of nearly all science and engineering fields of the future. Within the last 10 years, gains in HPC technology spurred a tenfold increase in useful computing capabilities. Research and development programs such as the Federal High Performance Computing and Communications (HPCC) Program, the DARPA HPC Program, and others sponsored by the Services and Defense Agencies are working to speed up gains in electronics, architectures, networking, software, applications, and other related HPC technologies. The HPCC Program is formulated to meet national needs from a variety of perspectives such as technology, science applications, human resources, and technology transition. These needs are identified from the participating agencies' missions. A number of these needs are related to solving intense large-scale computing problems. By 1996 these programs will produce a thousand-fold improvement in computing capability and a hundred-fold gain in computer communications capability.

Software

The main scope of this technology area covers the tools and techniques needed to generate, maintain, and improve applications software. This includes software for distributed systems, data bases, neural nets, and artificial intelligence. Additionally encompassed under this umbrella are software-intensive systems technology for rapid user-interface prototyping, computer system performance models, and generic domain-oriented software architectures. Software technology subareas are composed of the following: software and systems engineering, human-computer interaction and artificial intelligence, software for parallel and heterogeneous distributed systems, real-time/fault-tolerant software, and high assurance software.

Software and systems engineering includes the process and associated software support for all phases of the software and system life cycle. Software engineering refers to the processes by which software components and systems are synthesized to meet user needs. Currently there is no single software process model that supports the full range of development and post-development activities. As software environment and tool technology are principal means in managing large systems, the DoD is supporting major thrusts in this area through efforts in software prototyping, multilanguage interoperability, integration mechanisms, language foundations, and advanced tool approaches.

In human-computer interaction, the main objective is to support effective and efficient communication between human users and computer systems. With the emergence of better electronic/optic/audi technology, engineering solutions producing better communication have developed. Many systems currently in use are often single application for a single user or are multiple applications directly controlled by a single user, as represented by a workstation. The focus of the Thrust is to enable an expanded view of the computational facility support to include extremely complex integration across present levels.

The primary building blocks of artificial intelligence are knowledge representation, computer-based reasoning methods, and machine learning methods. Emphasis is on the development of new intelligent functionality and the engineering issues of integration, verification, validation, real-time performance, and life cycle maintenance. This calls for a close relationship between artificial intelligence technology and the other software technology subareas, especially software and systems engineering. The use of specific knowledge, usually acquired from human experts, and the ability to emulate human reasoning make this area attractive as a supplement to decision making and human expertise. Present efforts focus on the invention of powerful new functionality, advancing artificial intelligence technology, and integrating it with conventional software systems.

In the future, information processing systems will integrate multiple operating elements into seamless computing environments via local and wide-area networks. These parallel and heterogeneous distributed systems will then have the ability to increase throughput, survivability, and availability, all of which are crucial applications for the DoD. At the moment, there remains considerable work to be done in this area. Several efforts in distributed data bases are investigating replication data bases as an avenue for reliability, while other efforts are being directed at establishing and maintaining partitioned data bases to extend common data modes across multiple machines. Additional work is being conducted on software development tools and also on algorithms, which are primarily designed to upgrade mathematical libraries for new architectures.

All DoD operations rely on high performance, correctly functioning, real-time computer systems capable of withstanding severe stress without crashing. Dependency on electronic and computer technology as force multipliers is ever-increasing, and without reliable real-time/fault-tolerant software, advanced weapon systems lose much of their credibility and effectiveness. Many of the problems encountered in developing RT/FT software are similar to those arising in software and systems development in general and, specifically, in parallel and heterogeneous distributed systems. As it stands, technology for real-time software is too underdeveloped to work effectively in today's large complex systems. Current work in this area includes distribution tools to support robust system development, formal models of real-time systems, fault-tolerant data base management systems, a reconfigurable multicluster system, avionics fault-tolerant software, and prototype software for a real-time/fault-tolerant space-base signal processor.

High assurance is needed for software involving critical requirements representing specific characteristics whose inability to function at optimal level can cause serious problems in the operation of a system. These needs can be related to safety, security, performance, and other system attributes. DoD is addressing the situation through what it considers to be the key elements of high assurance software: identification and quantification of critical properties such as risk modeling and analysis; foundations for high assurance, including formal models of critical properties, formal specification languages, formal reasoning techniques, and programming language semantics; tools for high assurance; certification; and trusted and high assurance products related to security.

Sensors

Sensor technology concentrates on developing and applying fundamental principles and devices for sensor systems using radar sensors, electro-optics (EO) sensors, acoustics, and multisensor integration. Radar technologies include monostatic and multistatic radar techniques using various waveforms for coherent and non-coherent signal processing. Electro-optics technologies include passive and active sensing for infrared search and track, forward-looking IR (FLIR), visible sensing and displays, and signal processing. Acoustics includes passive and active sensors for underwater location/identification and battlefield non-line-of-sight detection, localization, tracking, and positive-hostile ID of ground combat vehicles. Multisensor integration is a combination of information from more than one sensor to provide a composite of the environment and to perform target extractions that would not otherwise be possible with a single sensor.

Monostatic technology is the traditional radar for surface, air, and space radar applications. This technology is directed at both coherent and non-coherent transmit/receive functions using pulsed continuous wave and more complex waveforms. Key elements for surface-base radar will focus on size/weight, stabilization, power levels, detection/classification, and survivability against anti-radiation missiles (ARM). Airborne intercept radar stresses development in detection at extended ranges, counter-ARM, and air target identification. Airborne ASW radar is also linked to the Navy's need to detect and attack submarine targets. This technology will address periscope and wake detection techniques, and incorporate design approaches for fixed- and rotary-wing aircraft that are both land and carrier based. The main areas offering the highest payoff are the Phased Array, Over-the-Horizon (OTH), SAR, and ISAR.

Multistatic radar has emerged as the predominant sensor technology for many surveillance functions and operations. It comprises four major subareas that are scenario/platform/target driven. These subareas are Phased Array, Over-the-Horizon, SAR/ISAR, and Wideband/Ultra-Wideband. In multistatic radar, the transmitter and receiver are separated by a significant distance and provide additional capability to counter low observables. Technological issues include transmitter and receiver timing and maintaining the bistatic angle.

Electro-Optics sensors include both passive (sensors that do not emit radiation in order to find targets, but rather receive emitted energy) and active (primarily laser radars, laser rangefinders, and target designators) sensors. Passive sensors have become increasingly important in order to counter enemy observations across many frequency bands. The advantage of passive sensors is that they are stealthy systems that do not offer information to the enemy about the host platform, while at the same time maintaining the platform's own covertness. Active sensors, on the other hand, provide advantages of bandwidth, physical size reduction, and higher resolution. This is evident in the use of laser radars which provide a highly accurate tracking and weapon control capability and can be used for remote environmental monitoring including chemical agent or persistent nuclear dust cloud detection.

Active acoustics emphasizes sonar technologies required for operation in harsh, shallow water and for torpedo defense alerting for both surface ships and submarines. With submarines reducing their radiated noise, more sensitive acoustic arrays have become very import to naval strategy. Acoustic arrays are also being used for detection and identification of aircraft, ground vehicles, and troop movement; however, these applications are still in infant stages.

Passive acoustics provide non-line-of-sight detection, classification, localization, tracking, and identification. Such acoustics have long been the primary sensor technology for ASW. The principal effort in tactical passive acoustics is toward larger arrays to improve low frequency response and support multistatic active acoustic reception. Fiber-optic technology is considered to play a major role in the future in order to reduce array cost, space, weight, and eliminate electronic noise.

Multisensor integration is needed for combat management and for smart, beyond-visual-rage weapons in order to avoid killing ones own troops and noncombatants. Imaging techniques such as SAR and EO are now used for detection and identification of targets. SAR is used for ship classification. Ultra-high range resolution radar provides aircraft identification. Millimeter wave radar imaging will be used in air defense, missile defense, and fire-and-forget missile seekers. Continued development of MMW technology is considered critical for the Army with its arsenal of small smart munitions and precision-guided munitions.

Communications Networking

Communications networking uses shared media and common hardware/software applications to enable the timely, reliable, and secure receiving and sending of information from originators to DoD users in the support of joint-Service mission planning, simulation, rehearsal, execution, and assessment. Communications and decision support subsystems integrate the information needed by decision makers regardless of its form (voice, data, video, etc.) or where it originated or where it is being used. The technology focus is divided into three subareas: network management and capacity allocation subsystem, data retrieval and information production subsystem, and modular/programmable radios.

Global communications connectivity is essential to effective command and control. By using a combination of existing military and commercial communication systems whenever needed, the current focus on communications networking technology has shifted to establishing and managing these high capacity networks. The technology needed to connect military users into a global defense network is attainable. Indeed, a considerable amount of ground work has already been established by the military in the Multinet Gateway and related programs. This is a useful basis for automated assessment of user demands and priorities, development of protocol, routing, traffic management, and network allocation. However, the major developmental and acquisition issues related to the reality of a global, high-capacity network appears to be more political and economic than technical.

One of the results of the Persian Gulf War was the acknowledgement of a need for a joint planning system for data retrieval and information production. A single, integrated planning system designed from standardized functional modules could meet DoD needs while at the same time providing the uniformity necessary to perform joint operations. The principal concerns in realizing a joint-mission planning system are developing generic software capable of satisfying the needs of each Service and every mission; developing algorithms to allow for rapid replanning in case of unexpected changes or threats; and developing a distributed architecture for maximum computing efficiency while also minimizing network traffic. This will entail a fair amount of customizing in order to tailor the standard functional modules to unique applications, but a goal of 90 percent commonality should be attainable.

The abundance of incompatible radios has created a number of procurement and operational restrictions and burdens. Presently, users must carry several types of radio equipment in order to participate in multiple networks. The technology exists today to develop a single unit that can communicate with many types of radios through digital waveform generation and signal processing. Such a system will dramatically decrease life cycle costs and logistics support demands as only a small number of designs will have to be kept in inventory. The Integrated Communications, Navigation, Identification Avionics (ICNIA) Program has already demonstrated a significant portion of the technology needed to develop such a universal radio. Using digital storage and waveform synthesizer techniques, a single radio can use a wide variety of signal protocols, modulation techniques, and encryption schemes. However, it is the antenna subsystem that is providing the technical difficulty as it must span many decades of operation frequency. Additional issues center on the degree to which the size and weight of such a standard radio can be reduced by use of high density electronic circuity, as well as how the unit cost of this radio compares with that of lower-performance but less expensive models already in use.

Electronic Devices

Electronic device technology is centered around three broad subareas:

microelectronics, RF components, and electro-optics. These subareas are the building blocks of military systems. The advances in silicon technology and the semiconductor industry have contributed dramatically to the growth of microelectronics. Smaller circuitry has led to greater functionality at lower cost. Other compound semiconductor materials such as gallium arsenide (GaAs) promise to become increasingly important in the future as they enable faster ICs and have better radiation hardness than bulk silicon devices.

DoD's main thrust in the RF component subarea continues to be the Microwave and Millimeter Wave Monolithic Integrated Circuits (MIMIC) program. The program aims to ensure the availability of reliable, affordable, high-performance microwave components for a large spectrum of systems including missiles, radar, electronic warfare, communications, and other smart weapons. MIMIC has also helped expand device modeling tools, CAD software, and the development of software that will interface both analog and digital devices with systems design, procurement, and maintenance. Generic antenna technology, frequency control devices, and submillimeter wave systems are also being explored for improvements.

A major aim in the electro-optics subarea is the development of more efficient, reliable, and compact wavelength divers laser sources for rangefinder/designator, countermeasure, communication, chemical detector, and radar functions. These key issues will be addressed through increasing short pulse efficiency to 15 percent, increasing power output to 2W per pound, increasing available wavelengths of high power laser diodes to 3.5 um, and reducing the cost of the diode array that pumps solid-state lasers to less than $1 per peak watt. Also in the works is the development of a high-efficiency, space-qualified, tactical laser. Other important fields include focal plane array technology, display components, and photonics/fiber optics.

Environmental Effects

With military technology growing more complex and sophisticated, systems and operations are becoming more influenced by the variables in natural environmental conditions such as weather, oceans, and terrain, and by man-made phenomena such as acoustic noise from ships and obscurants such as smoke and haze found on all battlefields. Development in this field will provide prototype sensor and sensing technology that improves capability to measure and predict geophysical parameters worldwide. Special attention also needs to be given to environmental extremes such as cold and arid regions and shallow coastal waters where a system's performance is usually very restricted and the cost to maximize performance very expensive. The DoD is hoping greater knowledge in these areas will increase capabilities and generate large returns on any investments.

DEFENSE SCIENCE AND TECHNOLOGY STRATEGY

In the past, US cold war defense strategies and weapons acquisition were dictated by competition with an adversary (the former Soviet Union) who possessed an ever-increasing and ever-improving array of active weapons. With the change in the world's geopolitical environment, today's US defense and acquisition strategies focus on the potentially dangerous regional conflicts and the capability to respond to any emerging global threats. Regional powers have gained increasingly high access to both Western weaponry and high quality equipment from the former Soviet Union. This military equipment provides adversaries of the US with formidable fighting capability.

Technological superiority is a prime ingredient in maintaining peace. During a crisis it offers a wide range of options available to world and military leaders while providing confidence to the public and to allies. In a war, technological superiority enhances combat effectiveness and reduces the loss of troops and equipment as was demonstrated in the Persian Gulf War. The US will have to continue working hard to maintain a significant technological edge over its opponents.

In order to maintain a technological lead over other nations, the US Department of Defense has developed a new Science and Technology (S&T) strategy. The objective of this strategy is: one, to provide for the early, intensive, and continued involvement of military personnel; two, to fuel and exploit the information technology explosion; and three, to conduct extensive and realistic technology demonstrations. A key part of the S&T strategy is the early and continued participation of the military. Feedback from the users of the technology in providing concepts, doctrines, and needs to the developers is highly stressed. Also, the development of increasingly faster and more capable computers has revolutionized military operations through the creation of more effective Command, Control, Communications, and Intelligence (C3I) systems. This technology will be geared toward specific capabilities that can be proven with an Advanced Technology Demonstration (ATD). Such a demonstration, when coupled with simulations and exercises, will help ensure the technology is ready, manufacturing available, and operating concepts understood before formal procurement is undertaken.

SEVEN S&T THRUSTS

The S&T program is divided in to seven Thrusts that represent the demands being placed on the program by the DoD's most pressing military and operational requirements. Although there are agendas in the S&T program outside of these Thrusts, the vital success of the program demands attention be focused on the areas showing the greatest promise for enhancing future military capabilities. This is in contrast to past strategies which called for providing an across-the-board balance in all development options. Focus, as compared to balance, is the aim of the new S&T strategy.

The seven Thrusts are as follows:

<u>Global Surveillance and Communications</u> - develop the global aspects of emerging surveillance and communications capabilities that will

contribute to the exchange of information with communications and sensing systems in several other Thrusts

Precision Strike - destroy, with a high degree of confidence, high-value, time-sensitive fixed and mobile targets

Air Superiority and Defense - the ability to defend deployed forces from air attack requires heavy efforts in missile defense and air superiority

Sea Control and Undersea Superiority - the need to maintain overseas presence, conduct forcible entry, and operate in coastal regions presupposes a strong capability in sea control and undersea warfare

Advanced Land Combat - the ability to rapidly deploy ground forces to an area, execute a high degree of tactical mobility, and quickly overpower the enemy (with minimal casualties) in the presence of a heavy armored threat and smart weaponry requires highly capable land combat systems

Synthetic Environments - develop a broad range of accessible simulated battlefield environments to prepare leaders and troops for the real battlefield

Technology for Affordability - improve technologies that reduce unit and life cycle costs

Global Surveillance and Communications

This Thrust will provide the overall architecture needed for all the other Thrusts to interact effectively. It will need to be capable of carrying out regular earth surveillance, focus on any one specific area, and convey information to intelligence, C2 systems, and fighting forces. The main elements of this Thrust include expanded surveillance, communication, computing, and reference data capabilities integrated with other theater functions; C2 integrated with the surveillance and communications systems; user-friendly distributed systems providing degradation, multimedia sensing, and communication capability; surge capability and rapid partition sensing, data processing, exploitation, fusion, and dissemination through encryption; and responsive unmanned air vehicles, spacecraft, and launch systems. Such a design must provide users with a comprehensive global view and permit users to interact with the information as needed.

Precision Strike

Precision Strike is a set of integrated capabilities for locating, identifying, and killing high-value ground targets. This detection-engagement cycle must be executable in all weather conditions, day or night, with extreme accuracy. The solution to the time-sensitive target engagement problem is an integrated joint precision master system that can routinely detect, attack, and destroy enemy forces. Currently the military has developed excellent surveillance and strike sensors such as JSTARS, ASARS, and the APG-70. Other long-range weapons include

ATACMS, PGM, and TLAM. Success in Precision Strike will depend on achieving a seamless interface with Global Surveillance and Communications systems.

Air Superiority and Defense

The Air Superiority and Defense Thrust concentrates on developing technologies that dramatically improve or have completely new capabilities to defend against and engage tactical ballistic missiles, stealthy manned aircraft, cruise missiles, and helicopters. A main objective is to demonstrate an effective new capability against clutter-embedded and terrain-masked helicopters as well as naval sea-skimming cruise missiles. The planned Patriot PAC-3 and ground-based radar (GBR) and theater high altitude air defense (THAAD) programs will provide credible point and area defense capabilities against missiles up to 3,000 km in range. The S&T strategy will be based upon this foundation to enhance capabilities against future threats, including reduced signature and mass destruction warheads.

Sea Control and Undersea Superiority

This Thrust has been established to meet the military's growing need for the ability to operate in coastal areas. The objective is to identify, develop, and demonstrate capabilities for fixed and mobile platforms. These platforms will be outfitted with a full spectrum of sensors and improved communications netted together for fire support, carrier strike, missile defense, anti-submarine warfare, and anti-mine warfare. It will especially develop shallow water and regional conflict capabilities that do not exist today - while at the same time, maintain an adequate technology to counter deep water threats. This goal can be expressed in terms of three essential warfighting functions: search/target, attack/kill, and survive.

Advanced Land Combat

In dealing with regional conflicts, the prepositioning of equipment is less practical than during the time of the Cold War in Europe. All aspects of future advanced land combat will have to be highly deployable and able to execute missions outside of normal theater operations. These new combat requirements call for forces that are hard to see and hard to hit. Significant development towards this goal will be seen in integrated survivability (active and passive signature control and obscuration, threat warning sensors, etc.), non-exploitable identification friend or foe (IFF), and advanced C3I.

Synthetic Environments

Synthetic environments are internetted simulators ranging from war theaters to factory war production. These simulations are vastly different than traditional simulations in that they use a network of various computers and computer systems all interconnected to produce the environment. This allows complete visualization and total immersion into the environment being simulated. These environments will come in many shapes and sizes and will replicate real-world locations and conditions with precision. The technology in this Thrust will be used mainly for acquisition and for training and readiness.

Technology for Affordability

Investments in Technology for Affordability is considered a new mode of defense manufacturing. It includes four basic functions: process technology, to change the expectations in exploratory and advanced development programs to include a demonstrated production process before technologies are transitioned into engineering and manufacturing development; concurrent engineering, to invest in intelligent design tools, collaboration technology, and share product and process knowledge base technologies that will facilitate product and process design; manufacturing process, to develop flexible manufacturing systems that can make quick prototypes and production items in small lots at unit costs close to mass production costs; and manufacturing functions above the factory floor, to improve production control, inventory management, supplier and customer interface, and a host of manufacturing overhead functions which today account for over 60 percent of the costs of a complex product.

1/5 - (C) C.DMT
NO - DMT-0419435
ET - Seven S&T Thrusts Detailed In New Strategy Report
DT - JOURNAL ARTICLE
LA - ENG
PO - US
JT - Defense Week
SO - PP. N/A; DP. 27/07/92
OG - Dept/Ministry of Defense
TC - The Pentagon last week released the final version of its well-publicized science and technology strategy, laying out the details of seven key "thrusts" that will guide the department's R&D investments over the next decade.

Victor Reis, the Pentagon's director for defense research and engineering, billed the plan in a Pentagon press release as the "first comprehensive science and technology (S&T) strategy of the post-Cold War era. "

According to its boosters, the new S&T plan will give the Pentagon a badly needed R&D focus as budgets decline and the military threat becomes more amorphous. In the past, they said, the Pentagon's R&D efforts have been fragmented and too beholden to parochial service interests to meet the department's long-term needs.

The new S&T strategy is the most comprehensive and specific to date. And unlike previous Pentagon R&D "plans," the new one is "focused on those efforts which show the greatest promise for improving future military capabilities, rather than simply providing a 'balance' across all possible investment options," said the report. "Focus, not balance, is the watchword of the new S&T strategy. "

Three premises underlie the new plan, said Reis: Soldiers must be involved throughout a program's life to ensure that it remains responsive to the ultimate users needs; the Pentagon must take advantage of the recent explosion in information technologies to revolutionize military operations and the department must conduct extensive, realistic demonstrations of promising technologies to ensure technologies will deliver what is promised.

Details of the seven thrusts follow:

-- Global surveillance and communications. This thrust will focus on producing a system that can quickly and accurately detect targets, identify them and assess whether a strike against them was successful. The system will offer global coverage but also be built to focus, if needed, on individual hot spots like the Persian Gulf.

It will supplant current jury rigged systems that rely on ad hoc interconnections between a welter of competing sensors. And it will supposedly deliver a seamless flow of information to the operators who need it, a major gulf war shortfall.

The Pentagon will demonstrate key technologies through fiscal 2002. After that date components will be combined to provide "revolutionary functional capabilities," said Reis.

-- Precision strike. This thrust will be geared toward locating and destroying key mobile targets--like Scud missile launchers--that are outside the "immediate battle area. " Data gleaned from global surveillance and communications systems, will be passed directly to mission planners who, if need be, "can send that same information directly to the appropriate weapon delivery systems and munitions. "

The thrust will ensure that U. S. forces won't be caught trying to catch up with targets that have moved by the time a weapon can be brought to bear. U. S. efforts to destroy Scud launchers were stymied by cumbersome mission planning and the slow dissemination of targeting information.

The Joint Air/Land/Sea Precision Strike demonstration will begin in fiscal 1993. It will use simulation technologies developed under a so-called "Warbreaker" program in a Joint Precision Strike Testbed. And it will demo capabilities for delivering conventional weapons against "time-sensitive" targets developed under a program dubbed "Artemis".

-- Air Superiority and Defense. This thrust will focus on countering threats from

tactical ballistic missiles, stealthy manned aircraft, cruise missiles and helicopters. According to Reis, the Pentagon's concern is not manned conventional aircraft, an area in which the U. S. , has demonstrated its dominance.
The main concern is the "emergence of stealthy manned aircraft and cruise missile threats that would eliminate this advantage. " Also targeted are terrain-hugging choppers and sea-skimming cruise missiles.
-- Sea Control and Undersea Superiority. The Pentagon established this thrust to "respond to the military requirements posed by the growing need for naval forces to operate in coastal areas. All Navy platforms, including subs, will be given new capabilities for "shallow water and regional conflict" operations.
The Navy also will develop improved platform protection weapons under this thrust as well as continue work on unmanned vehicles and tactical environmental sensor systems.
-- Advanced Land Combat. Under this thrust, the Pentagon hopes to better prepare its land forces for rapid reaction to trouble spots. It will look at ways of minimizing the vulnerabilities of lightly armored vehicles and use advanced materials and electronic countermeasures to reduce the weight and improve the survivability of heavy weapons.
Other initiatives within the thrust will focus on improving identification friend-or-foe at extended ranges and improve units' situational awareness while on the move.
-- Synthetic environments. This thrust will focus on developing ways of cobbling several super-realistic simulators together to produce "environments. . . fundamentally different from the traditional simulations and models known today. "The environments will "allow complete visualization of and total immersion into the environment being simulated. "
The simulators will be used for such standard practices as training and doctrine and requirements development. But they will also be used for design, prototyping and manufacturing processes.
-- Technology for affordability. This thrust will develop design tools for transitioning flawlessly from prototypes to production. And it will develop "flexible" manufacturing processes that will allow production lines to quickly switch from building one item to another, eliminating the high cost associated with limited manufacturing runs.
Other initiatives under this thrust will speed the flow of information between customers and manufacturers to reduce overhead burdens that eat up 50 percent of "today's product cost," said the report.
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DE - Military R and D*; Defense Research and Development; Research and Development Outlays*; Planning and Information; United States*; Long full text
IP - Promt; Newsletter
PES - 8512010*; 9104150; 1USA*; 45*; 22
NCP - Military R and D 8512010; Defense Research and Development 9104150
NCE - Research and Development Outlays 45; Planning and Information 22
NCG - United States 1USA

2/5 - (C) C.DMT
NO - DMT-0419434
ET - Pentagon To Spend Billions Annually For Key Technologies
DT - JOURNAL ARTICLE
LA - ENG
PO - US
JT - Defense Week
SO - PP. N/A; DP. 27/07/92
OG - Dept/Ministry of Defense
TC - The Pentagon expects to spend roughly $10. 5 billion between fiscal 1992 and fiscal 1994 on 11 "key technologies" supporting the **seven** **thrusts** laid out in its new science and technology strategy, according to a Pentagon plan released last week.

The "primary objective" of the 11 key technologies is to "prove out and mature the technologies required to attain the goals of the S&T (science and technology) strategy thrusts," said the plan, which was prepared by Victor Reis, the Pentagon's technology chief.

Most of the money earmarked for key technologies will go toward advanced technology demonstrations (ATDs) that "range from assessing the military utility of new technological concepts in the laboratory to integrating and evaluating technology in as realistic an operational environment as possible," said Reis.

The 11 key technologies and the average amount the Pentagon plans to spend on them annually between fiscal 1992 and fiscal 1994 are: sensors ($675 million); electronic devices ($626 million); propulsion and energy conversion ($428 million); computers ($393 million); materials and processes ($387 million); environmental effects ($363 million); human-system interfaces ($209 million); software ($201 million); design automation ($76 million); communications networking ($54 million), and energy storage ($51 million).

In addition to identifying key technologies, Reis's plan also lists goals for 1995, 2000 and 2005 for each area and outlines the relationship of each technology area to the **seven** **thrusts**. It also lists the existing programs within the Pentagon budget--so-called line items--under which the R&D work will be funded. An assessment of how well the U. S. work stacks up against foreign competitors in each of the fields is also included.

The new plan will supplant the annual "critical technologies" strategy Congress had directed the Pentagon to begin submitting in fiscal 1990. Those plans had often been sharply criticized for being lists rather than real strategies that laid out specific goals and funding requirements.

With its new S&T objectives and clearly-defined plans on how to reach them in its key technologies plan, the Pentagon appears to have gone a long way toward satisfying its congressional critics.

The S&T strategy, which had gone through several well-publicized drafts, was released in its final form last week. Its seven thrusts are: global surveillance and communications, precision strike, air superiority and defense, sea control and undersea superiority, advanced land combat, synthetic environments and technology for affordability.

Following is a brief synopsis of the work that will be performed in each technology area and average annual funding:

-- In the computer arena, the Pentagon plans to focus its efforts on high performance computing (HPC), including scalable parallel systems that will "improve computational and communications capability by orders of magnitude. " Other focuses will include certain specialized computing and signal processing and optical processing systems.

The Pentagon plans to spend roughly $225 million annually on the "scalable" parallel HPC systems, $67 million on specialized computing and signal processing systems and $33 million on optical processing.

-- In the software arena, the Pentagon plans to focus on software and systems

engineering ($79 million); human computer interaction ($7 million); artificial intelligence ($56 million); software for parallel and heterogenous distributed systems ($35 million); real-time/fault tolerant software ($6 million) and high assurance software ($19 million).
-- Sensor work will examine radar sensor technology ($230 million), electro-optic sensor technology ($184 million), acoustics ($219 million) and multisensor integration ($41 million).
-- Communications networking research will emphasize network management and capacity allocation subsystems ($16 million); data retrieval and information production subsystems ($22 million) and modular/programmable radios ($12 million).
-- Microelectronics, radio-frequency components and electro-optical devices are the main thrusts in the electronic devices arena. They will be funded at approximately $268 million, $170 million and $188 million per year.
-- The environmental effects arena--which covers the impact natural conditions can have on weapons systems and operations--will focus on environmental sensing ($53 million), environmental characterization and prediction ($207 million) and scene-generation and environmental decision aids ($76 million).
-- R&D in the materials and processes arena will focus on structural materials processing and inspection ($101 million); high-temperature and anti-armor materials ($71 million); electromagnetic and armor protection materials ($99 million); electronic, magnetic and optical materials ($80 million) and special-function and biomolecular materials and processes ($60 million).
- Energy storage R&D will emphasize developments in energetic materials, power conditioning and energy/power sources. Expenditures will average $19 million, $12 million and $20 million per year.
- In the propulsion arena, the Pentagon plans to focus on IHP-TET, a program aimed at doubling aircraft gas-turbine propulsion system capability by the turn of the century ($139 million). It will also emphasize missile, space and aerospace vehicle propulsion ($175 million); surface/undersurface vehicle propulsion ($40 million) and energy conversion/power generation ($474 million).
- Design automation developments will center on design synthesis and analysis ($41 million); product and process definition ($15 million) and information flow and integration ($20 million).
- Human systems interfaces work will emphasize crew stations and operator equipment ($57 million); information management ($24 million); design and life cycle supportability ($65 million) and manpower training ($64 million).
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PES - 9104150*; 8512010; 1USA*; 90*
NCP - Defense Research and Development 9104150; Military R and D 8512010
NCE - Government Expenditures 90
NCG - United States 1USA

3/5 - (C) C.DMT
NO - DMT-0417604
ET - DOD introduces new S&T plan
DT - JOURNAL ARTICLE
LA - ENG
PO - US
JT - Defense & Aerospace Electronics
SO - PP. N/A; DP. 03/08/92
SN - 1056-747X
OG - Dept/Ministry of Defense
TC - The Pentagon has formally introduced its new science and technology (S&T) strategy for the post-Cold War era.

"This is the first comprehensive science and technology strategy of the post-Cold War (period), one that fully promotes a strong and dynamic defense technology base," said Victor Reis, director of Defense Research and Engineering. I believe that the strategy will provide the weapon systems our forces need for operations, readiness and training in the uncertain global environment we face. "

Additionally, it will foster "modern manufacturing methods," Reis explained in releasing the S&T plan in late July.

The plan revolves around three musts. They are: 1) users, or warfighters, must be involved in all stages of weapons growth -- from design to production through testing; 2) the latest information technologies must be exploited by the Defense Dept. ; and 3) DOD must perform extensive and realistic demonstrations of promising technologies.

- Involvement of warfighters: Warfighters provide feedback to the developers. Feedback and "feed-forward" loops will emerge from expanded and integrated sets of instrument training ranges and electronic battlefields. "Synthetic environments" are being connected throughout the scientific and development communities, bringing developers, scientists, engineers, manufacturers and warfighters together in identifying and solving problems.

- Information technology explosion: The idea here is to capture and exploit the tremendous growth in information technology for revolutionizing the way military operations are conducted. Computer networks are providing great opportunities for designing highly effective and affordable systems on the battlefield and at training centers.

DOD said the information revolution will improve the use and value of distributed simulation systems and exercises that involve the user directly and intimately in the development process.

- Advanced technology demonstration: Two essential elements of the S&T plan are the application of new technologies in specific areas and the verification of their capabilities via Advanced Technology Demonstrations (ATDs). The demos will be coupled with simulations and exercises to ensure the technologies are ready for the next stage. Simultaneously manufacturing processes will be readied and system operating concepts verified before entering the acquisition process.

ATDs come in two forms. One involves new systems and subsystem concepts; the other enabling technologies. ATD is not new to the DOD, however. "What is new is the scope and depth of the technology demonstrations, their central position in the acquisition process and the emphasis on ultimately demonstrating useful military capabilities," the DOD said.

"Each ATD will be designed to satisfy acquisition decision makers that the technology is feasible, affordable and compatible with the operational concepts and force structure envisioned for the base (military) force. "

Seven thrusts defined

To move the S&T program along a focused path, the Pentagon has identified seven thrust areas (DAE 3/9 and 3/30). They encompass:

- Global surveillance and communications: The ability to project power dictates a global surveillance and communications capabilities for covering troubled areas,

responding to surge requirements and supporting the needs of commanders.
Precision strike: A trim and cost-conscious military requires the ability to locate and destroy quickly opposing high-value fixed and mobile targets.
- Air superiority and defense: This thrust centers on protecting forces from aircraft and ballistic and cruise missiles, countering with them appropriate close air support and associate resources.
- Sea control and undersea superiority: The need to maintain overseas presence, conduct forcible entry and naval interdiction operations and operate in costal zones requires a strong capability in sea control and undersea warfare.
- Advanced land control: This thrust supports the need for mobile tactical land forces equipped with smart weapons for defeating heavy armor and other surface threats.
- Synthetic environments: Many information and human interaction technologies must be developed to synthesize present and future battlefields. DOD must synthesize factory-to-battlefield environments involving a mix of real and simulated objects and make them accessible from different locations. Such technologies will prepare "our leaders and forces for war and will go with them to the real battlefield," DOD said.
- Affordable technology: A Pentagon existing on tight budgets must trim the costs of producing high-tech weapons and systems. Advances are needed in technologies that support integrated product and process design; flexible manufacturing systems that separate costs from volume; enterprise information systems that improve program control and reduce overhead costs; and integrated software engineering environments.
The seven thrusts are further defined in the 1992 DOD Technologies Plan. The plan complies with congressional requirements that the Pentagon identify technologies considered essential for maintaining superiority in the U. S. arms inventory.
The DOD identified 11 "key technology areas" as: computers, software, sensors, communications networking, electronic devices, environmental effects, materials and processes, energy storage, propulsion and energy conversion, design automation and human-system interfaces.
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4/5 - (C) C.DMT
NO - DMT-0403519
ET - Critical technologies may lose status
DT - JOURNAL ARTICLE
LA - ENG
PO - US
JT - Defense & Aerospace Electronics
SO - PP. N/A; DP. 06/04/92
SN - 1056-747X
OG - Dept/Ministry of Defense
TC - HUNTSVILLE, Ala. -- Top Pentagon officials are preparing to unveil a long-range plan making space technology and simulation the top priority for research dollars during the next 10 to 15 years, putting "critical technologies" into a backseat role.

The plan, stemming from discussions beginning last fall among senior aides to Defense Secretary Dick Cheney and the top R&D representatives from each military branch, includes a list of seven top-priority funding areas.

Some officials believe the plan, known as the "**seven** **thrusts**," will transcend the year-old "critical technologies" initiative that has served as the touchstone for defense contractors mapping out their long-range business plans.

One of the elements of the plan is development of distributed, interactive simulation that has been made possible by dramatic improvements in computers, software and communications, said Victor Reis, director of defense research and engineering.

"These simulation techniques are now ready to become an integral part of the acquisition process as well, and we have made them a major thrust in our science and technology strategy," Reis told the House Appropriation's defense subcommittee last month.

Although Reis has disclosed few details about the **seven** **thrusts**, the plan is "almost in concrete," William Howard, an Army space official, told a conference here last month. "Funding lines are being developed among all the services on each one of them. "

The top three priorities are directly tied to space research: global surveillance and communication, precision strikes, and air superiority and defense (DAE 3/9).

Those categories "are what the senior R&D decision-makers think are going to be important," Howard said. "There's going to be a tendency to put more money into those areas as opposed to other areas" of interest.

The bottom four categories in the seven thrusts are sea control and undersea superiority, advanced land combat, synthetic environments (simulation and training) and technology for affordability (new procurement strategies).

Debate over critical technologies expected

Eventually the seven thrusts will probably eclipse the critical technologies plan because they involve the actual capabilities needed for 21st-century warfighting, rather than narrowly viewing specific, advanced technologies that may or may not prove valuable, Howard predicted.

"This can muddy the waters somewhat if we're not careful," Howard said. "I think what will happen is that if you're directly connected with the seven thrusts, fate will smile on you. If not, then the services will come along and -- if they like what you're doing -- then you'll be under special protection of the services and the agencies. "

Global surveillance, the top priority, deals almost exclusively with space technology. Precision strikes provides theater forces with the information gleaned from a surveillance area. Air superiority and defense, which counters the threat of aircraft and cruise missiles, has historically received little funding.

Search for "seamless" assets

In global surveillance and communication, Pentagon officials are aiming for integrated collection systems with expanded sensing capability, wider spectral wavelengths and increased capacity. The concept involves a "seamless" flow of information so that services, intelligence and operations units can interconnect, Howard said.

Another priority is rapid surge and worldwide deployability, particularly as the U. S. scales back its military force overseas. "Particularly if we have to turn around at a drop of the hat and become rapidly deployable, the ability to have global surveillance and have good communications to back up all of that is going to be worth its weight in gold," Howard said.

In precision strikes, there is a heavy push for joint service programs. "There is a push in trying to get program element lines of Army, Navy and Air Force in on all of these, in particular, technology demonstrations to a much greater degree than I've ever seen in the past," Howard added.

The priority for precision strikes is in developing joint all-weather capability, and quick reaction to time-sensitive targets. Other priorities are day-night operations that can penetrate all obstacles such as camouflage and cover. A fourth priority is battle damage assessment.

For air superiority and defense, the desired attributes are low leakage area defense against tactical ballistic missiles. So far, there has been little attention to cruise missiles and hand-carried threats. The problem is that cruise missiles are tiny, can fly under clouds out of reach of existing space sensors, and are impossible to counter within realistic budgets, Howard reasoned.

Stealth and stealth countermeasures represent another priority grouping. Another urgent item is high reaction capability against helicopters and low-flying missiles (cruises). Next there is netted systems for cooperative engagement among different services and long-range, precision weapon systems.

Depending on how and if the seven thrusts are implemented, it could slow programs. In the current acquisition process, many programs proceed to initial procurements without a technical demonstration phase.

However, many Pentagon officials believe the proposed system would save money without necessarily prolonging programs, Howard said.

"This may or may not slow up things," he said. "The tech demos -- if they're close enough to what you want -- are going to save money in the long term. It would be better to have one of them fail rather than to have 100 of them fail. " THIS IS THE FULL TEXT: Copyright 1992 by Pasha Publications, Inc.a has d

DE - Space Vehicles*; Defense Research and Development; Space Technology; Trainers and Simulators; Research and Development Outlays*; Government Expenditures; United States*; Long full text

IP - Promt; Newsletter

PES - 3761200*; 9104150; 9102250; 3662782; 1USA*; 45*; 90

NCP - Space Vehicles 3761200; Defense Research and Development 9104150; Space Technology 9102250; Trainers and Simulators 3662782

NCE - Research and Development Outlays 45; Government Expenditures 90

NCG - United States 1USA

1/3 - (C) C.cedocar
NO - DMT-0418701
ET - Pentagon To Spend Billions Annually For Key Technologies
DT - JOURNAL ARTICLE
LA - ENG
PO - US
JT - New Technology Week
SO - PP. N/A; DP. 03/08/92
SN - 0894-0789
TC - The Pentagon expects to spend roughly $10. 5 billion between fiscal 1992 and fiscal 1994 on 11 "key technologies" supporting the seven thrusts laid out in its new science and technology strategy, according to a Pentagon plan released last week.

The "primary objective" of the 11 key technologies is to "prove out and mature the technologies required to attain the goals of the S&T (science and technology) strategy thrusts," said the plan, which was prepared by Victor Reis, the Pentagon's technology chief.

Most of the money earmarked for key technologies will go toward advanced technology demonstrations (ATDs) that "range from assessing the military utility of new technological concepts in the laboratory to integrating and evaluating technology in as realistic an operational environment as possible," said Reis.

The 11 key technologies and the average amount the Pentagon plans to spend on them annually between fiscal 1992 and fiscal 1994 are: sensors ($675 million); electronic devices ($626 million); propulsion and energy conversion ($428 million); computers ($393 million); materials and processes ($387 million); environmental effects ($363 million); human-system interfaces ($209 million); software ($201 million); design automation ($76 million); communications networking ($54 million); and energy storage ($51 million).

In addition to identifying key technologies, Reis's plan also lists goals for 1995, 2000 and 2005 for each area and outlines the relationship of each technology area to the seven thrusts. It also lists the existing programs within the Pentagon budget--so-called line items--under which the R&D work will be funded. An assessment of how well the U. S. work stacks up against foreign competitors in each of the fields is also included.

The new plan will supplant the annual "critical technologies" strategy Congress had directed the Pentagon to begin submitting in fiscal 1990. Those plans had often been sharply criticized for being lists rather than real strategies that laid out specific goals and funding requirements.

With its new S&T objectives and clearly defined plans for how to reach them in its key technologies plan, the Pentagon appears to have gone a long way toward satisfying its congressional critics.

The S&T strategy, which had gone through several well-publicized drafts, was released in its final form last week. Its seven thrusts are: global surveillance and communications, precision strike, air superiority and defense, sea control and undersea superiority, advanced land combat, synthetic environments and technology for affordability.

Following is a brief synopsis of the work that will be performed in each technology area and average annual funding:

- In the computer arena, the Pentagon plans to focus its efforts on high performance computing (HPC), including scalable parallel systems that will "improve computational and communications capability by orders of magnitude. " Other focuses will include certain specialized computing and signal processing and optical processing systems.

The Pentagon plans to spend roughly $225 million annually on the "scalable" parallel HPC systems $67 million on specialized computing and signal processing systems and $33 million on optical processing.

- In the software arena, the Pentagon plans to focus on software and systems engineering ($79 million); human computer interaction ($7 million); artificial intelligence ($56 million); software for parallel and heterogenous distributed systems ($35 million); real-time fault tolerant software ($6 million) and high assurance software ($19 million).

- Sensor work will examine radar sensor technology ($230 million), electro-optic sensor technology ($184 million), acoustics ($219 million) and multisensor integration ($41 million).
- Communications networking research will emphasize network management and capacity allocation subsystems ($16 million); data retrieval and information production subsystems ($22 million) and modular/programmable radios ($12 million).
- Microelectronics, radio-frequency components and electro-optical devices are the main thrusts in the electronic devices arena. They will be funded at approximately $268 million, $170 million and $188 million per year.
- The environmental effects arena--which covers the impact natural conditions can have on weapons systems and operations--will focus on environmental sensing ($53 million), environmental characterization and prediction ($207 million) and scene-generation and environmental decision aids ($76 million).
- R&D in the materials and processes arena will focus on structural materials processing and inspection ($101 million); high-temperature and anti-armor materials ($71 million); electromagnetic and armor protection materials ($99 million); electronic, magnetic and optical materials ($80 million) and special-function and biomolecular materials and processes ($60 million).
- Energy storage R&D will emphasize developments in energetic materials, power conditioning and energy/power sources. Expenditures will average $19 million, $12 million and $20 million per year.
- In the propulsion arena, the Pentagon plans to focus on IHPTET, a program aimed at doubling aircraft gas-turbine propulsion system capability by the turn of the century ($139 million). It will also emphasize missile, space and aerospace vehicle propulsion ($175 million); surface/undersurface vehicle propulsion ($40 million) and energy conversion/power generation ($474 million).
- Design automation developments will center on design synthesis and analysis ($41 million); product and process definition ($15 million) and information flow and integration ($20 million).
- Human systems interfaces work will emphasize crew stations and operator equipment ($57 million); information management ($24 million); design and life cycle supportability ($65 million) and manpower training ($64 million).

Author: ANDREW WEINSCHENK THIS IS THE FULL TEXT: elimina

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NCE - Government Expenditures 90
NCG - United States 1USA

2/3 - (C) C.cedocar
NO - DMT-0418697
ET - Defense Department Releases Strategy For Science & Tech
DT - JOURNAL ARTICLE
LA - ENG
PO - US
JT - New Technology Week
SO - PP. N/A; DP. 03/08/92
SN - 0894-0789
TC - The Department of Defense has issued its long-awaited science and technology strategy for the coming decade. It is the "first comprehensive science and technology strategy of the post-Cold War era" says Victor Reis, the Pentagon's Director of Defense Research and Engineering. Entitled the DOD Key Technologies Plan, the strategy calls for the all-out development of 11 technologies in seven "thrust areas. "

The plan calls for spending about $10. 5 billion between 1992 and 1994 on the 11 technologies, with a majority of the funds directed at information and communications technologies.

According to its boosters, the new science and technology plan will give the Pentagon a badly needed research and development focus as budgets decline and the military threat becomes more amorphous. In the past, they said, the Pentagon's R&D efforts have been fragmented and too beholden to parochial service interests to meet the needs of the department's long-term objectives.

The strategy is the most comprehensive and specific to date. And unlike previous Pentagon R&D plans, the new one is "focused on those efforts which show the greatest promise for improving future military capabilities rather than simply providing a 'balance' across all possible investment options," says the report. "Focus, not balance is the watchword of the new S&T strategy. "

Three premises underlie the new plan, says Reis: Soldiers must be involved throughout the program's life to ensure that it remains responsive to the ultimate users' needs; the Pentagon must take advantage of the recent explosion of information technologies to revolutionize military operations; and the department must conduct extensive, realistic demonstrations of promising technologies to ensure that they deliver what is promised.

The detailed plan lays out budget projections for each of the technology plans. Details of the seven thrusts follow:

- Global surveillance and communications. This thrust will focus on producing a system that can quickly and accurately detect targets, identify them and assess whether a strike against them was successful. The system will offer global coverage but also be built to focus, if needed, on individual hot spots like the Persian Gulf.

It will supplant current jury rigged systems that rely on ad hoc inter-connections between a welter of competing sensors. And it will supposedly deliver a seamless flow of information to the operators who need it, a major gulf war shortfall.

The Pentagon will demonstrate key technologies through fiscal 2002. After that date, components will be combined to provide "revolutionary functional capabilities," said Reis.

- Precision strike. This thrust will be geared toward locating and destroying key mobile targets--like Scud missile launchers--that are outside the "immediate battle area. " Data gleaned from global surveillance and communications systems, will be passed directly to mission planners who, if need be, "can send that same information directly to the appropriate weapon delivery systems and munitions. "

The thrust will ensure that U. S. forces won't be caught trying to catch up with targets that have moved by the time a weapon can be brought to bear. U. S. efforts to destroy Scud launchers were stymied by cumbersome mission planning and the slow dissemination of targeting information.

The Joint Air/Land/Sea Precision Strike demonstration will begin in fiscal 1993.

It will use simulation technologies developed under a so-called "Warbreaker" program in a Joint Precision Strike Testbed. And it will demo capabilities for delivering conventional weapons against "time-sensitive" targets developed under a program dubbed "Artemis. "

- Air Superiority and Defense. This thrust will focus on countering threats from tactical ballistic missiles, stealthy manned aircraft, cruise missiles and helicopters. According to Reis, the Pentagon's concern is not manned conventional aircraft, an area in which the U. S. has demonstrated its dominance.

The main concern is the "emergence of stealthy manned aircraft and cruise missile threats that would eliminate this advantage. " Also targeted are terrain-hugging choppers and sea-skimming cruise missiles.

- Sea Control and Undersea Superiority. The Pentagon established this thrust to "respond to the military requirements posed by the growing need for naval forces to operate in coastal areas. All Navy platforms, including subs, will be given new capabilities for "shallow water and regional conflict" operations.

The Navy also will develop improved platform protection weapons under this thrust as well as continue work on unmanned vehicles and tactical environmental sensor systems.

- Advanced Land Combat. Under this thrust, the Pentagon hopes to better prepare its land forces for rapid reaction to trouble spots. It will look at ways of minimizing the vulnerabilities of lightly armored vehicles and use advanced materials and electronic countermeasures to reduce the weight and improve the survivability of heavy weapons.

Other initiatives within the thrust will focus on improving identification of friend-or-foe at extended ranges and improve units' situational awareness while on the move.

- Synthetic environments. This thrust will focus on developing ways of cobbling several super-realistic simulators together to produce "environments . . . fundamentally different from the traditional simulations and models known today. " The environments will "allow complete visualization of and total immersion into the environment being simulated. "

The simulators will be used for such standard practices as training and doctrine and requirements development. But they will also be used for design, prototyping and manufacturing processes.

- Technology for affordability. This thrust will develop design tools for transitioning flawlessly from prototypes to production. And it will develop "flexible" manufacturing processes that will allow production lines to quickly switch from building one item to another, eliminating the high cost associated with limited manufacturing runs.

Other initiatives under this thrust will speed the flow of information between customers and manufacturers to reduce overhead burdens that eat up 50 percent of "today's product cost," said the report.

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3/3 - (C) C.cedocar
NO - DMT-0415716
ET - DOD seeks domination in six technologies
DT - JOURNAL ARTICLE
LA - ENG
PO - US
JT - Defense & Aerospace Electronics
SO - PP. N/A; DP. 20/07/92
SN - 1056-747X
TC - There are many technologies the Defense Dept. wants to develop, but six are identified as those it wants to command totally for developing advanced weapons. These six "military critical technologies" represent overall areas in which the United States is the leader although other countries may be skilled in portions of the technologies, the General Accounting Office (GAO) notes in a report on "Defense Technology Base: Risks of Foreign Dependencies for Military Unique Technologies" (B-248741).

"In an interdependent global economy, foreign sources of technology abound in both the commercial and defense sectors," the report says.

"There are sometimes economic, political and military advantages to using foreign sources of supply for technology. The concern over foreign sourcing relates to whether a dependency constitutes a risk, or vulnerability, to the United States," it adds. Such would be the case if the U. S. were dependent on foreign systems and technologies and had no other means of obtaining the most advanced technologies for developing new weapons and systems.

Any trend toward the reliance on foreign suppliers must be monitored "to reduce potential national security risks," the GAO says in its report to Rep. Les Aspin, D-Wis. , chairman of the House Armed Services Committee.

The six technologies identified by the DOD as critical to future weapons development involve:

* Sensitive radar: These are sensors capable of detecting low-observable targets or capable of identifying targets that can't or won't identify themselves. The category includes wideband, synthetic aperture, bistatic, laser and advanced over-the-horizon radars.

* Signature control: SC technology involves the ability to control the target signature for improving the survival of a launch platform or the weapon itself. Technology concerns include reduction of wakes created by vehicles moving through water or air, and by emissions, such as rocket plumes. Affected systems include the B-2 bomber, the F-22 Advanced Tactical Aircraft, AX airplanes, helicopters and submarines.

* Weapon system environment: This involves the understanding of the natural environment, both data and models, and its influence on weapon system design and performance for determining weapon or system limitations. Weapon systems supported by this technology include anti-submarine warfare systems and strike aircraft such as the F-15, F-16 and A-6 with smart weapons.

* Pulsed power: Here scientists are interested in the generation of repetitive, short-duration, high-peak power pulses with relatively lightweight, low-volume devices for weapons and sensors. It includes techniques for conversion, storage, pulse-forming and transmission of energy. Also pulsed power technology is required for directed energy and kinetic energy weapons and ground- and space-based identification and surveillance systems. Directed energy weapons such as lasers, microwaves and particle beams, provide speed-of-light operations with high-firing rates at great distances. Kinetic energy weapons employ hypervelocity projectiles for anti-missile and anti-armor defense.

* Hypervelocity projectiles and propulsion: Emphasis here is on moving projectiles at greater than conventional velocities -- more than 2 kilometers a second. Propulsion systems employing this technology, under development by the Pentagon, include electromagnetic, electrothermal and traveling charge guns with liquid or

solid high-energy propellants, hypervelocity rockets and explosively-driven shock tubes.
* High-energy density materials: Engineers are working with high-energy ingredients for explosives, propellants and pyrotechnics. The basic idea is to destroy a target by direct hit, fragmentation or blast. The technology is applicable to bullets, missiles/rockets or kinetic energy systems.
The six areas are included in the 1991 Critical Technology Plan issued by the DOD, and are expected to be included in a revised scheme slated for release in the next several months. This report also is expected to reflect the new "seven thrusts" philosophy developed by the DOD in conjunction with the armed services (DAE 4/6 and 3/9). THIS IS THE FULL TEXT: Copyright 1992 by Pasha Publications, Inc.oreign

DE - Radar Systems and Equip*; Military Electronics; Product Design and Development*; United States*; Long full text
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PES - 3662540*; 3601011; 1USA*; 33*
NCP - Radar Systems and Equip 3662540; Military Electronics 3601011
NCE - Product Design and Development 33
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ANNEXE 6

EXEMPLE CONCERNANT LA FUSION DE DONNEES

Fusion de données pour le renseignement
Data Fusion for Intelligence

BENOIT FALLER
CAP SESA DEFENSE - PUTEAUX

RESUME - Nous présentons les concepts opérationnels et techniques de la fusion de données dans le domaine du renseignement. Ce contexte nécessite une fusion de haut niveau et traitant d'informations symboliques hétérogènes. Les principales fonctions de la fusion, ainsi que la notion de situation, sont présentées. Une courte bibliographie est enfin fournie.

ABSTRACT - We present operational and technical concept of data fusion for intelligence. This context requires a high level fusion, with heterogeneous symbolic informations. Main functions of fusion and the notion of situation are presented. At the end, we give some commented references.

La fusion de données fait l'objet depuis longtemps de nombreux travaux tant dans les milieux de l'industrie que dans ceux de la défense. Si la fusion numérique, proche des capteurs, a déjà conduit à diverses réalisations opérationnelles, la fusion symbolique n'est pas actuellement traitée de façon automatique. L'objet de cet article est, après une brève introduction, de présenter cette fusion de données pour le renseignement et de donner une synthèse des travaux actuels sur le sujet.

1 - DE LA FUSION NUMERIQUE A LA FUSION SYMBOLIQUE

La fusion de données consiste à unifier un flux d'informations. Les données proviennent de plusieurs capteurs de même type (des radars, par exemple), ou hétérogènes . Le flux d'informations peut être synchrone ou asynchrone. Les informations sont des éléments d'observation, et sont donc par nature partielles et éventuellement bruitées.

La fonction de fusion existe dans toutes les situations multi-capteurs, mais elle est souvent encore réalisée de façon manuelle. La fusion automatique a pour but d'augmenter la couverture spatiale et temporelle, d'améliorer les performances de détection et d'accroître la robustesse du processus de perception.

Le domaine de la fusion de données est très vaste : il va de la corrélation spatiale de capteurs, tels que deux radars, à l'évaluation de situation. Ces deux exemples recouvrent deux mondes différents :

- la **fusion numérique**, plus proche des systèmes d'armes, qui s'intéresse essentiellement à des mesures numériques, avec des primitives de corrélation associées (moyennes, écarts types, probabilités bayésiennes...). Elle est par exemple mise en œuvre pour fusionner les pistes issues de deux radars de surveillance aérienne ;

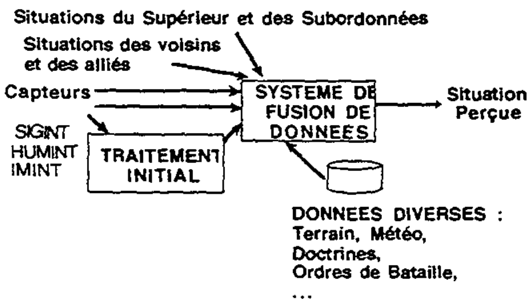
- la **fusion symbolique**, plus proche des SIC (Systèmes d'Information et de Commandement), qui traite d'informations symboliques, provenant de capteurs de plus haut niveau (par exemple, des observateurs humains), ou de capteurs de bas niveau (des sonars, par exemple), mais en ayant suivi un premier traitement qui a transformé certaines des informations numériques (plots et pistes) en informations plus symboliques (type de l'avion, trajectoire...).

Ces deux types de fusion font appel à des techniques de fusion différentes. Néanmoins, cette classification n'est pas rigide : les informations fournies par les capteurs sont souvent à la fois numériques (position x, y, z) et symboliques ("attitude offensive"). Par la suite, nous nous intéresserons surtout aux systèmes de fusion symbolique, à des fins de renseignement.

2 - MESSAGES ET SITUATIONS

Le processus de fusion consiste à prendre en compte un flux d'informations pour établir une situation. Les données en entrée sont généralement des **messages** provenant des capteurs : il s'agit le plus souvent d'observations brutes, mono-source, portant sur une partie très limitée de l'espace et datées. Les sorties d'un système de fusion sont des **situations**, qui servent de référence à un processus d'évaluation et de décision. Ces situations portent généralement sur une grande zone, en privilégiant soit la précision et la fiabilité (pour une situation décrivant les cibles potentielles), soit une description complète et globale de ce qui se trouve en face (pour une situation de référence servant à évaluer le déploiement ennemi et ses intentions).

Dans le cas le plus général, un système de fusion utilise d'autres types d'informations : par exemple, les situations transmises par le supérieur et les subordonnés. En outre, diverses données permanentes ou quasi permanentes sont utilisées, suivant le schéma ci-dessous :



Modèle de la fusion de données

Une démarche complète et progressive

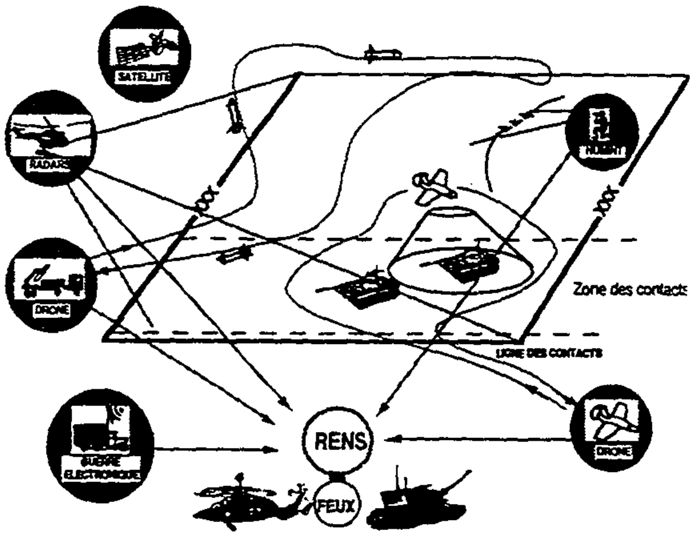
Au delà des techniques employées, il est très important de prendre en compte l'ensemble des données disponibles, qu'il s'agisse d'information déjà traitée, comme des situations, ou de données théoriques, comme des ordres de bataille.

En outre, la fusion doit toujours être replacée dans le contexte plus général du renseignement, avec en particulier le cycle "Diriger. Rechercher. Exploiter". Par exemple, le champ de bataille fait l'objet d'une préparation spécifique, optimisant le déploiement des capteurs et les missions associées. De même, au cours de l'action, il est souvent possible d'orienter la recherche de certains capteurs pour obtenir une confirmation, par exemple.

Enfin, les techniques actuelles de fusion n'ont pas une fiabilité telle qu'il soit possible de se passer de l'homme : il est donc nécessaire de prévoir des possibilités d'interventions humaines au cours du processus, ainsi qu'une validation finale.

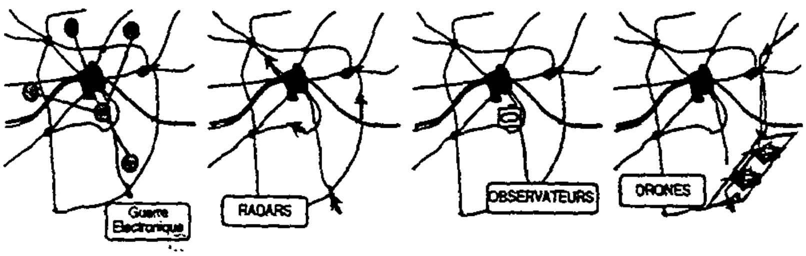
3 - EXEMPLE DE L'ARMEE DE TERRE

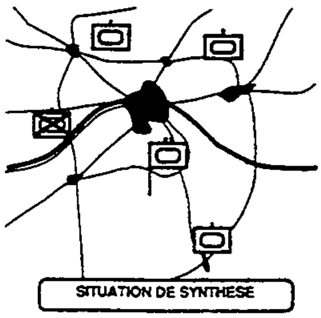
Nous prendrons par la suite l'exemple de l'Armée de Terre. Voici par exemple un schéma synthétique de différents capteurs d'une grande unité.



Le renseignement vu d'une grande unité terrestre

Chaque capteur, pour lesquels nous donnons ci-après un exemple de perception, contribue à l'élaboration de la situation dite de référence.





Des messages aux situations

Les informations fournies par les capteurs sont de différentes natures. Elles portent par exemple sur des caractéristiques directement mesurables telles que la position, mais aussi sur des comportements temporels ("en cours de déploiement"), des activités tactiques ("attitude défensive"), etc. De plus, le contexte de détection de la cible ou de l'événement est essentiel et permet en particulier d'apprécier le message dans son contexte.

Sans aborder tous ces aspects, voici un exemple très simple de quatre messages fournis par des capteurs divers :

M1 : 8 chars en position x1, y1 au temps T1 -

M2 : une dizaine de T80 en position x2, y2 au temps T2 -

M3 : deux compagnies d'un bataillon de chars passant par le carrefour P3 au temps T3 -

M4 : le bataillon de char B32 passe sur route N23 au temps T4 -

Ces messages indiquent une présence datée de chars : outre la corrélation sur la position et sur la date, le processus de fusion nécessite la prise en compte d'informations symboliques sur la notion de compagnie, le nombre de chars théorique ou réel d'une compagnie, etc.

3.1 - Pistage et corrélation spatio-temporelle

Ce premier niveau de fusion consiste à faire des associations dans l'espace ou dans le temps, afin d'associer au mieux les informations sur des événements ou des cibles. Diverses techniques sont utilisées, depuis des calculs de moindre carré ou le filtrage de KALMAN, jusqu'aux estimations bayésiennes [7].

3.2 - Corrélation symbolique

Pour des attributs plus symboliques, des informations plus générales doivent être utilisées : par exemple, une compagnie de chars regroupe en théorie dix chars ; néanmoins il se peut que son effectif ne soit pas complet, compte tenu des pannes, de la sous-dotation, etc. Un raisonnement est donc nécessaire pour corréler des messages comptabilisant des chars et décrivant des compagnies. Cette opération est appelée le **typage**, elle permet par exemple de transformer "7 à 10 chars T72" en "une compagnie de chars T72".

De plus, les informations fournies par les capteurs peuvent être incertaines, par exemple :

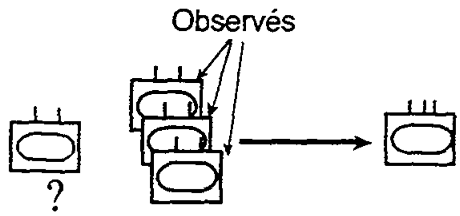
- "localisation et identification probable d'un PC de régiment, sans doute d'infanterie mécanisée" ;

- "perception d'une colonne d'une centaine de véhicules, dont des chars, à vitesse maximale".

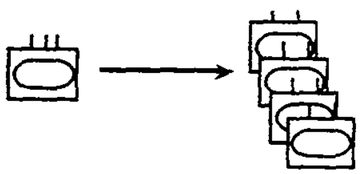
La nature incertaine ou imprécise des informations perçues nécessite des techniques particulières. Diverses méthodes d'inférences classiques (systèmes experts), bayésiennes (probabilités) ou floues (logique floue, théorie des possibilités) sont utilisées. De même, les réseaux de neurones sont souvent proposés pour aider ce processus [7].

3.3 - Agrégation et éclatement

L'agrégation a pour but de regrouper plusieurs unités afin d'en déduire l'unité supérieure dont elles sont les composantes. Diverses règles plus ou moins empiriques sont ici utilisées afin de traiter des éléments incomplètement perçus : il est possible par exemple de décider de la présence d'un régiment dès qu'une certaine proportion de ses composants a été observée (les 2/3 ou les 3/4 par exemple).



Si l'agrégation est une fonction essentielle, il est intéressant de noter la notion duale, celle de **l'éclatement**, qui découpe en composants de plus bas niveau une unité. Cette opération permet d'utiliser la situation fournie par le supérieur, qui ne s'intéresse pas au même niveau de détail.



3.4 - Détermination de situation

A l'issue du processus d'agrégation, la situation de référence est établie comme une vue complète et datée, qui permet l'évaluation de l'ennemi afin d'en déduire ses intentions et les actions à entreprendre.

4 - TRAVAUX EN COURS ET A VENIR

La fusion de données pour le renseignement fait l'objet au sein du ministère de la défense d'un certain nombre de travaux, tant au profit de chaque armée que dans un but interarmée. Si la fusion symbolique repose encore essentiellement sur l'homme, diverses études et prototypages ont montré les bénéfices potentiels de l'approche, et divers développements devraient être lancés.

Il nous semble néanmoins essentiel que ces développements soient réalisés dans un contexte le plus réaliste possible :

- la fusion de données doit être expérimentée sur des messages conformes à la réalité et non appauvris ;

- le terrain doit être pris en compte ;

- l'officier de renseignement doit pouvoir intervenir à tout moment pour obtenir des explications, modifier des données ou des conclusions.

- le caractère incertain de la situation perçue doit être pris en compte ;

- le processus doit être capable d'agir de façon asynchrone, face à un flux continu d'informations.

Il faut enfin noter la signature prochaine d'un accord international regroupant sept pays dont la France avec le double but de réaliser un "démonstrateur" de fusion de données et de favoriser les recherches sur ce sujet. Le démonstrateur devrait permettre d'évaluer qualitativement et quantitativement les techniques de fusion automatique.

5 - QUELQUES REFERENCES BIBLIOGRAPHIQUES

Les travaux du domaine sont le plus souvent classifiés. Nous avons néanmoins regroupé ici quatre références de la littérature ouverte. La première porte sur un modèle original de corrélation. Les deux suivantes montrent des réalisations britanniques, représentatives des choix actuels. La dernière est une référence importante sur la comparaison des techniques de fusion, principalement sur la représentation de l'incertain.

5.1 - Etude SACRE

L'étude SACRE, financée par la SEFT [1], est un modèle de corrélation symbolique pour une grande unité de l'Armée de Terre.

SACRE distingue deux types de données :

- Les **indices**, données de plus bas niveau d'abstraction, sont extraites des messages. Suivant que ces indices permettent d'identifier des unités ou des activités, ils sont dits d'identification ou tactiques ;

- Les **entités** sont les représentants d'une unité (ex. reconnaissance régimentaire), d'une activité (ex. franchissement d'une rivière) ou d'une évolution (du milieu ou d'une activité).

Le but de la corrélation est de passer du niveau le moins abstrait, les indices, au niveau le plus abstrait, les entités. Pour ceci, SACRE, selon un modèle "data-driven", établit des relations de dépendances entre des données de différents niveaux. L'établissement de ces relations se fait en deux étapes, la décision établit les relations, l'exécution entérine la décision. La structure de données ainsi créée, est appelée REX :

- les nœuds sont les informations ;

- les arcs orientés et "valués" sont les relations.

Les relations qui peuvent être établis par la décision sont de deux types, l'association et l'interprétation. **L'association** cherche les points communs entre les informations. Elle établit trois relations, l'équivalence, l'inclusion et le recoupement. Les contraintes liées aux terrains sont introduites à ce niveau. **L'interprétation** s'attache au contenu sémantique des informations. La première relation est l'identification (ex. le volume d'une colonne permet de déduire son niveau d'unité). La seconde est la réduction d'ambiguïtés. Il s'agit d'affiner une information en s'appuyant sur la doctrine et sur l'environnement propre de l'information.

Une fois les décisions prises, il faut fusionner les informations associées ou interprétées, et propager les effets de la fusion aux informations voisines (au sens des relations établies). La propagation modifie des attributs d'une information ou modifie la structure même du REX par simplification ou combinaison.

La simplification du REX consiste pour l'essentiel à supprimer dans la structure les relations d'équivalence, de recoupement et de réduction pour ne laisser présentes que les relations d'inclusion, de non-équivalence, de non-recoupement, et d'identification.

La combinaison a deux buts, le premier est de détecter des conflits, le second est d'affiner la valeur des attributs par le calcul de nouvelles relations (ex. transitivité de l'équivalence).

5.1.1 - La gestion des conflits

Deux types de conflits peuvent exister dans REX, le conflit de fusion et de réseau. Le conflit de fusion apparaît au cours de la fusion de deux informations dont un ou des attributs ont des valeurs contradictoires. Il est impossible d'anticiper des cas d'incohérences apparaissant après propagation. Deux solutions sont possibles :

- une résolution locale mettant en doute la validité d'une des sources ;

- une résolution globale mettant en cause les choix à l'origine de l'incohérence.

Une information non-équivalente à elle-même constitue un exemple de conflit dans le réseau. La détection des hypothèses à l'origine du conflit permet d'envisager des opérations le supprimant a priori.

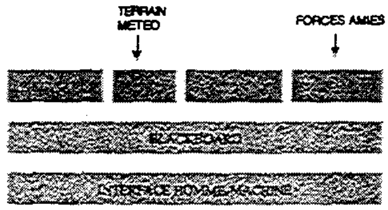
5.1.2 - Conclusion

SACRE ne permet pas d'envisager des solutions concurrentes, mais permet de maintenir la cohérence de la solution unique. Ce modèle partiel, ne couvrant que la corrélation, n'a pas été retenu dans le cadre des études sur le renseignement des grandes unités de l'Armée de Terre.

5.2 - ECRES

L'objectif du système britannique ECRES (Ennemy Contact REport System) est d'analyser les rapports d'activité ennemis pour fournir une interprétation valable du champ de bataille [2].

ECRES utilise une architecture de type "blackboard".



5.2.1 - Les différents sous-systèmes

L'analyse des "Ennemy Contact Reports" trie les messages entrant suivant leur niveau de détail, et attribue une note de crédibilité aux messages. Cette note, combinée avec la qualité de la source, permet l'utilisation de la Théorie de l'Evidence.

La fusion de données utilise trois sous-modules :

- Forces Movement Capability Subsystem (FMCS) ;

- Forces Organisation Subsystem (FOS) ;

- Equipment Identification Subsystem (EIS).

FMCS regroupe toutes les règles régissant le mouvement sur le champ de bataille. Sont nécessaires un modèle du terrain, des informations sur les capacités de mouvement des équipements et sur la doctrine militaire.

FOS regroupe des informations sur la composition et l'organisation des unités ainsi que l'ordre de bataille.

EIS décrit les caractéristiques des équipements utilisés.

En utilisant ces trois sous-modules, le module "data fusion" va proposer des candidats à la fusion.

5.2.2 - La gestion des hypothèses

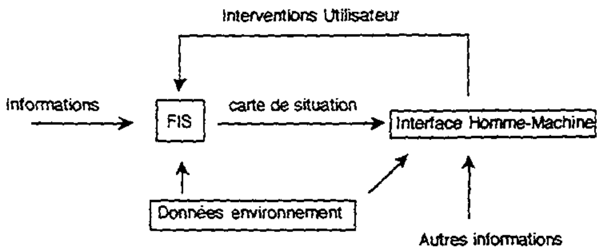
A partir d'un message reçu, plusieurs hypothèses de fusion peuvent être retenues. Ce module traite les hypothèses multiples et cherche, en fonction des nouvelles informations disponibles, à réduire les diverses possibilités. Deux problèmes se posent, la recherche efficace parmi les hypothèses envisageables et la mise en mémoire des différentes hypothèses et des liens entre elles.

Ce module évalue, en fonction des hypothèses retenues et des connaissances a priori (préparatifs nécessaires pour le franchissement d'une rivière), les menaces. Il s'agit donc d'interpréter les mouvements des unités sur le champ de bataille.

5.3 - Le système IDA

IDA (Intelligent Datafusion Aid) est développé par British Aerospace [3].

Le système utilise une architecture du type "distributed blackboard".



Le module "Force Identification System" fournit la carte de situation à l'utilisateur.

Dans une première étape, les nouveaux messages sont corrélés avec les informations présentes.

Ensuite, les contacts sont regroupés en unités (division, régiment, etc.).

Les informations sont alors fusionnées pour identifier les forces en présence et leurs intentions.

A chaque niveau du processus, on trouve un "blackboard". Pour l'identification des forces, un "blackboard" est utilisé pour représenter chacune des forces en cours d'identification.

L'incertitude est prise en compte par l'utilisation du critère de Dempster-Shafer avec combinaison et propagation par les Sommes Orthogonales de Dempster [4-5].

5.4 - Procédures d'aides à la décision multi-informateurs

La référence [6] fournit une présentation succincte et comparative de différentes techniques de fusion, telles que l'Inférence Bayésienne, le Maximum d'Entropie, la théorie de l'Evidence (Dempster-Shafer), la théorie des ensembles flous (Zadeh) ou un classement statistique direct. La méthode fondée sur la Théorie de L'Evidence présente un atout considérable pour la fusion de données multi-sources et pour l'allocation des ressources.

6 - CONCLUSION

Pour les techniciens, la fusion de données est un domaine vaste et passionnant, recouvrant des techniques innovantes très diverses. Elle a souffert d'avoir été d'abord étudiée en acceptant des handicaps insurmontables : pauvreté artificielle de l'information, non prise en compte du caractère cyclique et fortement interactif du renseignement, faible utilisation des apports de la doctrine et de l'étude préparatoire du terrain.

La nouvelle approche a pour principe de suivre d'aussi près que possible le processus de l'expertise opérationnelle. Elle sera d'autant plus efficace qu'elle apportera aux officiers traitant une aide progressive et efficace, devenant rapidement indispensable et ouvrant ainsi la voie à une informatisation plus poussée.

REFERENCES

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[2] - "ECRES" . P. DENHOLM. Advanced Techniques Department, Plessey Defence Systems Ltd. AFCEA Europe Rome Seminar.

[3] - "Data Fusion in the land battle environment". P. H. EDWARDS. Fusion Research Group, Defence Systems Integration, British Aerospace PLC. Military Aircraft Division.

[4] - "Artificial Intelligence : a new dimension in EW". T. H. GREER, Defence Electronics, October 1985.

[5] - "A method for managing evidential reasonning in a hierchical hypothesis space". J. GORDON. E. H. SHORTLIFE. AI 26.

[6] - "Procédures d'aide à la décision multi-informateurs : Application à la classification multi-capteurs de cibles". A. J. APPRIOU. Symposium de l'Avionics Panel (AGARD) "Software Engineering and its applicationto Avionics". Turquie. 25-29 avril 1988.

[7] - Séminaire de J. LLINAS "DATA FUSION". présenté plusieurs fois par année.

69/88 - (C) C.cedocar
NO - C-92-F02833
FT - Fusion de données pour le renseignement.
CT - SCIENCES ET DEFENSE 92 Nouvelles avancées scientifiques et techniques.
LC - Paris (FR)
DC - 1992/05/12-1992/05/13
AU - FALLER B.
AF - CAP SESA DEFENSE Puteaux (FR)
DT - Mémoire congrès
LA - FRE
PO - FR
ED - Dunod Paris.
SO - VOL. 1; 290-299; 7 Réf.; DP. 1992
BN - 2-1000-1420-X
LO - 05; M6039-4/1992
AB - Concepts techniques et opérationnels de la fusion dans le domaine du renseignement. Ce contexte nécessite une fusion de haut niveau et traite d'informations symboliques hétèrogenes. Principales fonctions de la fusion , notion de situation, quelques travaux en cours dans ce domaine.
AN - INFO/VU
CC - 15 04; 09 02
NCC - 25/05/00; 15/04/00
DE - FUSION DONNEE*; RENSEIGNEMENT TACTIQUE*; RENSEIGNEMENT MILITAIRE; RENSEIGNEMENT SUR TERRAIN; COMMANDEMENT CONDUITE TACTIQUE; CENTRE ANALYSE INFORMATION

36/88 - (C) C.cedocar
NO - C-94-006829
FT - Applications de la fusion de données.
CT - Workshop on data fusion applications.
LC - BRUXELLES (BE)
DC - 1992/11/25
CS - ESPRIT/DIMUS
DT - Congrès
LA - ENG
PO - BE
ED - Springer-Verlag (HEIDELBERG).
SO - NO. EUR15247EN; 265p.; nb Réf.; nb Fig.; nb Phot.; DP. 1993/06
BN - 3-540-56973-1
LO - 05; 13528-13/2
AB - Le projet 5345-DIMUS (data integration in multisensor systems) fait partie du sous-programme "information processing systems and software" du programme ESPRIT (European strategic programme for research and development in information technology). Ce fascicule est le 1er volume des rapports de recherche du projet DIMUS ; il est consacré aux applications de la fusion de données. Il contient les exposés présentés au cours du congrès ESPRIT de 1992 ainsi que quelques articles retenus pour leur pertinence. L'ensemble constitue un instantané sur le développement et la validation des techniques de fusion de données dans une grande variété d'applications, allant de la fusion de données visuelles à l'intégration de systèmes multi-capteurs, et couvrant la plupart des problèmes essentiels, c'est à dire : les architectures, les réponses en temps réel et les besoins pour lesquels la sécurité est un facteur critique. Plusieurs applications présentées concernent d'autres projets du programme ESPRIT : 6373-TRACS, 7207-AZZURRO, 3274-FIRST, 6757-EMS.
AN - INFO/CR
CC - 09 04; 12 01
NCC - 12/09/00; 12/01/00
DE - FUSION DONNEE*; TECHNIQUE CORRELATION*; INTELLIGENCE ARTIFICIELLE*; IMAGERIE MEDICALE; SYSTEME EXPERT; SYSTEME CONTROLE TRAFIC; TRAFIC MARITIME; CAPTEUR MULTIPLE; IMAGERIE MULTISPECTRALE; SURVEILLANCE OCEAN; VISION ARTIFICIELLE; LOGIQUE FLOUE; TRAITEMENT IMAGE; ANGIOGRAPHIE; RESONANCE MAGNETIQUE; SYSTEME NEUROVASCULAIRE; ROBOTIQUE; COMMANDE AUTOMATIQUE MACHINE OUTIL; ROBOT MOBILE; RECONNAISSANCE FORME; DETECTION CONTOUR IMAGE; ANALYSE CORRESPONDANCE; SYSTEME CONTROLE ENVIRONNEMENT

39/88 - (C) C.cedocar
NO - C-94-004704
FT - Fusion de données.
ET - Data fusion.
AU - MORLAN B. W.
AF - AFIT, (US)
DT - Ouvrage
LA - ENG
PO - US
ED - AIAA (Washington).
SO - pp.41-51; 1 Réf.; 1 Fig.; 1 Tabl.; DP. 1991
BN - 1-56347-009-8
LO - 05; 392-3/15
AB - Intégré dans le manuel "Critical Technologies for National Defense" préparé par l'AFIT (Air Force Institute of Technology), ce chapitre présente les principes physiques, l'ingénierie, la technologie et l'impact de la fusion de données sur les futurs systèmes d'armes. En se basant sur des exemples concrets, l'auteur montre que le délai accordé à la prise de décision dans les opérations militaires est de plus en plus réduit et que le recours à l'intelligence artificielle (systèmes experts, raisonnement logique, traitement de l'incertitude notamment par les ensembles flous) est nécessaire pour assurer, efficacement et en temps voulu, la fusion de données multi-modales provenant de sources multiples. Les parties consacrées à la technologie de la fusion de données et à son influence sur les systèmes d'armes de l'avenir sont reproduites du "DoD Critical Technologies Plan" du 15 mars 1990 ; elles font apparaître cinq domaines critiques : l'interface homme-machine, les systèmes temps réel répartis, la sécurité à plusieurs niveaux, le développement des algorithmes et celui des systèmes experts.
AN - INFO/CR
CC - 09 04
NCC - 12/09/00
DE - FUSION DONNEE*; AIDE A LA DECISION; SYSTEME EXPERT; IDENTIFICATION AMI ENNEMI; THEORIE DECISION; ANALYSE ASSISTEE PAR ORDINATEUR; C3 COMMANDEMENT CONDUITE COMMUNICATION; PROGRAMME MILITAIRE; US DOD ORGANISME; ARME FUTURE

57/88 - (C) C.cedocar
NO - C-93-005683
FT - Fusion de données multicapteur.
ET - Multisensor data fusion.
AU - WALTZ E.; LLINAS J.
AF - Allied Signal Aerospace Company (US);DOD (US)
DT - Ouvrage
LA - ENG
PO - US
ED - ARTECH HOUSE Boston.
SO - 465 p; nb Réf.; nb Fig.; DP. 1990
BN - 0-89006-277-3
LO - 05; 13897/32
AB - Motivations et applications de la fusion de données, modèle fonctionnel du processus de fusion . Taxonomie des architectures fonctionnelles. Les applications de défense de la fusion de données. Capteurs, sources et liaisons de communications. La gestion des capteurs. Fusion de données pour l'estimation d'état. Fusion de données pour l'identification d'objet. Concepts militaire de situation et d'évaluation de menace. Approches programmées pour l'évaluation de situation tactique et de menace. Fusion de données et architectures. Modèlisation de systèmes et évaluation de performance. L'émergence des techniques d'intelligence artificielle.
AN - INFO/VU
CC - 09 02; 15 04
NCC - 25/05/00; 15/04/00
DE - FUSION DONNEE*; C3 COMMANDEMENT CONDUITE COMMUNICATION*; COMMANDEMENT CONDUITE TACTIQUE*; RENSEIGNEMENT TACTIQUE*; CENTRE INFORMATION COMBAT*; EVALUATION MENACE; ARCHITECTURE ORDINATEUR; FLUX DONNEE; ACCES DONNEE

71/88 - (C) C.cedocar
NO - C-92-F02798
FT - La fusion de données : principes et applications.
AU - ROULSTON J.
AF - GEC Ferranti (GB)
DT - Publication en série
LA - FRE
PO - GB
JT - DEFENSE & TECHNOLOGIE INTERNATIONAL (FR).
SO - NO. 7; pp. 114-119; 1 Phot.; DP. 1991/12
CD - DFTI2C
SN - 1155-3480
LO - 05; P2719
AB - La fusion de données intervient dans la conception de nombreux nouveaux systèmes. Rédigé à l'intention du profane, cet article fait brièvement le point de la question en présentant les bases de la fusion de données (théorie de l'estimation linéaire), en traitant de l'association de données et en décrivant deux catégories d'applications types de la fusion de données, selon que le gain escompté vient du processus de filtrage ou du processus d'association.
AN - INFO/CR
CC - 15 04; 12 01
NCC - 15/04/00; 12/01/00
DE - RENSEIGNEMENT TACTIQUE*; FUSION DONNEE*; FILTRE WIENER; FILTRE KALMAN; CAPTEUR MULTIPLE; ESTIMATION LINEAIRE

SERVEUR CEDOCAR

78/88 - (C) C.cedocar
NO - C-91-011800
FT - Principes et applications de la fusion de données.
CT - Principles and applications of data fusion.
LC - Londres (GB)
DC - 1991/02/04
CS - IEE (GB)
DT - Congres
LA - ENG
PO - GB
JT - IEE Colloquium Digest (GB)
SO - NO 027; 32 p.; 53 Ref.; 18 Fig.; 8 résumés; DP. 1991
CD - DCILDN
LO - 05; ME131-4/1991/027
AB - Trois résumés traitent de technologies (architecture décentralisée, architecture orientée objet, intelligence artificielle répartie) applicables à la fusion de données, les autres présentent des applications de l'intégration de données provenant de plusieurs capteurs (détection de navires par des sous marins ; classification et détection de modifications d'images ; contrôle par système expert de l'anesthésie en cours d'opération ; robotique industrielle).
AN - INFO/CR
CC - 09 02; 09 04
DE - FUSION DONNEE*; INTEGRATION INFORMATION*; CAPTEUR MULTIPLE; DETECTEUR SOUS MARIN; LANGAGE ORIENTE OBJET; INTELLIGENCE ARTIFICIELLE; DETECTION MODIFICATION IMAGE

SERVEUR CEDOCAR

19/21 - (C) C.NTIS
NO - AD-A241 121/3
ET - General Theory for the Fusion of Data.
AU - GOODMAN I. R.
CS - Naval Ocean Systems Center, San Diego, CA.
CI - 055028000; 393159
DT - Report
LA - ENG
PO - US
SO - Availability: Pub. in Tri-Service Data Fusion Symposium Technical Proceedings, v1 p254-270, 9-11 Jun 87. Available only to DTIC users. No copies furnished by NTIS; NP. 20; DP. 11 Jun 91.
IS - U9202
CTN - NTIS Prices: Not available NTIS
AB - No abstract available.Reprint: General Theory for the Fusion of Data.
CC - 62 05; 45 07
DE - Information theory*; Multiple targets; Tracking; Command control communications; Algebra; Reprints
IT - Data fusion*; NTISDODXR

SERVEUR CEDOCAR

21/21 - (C) C.NTIS
NO - AD-A233 397/9/XAD
ET - Data Fusion: A Preliminary Study.
AU - KEENE A. P.; PERRE M.
CS - Physics and Electronics Lab. RVO-TNO, The Hague (Netherlands).
SP - Technisch Documentatie en Informatie Centrum voor de Krijgsmacht, The Hague (Netherlands).
CI - 085305000; 415687
DT - Report
LA - ENG
PO - NL
NU - FEL-90-B356
SO - Final rept; Abstract in English and French; NP. 62; DP. Dec 90.
IS - U9116
CTN - NTIS Prices: PC A04/MF A01
AGN - TDCK-TD-90-4515
AB - Military intelligence processing in an increasingly complex domain, due to the incorporation of data from multiple sensors. The information is distributed in space and time and is subject to uncertainty and incompleteness. The process of combining multi-sensor data into a model of the domain of interest is known as data fusion. This report aims to provide an initial insight into the ground that has to be covered by a system that will support data fusion. We address the tasks associated with intelligence processing. Several views on data fusion are discussed. We then present various methods and techniques from the areas of databases, artificial intelligence and probability theory that may provide solutions for dealing with some of the problems pertaining to multi-sensor data fusion.
CC - 74 06; 62 00
DE - Military intelligence*; Artificial intelligence; Data bases; Data processing; Models; Multisensors; Probability; Processing; Theory; Uncertainty
IT - Foreign technology*; Data fusion*; Multiple sensor data*; NTISDODXA; NTISFNNL

SERVEUR CEDOCAR

64/91 - (C) C.cedocar
NO - F-91-000115
LO - 02; DDSP/1080 0
PD - DIFFUSION LIMITEE
FT - L'horizon 2030.Quelles techniques militaires ?
AU - BASCARY; EYRIES; JOLIVET; BEZILLE; FOURNIER
CS - CHEAr
NU - CHEAR 90/04/TS
SO - 24 p.; DP. 1990/01/29
DP - 1990-01
PO - FR
LA - FRE
AB - Quelle sera la guerre en 2030. Quelles seront les menaces auxquelles la France aura à faire face. Quel sera l'armement à cette époque. Moyens et **techniques** actuels et armes futures
DE - EVALUATION MENACE; TACTIQUE MILITAIRE; ARMEMENT; GUERRE METEOROLOGIQUE; PROSPECTIVE; ARME FUTURE
CC - 15 03
DT - Rapport

1/3 - (C) C.cedocar
NO - AD-A234 900/9/XAD
ET - Department of Defense Critical Technologies Plan for the Committees on Armed Services United States Congress.
CS - Department of Defense, Washington, DC.
CI - 000139000; 109050
DT - Report
LA - ENG
PO - US
SO - NP. 375; DP. 1 May 91.
IS - U9118
CTN - NTIS Prices: PC A16/MF A02
AB - The purpose of the Department of Defense Critical Technologies Plan is to describe 21 technologies considered essential for maintaining the qualitative superiority of U.S weapon systems and to outline an investment strategy to manage and promote the development of these technologies. The Defense Critical Technologies are the leading edge of the DoD Science and Technology program. While all ST efforts are fundamental to achieving continued improvement in military capabilities, the Defense Critical Technologies represent those technologies that are likely to set the pace of innovation in the development of advanced weapon capabilities and the evolutionary modernization of today's systems. This third annual plan is more comprehensive than earlier editions. A new section has been added to document funding levels for individual Defense Critical Technologies for the relevant ST Program Elements; moreover, the individual detailed technology plans provide greater detail on specific milestones and technology objectives, as well as a more comprehensive discussion of related private sector and non-DoD government programs. The plans also include assessments of international technology developments and trends.
CC - 74 00; 79 00; 70 05
DE - Military research*; Weapon systems*; Technology forecasting; Military planning; Semiconductors; Microelectronics; Software engineering; Robotics; Artificial intelligence; Computerized simulation; Radar; Signal processing; Image processing; Air breathing engines; Fluid dynamics; High explosives; Composite materials; Superconductors; Biotechnology; Manufacturing; Industrial research; Department of Defense; Power equipment; Detectors
IT - Technology innovation*; Technology assessment*; Critical technologies plan; Photonics; Data fusion; Computational fluid dynamics; NTISDODXA

SERVEUR CEDOCAR

1/1 - (C) C.cedocar
NO - C-93-008557
FT - Les plans du DOD en matière de technologies critiques et de technologies clés pour la défense.
ET - DOD defense critical technologies plan/DOD defense key technologies plan.
CS - Forecast international/DMS Market intelligence report (US)
DT - Rapport
LA - ENG
PO - US
NU - DMS 1992 APPENDICE IV
SO - 16 p.; DP. 1992/08
LO - 05; 500-17/90APIV
AB - Ce rapport recense 21 technologies critiques (propulsion aérobie, biotechnologie, matériaux composites, dynamique des fluides informatisée, fusion de données, fabrication flexible, matériaux à haute densité d'énergie, informatique à hautes performances, propulsion et projectiles à hypervitesse, robotique et intelligence artificielle, senseurs passifs, photonique, puissance pulsée, circuits microélectroniques et matériaux semiconducteurs, radars sensitifs, traitement d'image et de signal, contrôle de signature, simulation et modélisation, génie logiciel, supraconductivité, environnement de systèmes d'armes) ainsi que 11 technologies clés (ordinateurs, logiciel, capteurs, réseaux de communications, dispositifs électroniques, effets de l'environnement, matériaux et procédés, stockage d'énergie, conversion d'énergie et propulsion, conception automatisée, interfaces homme-machine).
AN - INFO/CR
CC - 15 05
NCC - 15/05/00
DE - PLANIFICATION MILITAIRE*; DEVELOPPEMENT TECHNOLOGIQUE*; ETATS UNIS*; LOI PROGRAMME MILITAIRE; BESOIN MILITAIRE; RECHERCHE TECHNIQUE; MINISTERE DEFENSE

SERVEUR CEDOCAR

114/170 - (C) C.cedocar
NO - C-94-F01931
FT - Une révolution dans les conflits : Une perspective américaine.
AU - KREPINEVITCH A. F.
AF - (US)
DT - Publication en série
LA - FRE
PO - US
JT - DEFENSE NATIONALE - Problèmes politiques, économiques, scientifiques, militaires (FR).
SO - VOL. 50; NO. 1; pp. 57-71; DP. 1994/01
CD - DFNTAM
SN - 0336-1489
LO - 05; P1130
AB - Sommes-nous à la veille d'une révolution militaire résultant des technologies nouvelles ? Pour l'auteur, il y a une révolution militaire quand l'application de technologies nouvelles aux systèmes militaires se combine à des concepts opérationnels novateurs et s'accompagne d'une adaptation des organisations. Après avoir noté dans la guerre du Golfe des éléments précurseurs, il étudie successivement les quatre éléments constitutifs d'une révolution qui s'annonce : L'évolution technologique - découlant en particulier des progrès dans les technologies de l'information. Le développement des systèmes - l'intégration en réseau qui permettra d'obtenir et d'exploiter la supériorité de l'information. Les innovations opérationnelles - où il liste six domaines qui feront vraisemblablement l'objet d'évolutions majeures. Les adaptations d'organisation - qui devraient s'inspirer des progrès faits dans ce domaine par les entreprises industrielles et commerciales pour la souplesse et l'adaptation. Il examine enfin les implications pour les Etats-Unis : les risques dus à la large diffusion des technologies nouvelles et aux difficultés d'adaptation d'une structure militaire lourde et désavantagée par son évolution actuelle.
AN - INFO/BP
CC - 15 07; 15 03
NCC - 15/06/00; 15/01/00
DE - PRONOSTIC EVOLUTION*; STRATEGIE MILITAIRE*; ETATS UNIS; EVALUATION MENACE; INNOVATION TECHNOLOGIQUE; SYSTEME ARME; ETUDE CONCEPTION SYSTEME; CONDUITE OPERATION FORCE ARMEE; ORGANISATION COMMANDEMENT MILITAIRE; ORGANISATION MILITAIRE

10/27 - (C) C.cedocar
NO - C-94-F01670
FT - Dossier : Le **Livre** **Blanc**.
CS - Armées d'aujourd'hui (FR)
DT - Publication en série
LA - FRE
PO - FR
JT - ARMEES d'AUJOURD'HUI (ancien titre Forces Armées Françaises) (FR).
SO - NO. 189; pp. 39-53; 8 Fig.; Nb Phot.; DP. 1994/04
CD - ARAUDE
SN - 0338-3520
LO - 05; P0975
AB - Présentation et synthèse du Livre Blanc sur la Défense, perspective de la politique de défense pour les quinze ou vingt ans à venir. 10 thèmes : 1/ Introduction. 2/ Le contexte stratégique. 3/ Les objectifs. 4/ Le cadre international. 5/ La stratégie ; les 6 hypothèses d'emploi des forces. 6/ Capacités des forces armées. 7/ Les ressources humaines. 8/ Politique d'armement et stratégie industrielle. 9/ L'effort de défense. 10/ Défense et société.
AN - INFO/BP
CC - 05 04; 15 03
NCC - 05/04/00; 15/01/00
DE - POLITIQUE DEFENSE*; FRANCE*; GEOSTRATEGIE; STRATEGIE GLOBALE; POLITIQUE INTERNATIONALE; FORCE ARMEE FRANCE; PERSONNEL MILITAIRE; POLITIQUE ARMEMENT; INDUSTRIE ARMEMENT

90/368 - (C) C.cedocar
NO - C-94-F01377
FT - **Défense** et **technologie**.
CS - ENSEIGNEMENT MILITAIRE SUPERIEUR DE L'ARMEE DE TERRE - ECOLE D'ETAT-MAJOR (FR)
DT - Rapport
LA - FRE
PO - FR
NU - RAPPORT 1993
SO - 119 p.; Nb. Fig.; Nb. Tabl.; Nb. Phot.; DP. 1993/11
LO - 05; M1225/6
AB - Ce rapport regroupe un certain nombre de textes, de conférences, d'allocutions et d'informations portant sur les rapports entre la Défense et la Technologie. Après une introduction posant les principales questions reliant la Technologie à l'environnement de la Défense, le rapport aborde deux parties concernant respectivement l'adaptation nécessaire des besoins aux moyens, notamment financiers, et les problèmes rencontrés de la recherche à l'industrialisation. Un exemple, celui du char "Leclerc", illustre les thèses défendues.
AN - INFO/PI
CC - 15 03
NCC - 15/03/00
DE - DEFENSE*; TECHNOLOGIE*; VEILLE TECHNOLOGIQUE; BUDGET DEFENSE; LECLERC CHAR; INDUSTRIALISATION; PROSPECTIVE

1/2 - (C) C.cedocar
NO - C-94-F01363
FT - **Réflexions** sur la nature des futurs systèmes de défense.
AU - BAER A.
AF - CREST - Ecole Polytechnique (FR)
CS - **CREST** - Ecole Polytechnique (FR)
DT - Ouvrage
LA - FRE
PO - FR
ED - CREST - Ecole Polytechnique, Paris.
SO - 122 p.; 1 Fig.; DP. 1993/12
BN - 2-909188-09-4
LO - 05; M5170-6/12
AB - Comment s'adapter aux changements de notre environnement géopolitique ? Cinq parties : (1) Les facteurs déterminants à prendre en considération, et les modes d'action autonomes ou en coopération qui dessineront le champ de bataille du futur. (2) les caractéristiques et principes généraux des systèmes futurs, primauté du renseignement et besoins croissants de mobilité, flexibilité, adaptabilité pour être capables d'une action qui s'exerce dans la permanence et la continuité. (3) Thèmes de réflexion spécifiques : Le fait nucléaire, la manoeuvre médiatique, les circuits de décision et le besoin de simulation. (4) Pour une architecture cohérente de forces et de moyens. (5) Une perspective américaine sur la révolution à venir dans la nature des conflits.
AN - INFO/BP
CC - 15 07; 15 03
NCC - 15/06/00; 15/01/00
DE - STRATEGIE*; PROSPECTIVE*; FRANCE*; SYSTEME DEFENSE; PLANIFICATION STRATEGIQUE; CONDUITE OPERATION FORCE ARMEE; RENSEIGNEMENT STRATEGIQUE; APRES GUERRE FROIDE

SERVEUR CEDOCAR

1/44 - (C) C.cedocar
NO - F-94-001534
LO - 02; OTAN NIAG-D(92)1 4 VOL
PD - NON CLASSIFIE OTAN
FT - Perspectives technologiques pour la période post-2000
ET - Technology forecast post 2000 (TF-2000).
CS - Otan/Groupe Consultatif Industriel de l'Otan
NU - OTAN NIAGD92(1) 4VOL
SO - 41p.+ 200p.+ 364p.+ 530p.; DP. 1992/02
DP - 1992-02
PO - BE
LA - ENG
AB - Recensement par le sous-groupe 37 du NIAG des concepts de systèmes, des programmes de recherche et de développement et des **technologies**-clés que l'Otan peut envisager d'inclure dans ses plans afin d'assurer la sécurité en Europe en temps de paix, de crise et de guerre pendant les années 1992-2010. Vol I : Note de synthèse : - programmes recommandés en matière de R&D, - facteurs déterminants de l'étude, - contexte géopolitique et environnement de la menace, - concepts de systèmes et **technologies** clés, - utilité sur le plan **militaire**, - grandes tendances, - recommandations pour la suite de l'étude, - organisation de l'étude. Vol II : Rapport principal : - Programmes recommandés en matière de R&D, - facteurs déterminants de l'étude, - considérations d'ordre géopolitique, - résumé de la menace, - évolution **technologique**, - utilité des concepts de systèmes sur la plan **militaire**, - annexes. Vol III : recueil des contributions : - vol IIIA : concepts de systèmes et programmes de R&D, - vol IIIB : thèmes d'étude, documents analytiques et analyses géopolitiques.
DE - PREVISION TECHNOLOGIQUE; PROGRAMME ARMEMENT; INDUSTRIE ARMEMENT; RECHERCHE DEVELOPPEMENT; BESOIN MILITAIRE; EVALUATION MENACE; ETUDE CONCEPTION SYSTEME; PAYS OTAN
CC - 15 03
DT - Rapport

SERVEUR CEDOCAR

4/44 - (C) C.cedocar
NO - F-94-001493
LO - 02; DOSP/5056 0
PD - RESERVE DEFENSE
FT - Grandes lignes de la politique industrielle et technologique de défense de l'administration Clinton.
AU - L EBRELLEC I.
CS - SCAI
NU - SCAI DOSP/5056
SO - 7p; Réf. 1; Fig. 5; DP. 1994/06/30
DP - 1994-06
PO - FR
LA - FRE
AB - Ce document présente les différentes initiatives ainsi que leurs justification à prendre par l'administration Clinton face aux nouvelles formes de menace pour la sécurité des USA et la paix dans le monde.
DE - POLITIQUE DEFENSE; ETATS UNIS; POLITIQUE INDUSTRIELLE; LOCALISATION SOURCE MENACE; BUDGET DEFENSE; PROJET RECHERCHE; SECURITE DEFENSE; DOCUMENT DGA
CC - 15 03
DT - Rapport

SERVEUR CEDOCAR

5/44 - (C) C.cedocar
NO - F-94-001291
LO - 02; DOSP/5057 0
PD - RESERVE DEFENSE
FT - Rapport du groupe N¢10 : l'avenir des armements conventionnels en Europe.
CS - CHEAR
NU - CHEAR DOSP/5057
SO - 113p; Fig. 1; Tabl. 1; DP. 1994/06/02
DP - 1994-06
PO - FR
LA - FRE
AB - Le groupe de travail a tenté d'éclairer un débat difficile de l'avenir des armements conventionnels en Europe. Le groupe s'est interrogé sur la pertinence de l'adéquation d'armements spécifiques au seul théatre européen, même élargi à ses approches orientales et aux rives sud de la Méditerranée. Ce document comporte trois parties : - analyse **prospective** de l'environnement géostratégique, - les types d'actions possibles, - implications sur les structures industrielles.
DE - POLITIQUE ARMEMENT; FORCE CONVENTIONNELLE; PREVISION LONG TERME; THEATRE EUROPEEN OPERATION MILITAIRE; DEFENSE EUROPEENNE; STRUCTURE INDUSTRIELLE; FUTUR; PROSPECTIVE; GEOSTRATEGIE; DOCUMENT DGA
CC - 15 03
DT - Rapport

13/44 - (C) C.cedocar
NO - F-94-000990
LO - 02: OTAN AC/225-D/1244
PD - NON CLASSIFIE OTAN
FT - Evaluation militaire de l'étude du NIAG sur des prévisions technologiques post-2000.
CS - OTAN / Groupe Otan sur l'Armement des Forces Terrestres.
NU - OTAN AC225D1244
SO - 34p.; DP. 1992/08/26
DP - 1992-08
PO - BE
LA - FRE
AB - Evaluation **militaire** par la commission 11 du Groupe Otan sur l'Armement des Forces Terrestres de l'étude effectuée par le NIAG (SG-37) sur " la **défense** aérienne élargie et le combat antichar " (TF-2000).
DE - INDUSTRIE ARMEMENT; PROGRAMME ARMEMENT; PREVISION TECHNOLOGIQUE; OBSERVATION MILITAIRE
CC - 15 03
DT - Rapport

SERVEUR CEDOCAR

12/44 - (C) C.cedocar
NO - F-94-000989
LO - 02; OTAN AC/243-N/352
PD - NON CLASSIFIE OTAN
FT - Perspectives technologiques pour la période postérieure à l'an 2000 (TF-2000).
CS - OTAN/ Groupe sur la Recherche pour la Défense.
NU - OTAN AC243N352
SO - 68p.; DP. 1992/04/16
DP - 1992-04
PO - BE
LA - FRE
AB - Note de synthèse constituant le premier des trois volumes du rapport final préparé par le sous-groupe 37 du NIAG qui a été chargé de recenser les concepts de systèmes, les programmes de recherche et de développement et les **technologies** clés que l'Otan pouvait envisager d'inclure dans ses plans afin d'assurer la sécurité en Europe en temps de paix, de crise et de guerre pendant les années 1992 à 2010.
DE - INDUSTRIE ARMEMENT; RECHERCHE DEVELOPPEMENT; PREVISION TECHNOLOGIQUE; BESOIN MILITAIRE; PAYS OTAN
CC - 15 03
DT - Rapport

SERVEUR CEDOCAR

25/44 - (C) C.cedocar
NO - F-94-000270
LO - 02; OTAN AC/243-TP/4
PD - NON CLASSIFIE OTAN
FT - L'avenir de la recherche pour la défense.
ET - The future of defence research
AU - LESTEL J.
CS - OTAN/Groupe sur la Recherche pour la Défense
NU - OTAN AC243TP4
SO - 79 p; Fig. nbses; DP. 1992/03/03
DP - 1992-03
PO - BE
LA - ENG
AB - (Conférence en l'honneur du 25ème anniversaire de GRD). Deux parties : l'expérience du GRD dans le domaine de la recherche pour la **défense** et perspectives et orientations de cette recherche pour l'avenir.
DE - RECHERCHE DEFENSE; PROSPECTIVE; COOPERATION INTERNATIONALE
CC - 15 03
DT - Rapport

94/368 - (C) C.cedocar
NO - C-94-004999
FT - **Technologies** critiques pour la **défense** nationale des Etats-Unis.
ET - Critical **technologies** for national defence.
CS - AIAA EDUCATION SEMES AIR FORCE INSTITUTE OF TECHNOLOGY (US)
DT - Ouvrage
LA - ENG
PO - US
ED - AIAA.
SO - 325 p.; Nb. Fig.; Nb. Tabl.; DP. 1991
BN - 1-56347-009-8
LO - 05; 392-3/15
AB - Ce document a été rédigé par un groupe d'experts sous la direction de l'Air Force Institute of Technology (AFIT) avec pour objectif de fournir un état de l'art concernant les vingt technologies critiques identifiées à l'horizon 1990 et ayant une importance prépondérante pour les besoins de défense américaine, en réponse à un document élaboré par le DOD (Départment of Defense) américain. Chaque technologie est abordée sous 3 aspects : principe physique ou technique, description et technologie associées, impacts sur les systèmes d'armes futurs. Parmi les sujets abordés figurent : les matériaux composites, la dynamique des fluides, la fusion de données, les senseurs passifs, les semiconducteurs et la micro-électronique, le traitement du signal, la robotique, les architectures parallèles, le contrôle des signatures, la simulation et la modélisation, l'environnement, la biotechnologie, les projectiles hyper-véloces, la supraconductivité.
AN - INFO/IN
CC - 08 06; 15 03
NCC - 08/06/00; 15/03/00
DE - ETATS UNIS*; DEFENSE*; US DOD ORGANISME; UTILISATION TECHNOLOGIE; TECHNOLOGIE
CLI - TECHNOLOGIES DE DEFENSE

SERVEUR CEDOCAR

32/44 - (C) C.cedocar
NO - F-93-001357
LO - 02; DOSP/3869 0
PD - RESERVE DEFENSE
FT - Rapport des travaux de la 28ième session : adaptation des armements face à l'évolution des menaces
CS - CHEAR
NU - CHEAR 91/14/COM
SO - 52 p; DP. 1992/04
DP - 1992-04
PO - FR
LA - FRE
AB - Réflexions sur l'état actuel de la **défense** française (lacunes mises en évidence par la Guerre du Golfe). Tentative de **prospective** géopolitique. Suggestions pour mieux adapter les armements aux risques probables.
DE - POLITIQUE ARMEMENT; EVALUATION MENACE; PROSPECTIVE; GEOPOLITIQUE; DOCUMENT DGA
CC - 15 03
DT - Rapport

21/27 - (C) C.cedocar
NO - F-93-001236
LO - 02; DOSP/3848 1/2 2/2 0
PD - RESERVE DEFENSE
FT - Plan directeur scientifique et technologique de l'US Army
ET - Army science and technology master plan
CS - Department of Defense
NU - USDOD DOSP/3848
SO - nbses p; Fig. nbses; DP. 1992/11
DP - 1992-11
PO - US
LA - ENG
AB - Programme scientifique et **technologique** de l'US Army prévu pour assurer l'adéquation des **techniques** d'armement aux besoins actuels et futurs.
DE - RECHERCHE DEFENSE; US ARMY; PROGRAMME ARMEMENT; DEVELOPPEMENT TECHNOLOGIQUE; MODERNISATION; RECHERCHE SCIENTIFIQUE; AVANCE TECHNOLOGIQUE
CC - 15 03
DT - Rapport

37/44 - (C) C.cedocar
NO - F-93-000901
LO - 02; DOSP/3573 0
PD - DIFFUSION LIMITEE
FT - Fiche : schéma directeur des recherches de base de l'US Army (Army science and technologie Master plan) (ASTMP)
AU - KAPLAN F.
CS - SAA Washington
JT - Bulletin d'information SAA Etats-Unis
SO - No. 3; pp G17 - G22; DP. 1993/03
DP - 1993-03
PO - FR
LA - FRE
AB - Présentation de l'ASTMP 1993. Ce document décrit la stratégie adoptée par l'US Army en matière de recherche de base et les principaux efforts en cours.
DE - ARMEMENT TERRESTRE; RECHERCHE MILITAIRE; BESOIN MILITAIRE; US ARMY; ETATS UNIS; TECHNOLOGIE; DOCUMENT DGA
CC - 15 03
DT - Publication en série

39/44 - (C) C.cedocar
NO - F-93-000757
LO - 02: DOSP/3242 O
PD - DIFFUSION LIMITEE
FT - Stratégie scientifico-technologique de la défense américaine
AU - TANGUY M.; CHEVIGNARD D.
CS - DRET
NU - DRET 18125/CMM
SO - 20 p; DP. 1992/11/12
DP - 1992-11
PO - FR
LA - FRE
AB - Synthèse d'un document publié par le DoD le 16/07/92. Sujets abordés : **technologie** et stratégie **militaires** nationales américaines, la stratégie de **défense** de la guerre froide, la nouvelle stratégie de **défense**, la nouvelle stratégie scientifico-**technologique**, les 7 besoins essentiels et les onze **technologies** susceptibles de les satisfaire.
DE - DOCTRINE MILITAIRE; ETATS UNIS; STRATEGIE MILITAIRE; TECHNOLOGIE; ARMEMENT; PROGRAMME MILITAIRE; PREVISION TECHNOLOGIQUE; BESOIN MILITAIRE; DOCUMENT DGA
CC - 15 03
DT - Rapport

SERVEUR CEDOCAR

42/44 - (C) C.cedocar
NO - F-93-000353
LO - 02; DOSP/3121 0
PD - DIFFUSION LIMITEE
FT - Les technologies stratégiques pour l'US Army du 21ème siècle.
CS - SAA Washington
JT - Bulletin d'informations SAA Etats-Unis
SO - No. 11; pp G8 - G18; Phot. 2; DP. 1992/11
DP - 1992-11
PO - FR
LA - FRE
AB - Rapport de l'Académie Nationale des Sciences (NAS) et du Conseil National de la Recherche (NRC) sur les **technologies** prévisibles les plus importantes pour le combat aéroterrestre à l'horizon 2000, les stratégies de développement qui seraient à même de permettre le meilleur usage de ces **technologies**, et les répercussions qu'auraient ces bouleversements **technologiques** sur l'organisation des forces et la stratégie **militaire**. (Ce rapport diffère de celui publié par l'Army technology base master plan, cf : Bulletin SAA de Juillet 92).
DE - PREVISION TECHNOLOGIQUE; FORCE ARMEE ETATS UNIS; BATAILLE AEROTERRESTRE AN 2000; DOCUMENT DGA
CC - 15 03
DT - Publication en série

59/234 - (C) C.cedocar
NO - C-92-F04631
FT - L'industrie européenne de défense en 1990 et ses retombées sur les technologies de pointe.
AU - VOLSFELTS P.
CS - Université de Lille (FR)
DT - Thèse
LA - FRE
PO - FR
SO - 142 p; nb Réf.; 3 Fig.; 5 Tabl.; DP. 1990
LO - 05; M318-2/7
AB - Mémoire articulé en deux parties de valeur inégale. La première partie est une description assez complète de la structure de l'industrie européenne de défense, soulignant ses aspects globaux dans les principaux états européens et les secteurs clés que sont l'armement terrestre, la construction navale, l'aéronautique, les engins, l'électronique et l'informatique. La seconde partie se veut plus théorique en matière de haute technologie et de compétitivité structurelle ; elle aborde l'aspect dynamique de la haute technologie ainsi que les problèmes généraux de la coopération européenne et des technologies d'application duale (civile et militaire). Le programme EUREKA est évoqué ; l'auteur souligne que l'importance croissante de la "recherche-développement" militaire devrait inciter chaque pays européen à se procurer les meilleurs équipements au moindre coût au lieu de vouloir tout produire. Il reconnaît cependant que la préservation des intérêts nationaux peut poser problème. Une annexe rapporte les réponses de quatre représentants de l'industrie française d'armement (SFIM, AEROSPATIALE, THOMSON et ESD) à quelques questions posées sur l'industrie européenne de défense.
AN - INFO/BR
CC - 05 03
NCC - 05/03/00
DE - INDUSTRIE ARMEMENT*; TECHNOLOGIE EMERGENTE*; RETOMBEE TECHNOLOGIQUE; EUROPE OUEST; FRANCE; ECONOMIE DEFENSE; STATISTIQUE ECONOMIQUE; INNOVATION; TECHNOLOGIE DUALE; COOPERATION EUROPEENNE; RECHERCHE DEVELOPPEMENT; COOPERATION INDUSTRIELLE; ALLEMAGNE; ROYAUME UNI; ITALIE; ESPAGNE; GRANDE BRETAGNE

SERVEUR CEDOCAR

208/368 - (C) C.cedocar
NO - C-92-F02473
FT - Les **technologies** naissantes et la **défense**.
AU - PEREZ UORCA J.
DT - Publication en série
LA - FRE
PO - ES
JT - Documents de l'Assemblée de l'Atlantique Nord (BE).
SO - VOL. 91; pp. 1-141; DP. 1991/10
CD - DAAN2X
LO - 05; M1337-6/1; 84; P1
AB - Bon nombre de réflexions ont été publiées sur la place que les armes faisant appel à des technologies de pointe ont tenue dans le conflit du golfe, et nombreux sont ceux qui ont été surpris par le potentiel qu'offraient les systèmes utilisés. Elaboré par la Commission scientifique et technique de l'Assemblée de l'Atlantique Nord, le présent rapport, annuel, sur les technologies naissantes et la défense propose tout d'abord une description des technologies de la guerre moderne. Toutefois, ce rapport offre davantage qu'une simple description du fonctionnement des systèmes les plus avancés : il indique également quels sont les types de systèmes qui deviennent disponibles et il contient un certain nombre de réflexions sur la façon dont ceux-ci pourraient trouver leur place dans les forces armées futures. Cet ouvrage souligne ainsi que le degré de sophistication des armes -ainsi que leur coût- étant en constante augmentation, et les acquisitions faisant l'objet de réductions, il faudra s'efforcer davantage de maîtriser les dépenses : la nécessité de mettre au point et de fabriquer des armements en coopération s'avère plus impérative que jamais.
AN - YS/AL
CC - 15 03
NCC - 15/03/00
DE - DEFENSE*; TECHNOLOGIE*; ARMEMENT*; GUERRE; FORCE ARMEE; AIDE MILITAIRE
CLI - COPSGD

SERVEUR CEDOCAR

152/368 - (C) C.cedocar
NO - C-92-013209
FT - Le département de la **défense** révèle des détails sur les septs domaines prioritaires de la stratégie science et **technologie**.
ET - DOD releases details on seven S and T thrusts.
CS - Rédaction revue
DT - Publication en série
LA - ENG
PO - US
JT - DEFENSE DAILY (US).
SO - VOL. 176; 4 p.; 7 Tabl.; DP. 1992/07/29; Spécial suppl ment
CD - DEDA23
LO - 05; P2108
AB - Le département américain de la Défense vient de révéler des détails sur la programmation de sa stratégie "Science et Technologie", qui concerne les 7 domaines prioritaires suivants : 1) communications et surveillance globales 2) frappe de précision 3) supériorité et défense aériennes 4) contrôle maritime et supériorité ous-marine 5) combat terrestre avancé 6) démonstrations de synthèse portant sur les 5 domaines précédents 7) divers programmes de haute technologie.
AN - INFO/DH
CC - 05 01; 15 07
NCC - 05/01/00; 15/06/00
DE - ETUDE DEVELOPPEMENT PROGRAMME*; PROGRAMME MILITAIRE*; ETATS UNIS; FORCE ARMEE ETATS UNIS; UTILISATION TECHNOLOGIE; BESOIN MILITAIRE; TECHNOLOGIE MILITAIRE; PROSPECTIVE

21/27 - (C) C.cedocar
NO - C-92-008563
FT - "Choix en vue d'un changement" : l'Armée de Terre.Analyse du **livre** **blanc** en ce qui concerne l'Armée de Terre Britannique pour les années 1990, CM1595.
ET - Options for change : Army-review of the white paper, Britain's Army for the 90's, CM1595.
CS - The House of Commons, Defense Committee
DT - Ouvrage
LA - ENG
PO - GB
ED - HMSO, London (GB).
SO - 142 p.; Nb Tabl.; DP. 1992/02/12
LO - 05; 453-11/2
AB - Troisième Rapport du Comité de Défense, session 1991-1992 de la Chambre des Communes. Onze parties : 1/ Introduction. 2/ Missions de l'Armée de Terre. 3/ Chiffres : effectifs, crédits. 4/ Les armes autres que l'infanterie, les services. 5/ L'infanterie. 6/ Les tches d'intérêt public. 7/ Fusionnements d'unités. 8/ La Brigade des Gurkhas. 9/ Cadre de vie des personnels. 10/ Une Armée de Terre réduite mais meilleure ? 11/ Conclusion.
AN - INFO/DH
CC - 15 03
NCC - 15/01/00
DE - FORCE ARMEE GRANDE BRETAGNE*; ARMEE TERRE*; GRANDE BRETAGNE; STRUCTURE MILITAIRE; ORGANISATION MILITAIRE; RESTRUCTURATION; LIVRE BLANC; PROSPECTIVE

209/368 - (C) C.cedocar
NO - C-92-007324
FT - Etats Unis : les **technologies** critiques dans le domaine de la **défense** en 1991.
ET - US defence critical **technologies** in 1991.
CS - Rédaction revue
DT - Publication en série
LA - ENG
PO - US
JT - DEFENSE and ECONOMY WORLD REPORT and SURVEY (US).
SO - NO. 1225/441; pp. 441-448; 2 Tabl.; DP. 1991/09/18
CD - GDEW2W
SN - 0364-9008
LO - 05; P2110
AB - Le Troisème Plan pour les technologies critiques de Défense (Defense Critical Technologies Plan ou DCTP) prévoit des crédits estimés à 3874 millions de dollars our l'année fiscale 1992, en augmentation de 5,2 pour cent par rapport à l'année fiscale 1991. Liste des 21 technologies concernées. Un tableau donne, en ce qui concerne le développement de chacune de ces 21 technologies, la position occupée par l'URSS, les pays de l'OTAN et le Japon.
AN - INFO/DH
CC - 05 03; 15 03
NCC - 05/03/00
DE - INDUSTRIE ARMEMENT*; SECURITE DEFENSE*; TECHNOLOGIE*; TECHNOLOGIE MILITAIRE; ETATS UNIS; TECHNOLOGIE DUALE; RECHERCHE DEVELOPPEMENT; BUDGET DEFENSE; 1991 ANNEE

21/27 - (C) C.cedocar
NO - C-92-008563
FT - "Choix en vue d'un changement" : l'Armée de Terre.Analyse du **livre** **blanc** en ce qui concerne l'Armée de Terre Britannique pour les années 1990, CM1595.
ET - Options for change : Army-review of the white paper, Britain's Army for the 90's, CM1595.
CS - The House of Commons, Defense Committee
DT - Ouvrage
LA - ENG
PO - GB
ED - HMSO, London (GB).
SO - 142 p.; Nb Tabl.; DP. 1992/02/12
LO - 05; 453-11/2
AB - Troisième Rapport du Comité de Défense, session 1991-1992 de la Chambre des Communes. Onze parties : 1/ Introduction. 2/ Missions de l'Armée de Terre. 3/ Chiffres : effectifs, crédits. 4/ Les armes autres que l'infanterie, les services. 5/ L'infanterie. 6/ Les tches d'intérêt public. 7/ Fusionnements d'unités. 8/ La Brigade des Gurkhas. 9/ Cadre de vie des personnels. 10/ Une Armée de Terre réduite mais meilleure ? 11/ Conclusion.
AN - INFO/DH
CC - 15 03
NCC - 15/01/00
DE - FORCE ARMEE GRANDE BRETAGNE*; ARMEE TERRE*; GRANDE BRETAGNE; STRUCTURE MILITAIRE; ORGANISATION MILITAIRE; RESTRUCTURATION; LIVRE BLANC; PROSPECTIVE

196/234 - (C) C.cedocar
NO - C-89-F02862
FT - Rapport d'information fait au nom de la commission des affaires étrangères, de la défense et des forces armées, sur les diverses conséquences des nouvelles technologies dans le domaine des armements conventionnels.
AU - GENTON J.
AF - Senat (fr)
DT - Publication en série
LA - FRE
PO - FR
JT - Journal Officiel de la République Française, Documents du SENAT (FR)
SO - NO 267; 152 p.; 1 Tabl.; DP. 1989/04/26
CD - JORF3L
LO - 05; P2530
AB - Sept chapitres principaux : 1) Les **technologies** **émergentes** : description sommaire et principales applications militaires. 2) L'évolution de la doctrine militaire soviétique. 3) Tentative d'esquisse des conséquences de l'introduction des systèmes d'armes nouveaux sur la question d'un éventuel conflit aéroterrestre. 4) La guerre électronique. 5) Les confontrations aériennes et les nouvelles technologies. 6) Les engagements navals et les nouvelles technologies. 7) Les limites des nouvelles technologies.
AN - INFO/DH
CC - 14 07; 15 05
DE - Utilisation technologie*; Besoin militaire*; Evaluation menace; URSS; Arme future; Guerre électronique; Force armée France; Technologie émergente*; Doctrine militaire; Engagement combat; Guerre conventionnelle

SERVEUR CEDOCAR

199/234 - (C) C.cedocar
NO - C-89-006100
FT - Les technologies émergentes et la défense conventionnelle de l'OTAN.
ET - Emerging technologies and the conventional defense of nato.
AU - TUCKER J. B.
DT - Ouvrage
LA - ENG
PO - ZZ
ED - American Association for the Advancement of Science (AAAS. (US)
SO - 74 p.; 46 Ref.; 3 Fig.; 1 Tabl.; DP. 1987/11
BN - 0-871-68328-8
LO - 05; 13771
AB - Six chapitres principaux : 1/ La guerre sur le front central 2/ Les armes antichars à tir direct 3/ Les armes antichars à tir indirect 4/ Les armes à **technologies** **émergentes** (Emerging Technologies Weapons ou Et Weapons) 5/ Les armes antiaériennes offensives 6/ Conséquences stratégiques des armes à **technologies** **émergentes**.
AN - INFO/DH
CC - 15 03
DE - Sécurité défense*; Arme antichar; Défense antiaérienne; Arme future; Arme laser; Technologie émergente*; Guerre conventionnelle*; Système défense OTAN*; Bataille aéroterrestre an 2000; Fofa concept; Sous munition

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- Monographies sur un pays ;
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- Systèmes d'arme.

En général, ces dossiers ne sont pas des études directement exploitables, mais des références aussi complètes que possible permettant de situer un système d'arme futur dans son contexte concurrentiel, de préparer une mission ou une négociation, de faire le point des informations non confidentielles disponibles. Les documents cités dans les dossiers sont sélectionnés parmi des millions de titres.

Destinés à éveiller l'attention du lecteur sur tel ou tel fait particulier ces dossiers peuvent être le point de départ d'une étude plus approfondie.

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