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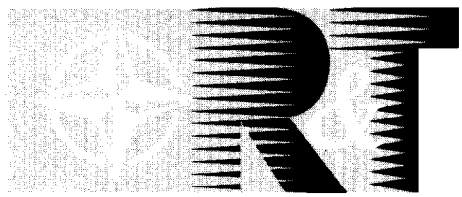

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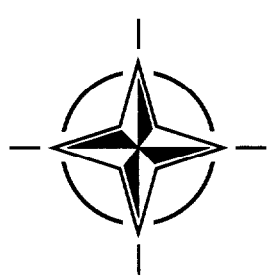
(la Fusion de données de senseur et l'intégration du facteur humain)

Papers presented at the System Concepts and Integration (SCI) Symposium held in Ottawa, Canada, 14-17 September 1998.



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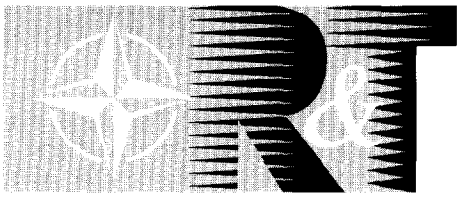

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RTO reports both to the Military Committee of NATO and to the Conference of National Armament Directors. It comprises a Research and Technology Board (RTB) as the highest level of national representation and the Research and Technology Agency (RTA), a dedicated staff with its headquarters in Neuilly, near Paris, France. In order to facilitate contacts with the military users and other NATO activities, a small part of the RTA staff is located in NATO Headquarters in Brussels. The Brussels staff also coordinates RTO's cooperation with nations in Middle and Eastern Europe, to which RTO attaches particular importance especially as working together in the field of research is one of the more promising areas of initial cooperation.

The total spectrum of R&T activities is covered by 6 Panels, dealing with:

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

These Panels are made up of national representatives as well as generally recognised 'world class' scientists. The Panels also provide a communication link to military users and other NATO bodies. RTO's scientific and technological work is carried out by Technical Teams, created for specific activities and with a specific duration. Such Technical Teams can organise workshops, symposia, field trials, lecture series and training courses. An important function of these Technical Teams is to ensure the continuity of the expert networks.

RTO builds upon earlier cooperation in defence research and technology as set-up under the Advisory Group for Aerospace Research and Development (AGARD) and the Defence Research Group (DRG). AGARD and the DRG share common roots in that they were both established at the initiative of Dr Theodore von Kármán, a leading aerospace scientist, who early on recognised the importance of scientific support for the Allied Armed Forces. RTO is capitalising on these common roots in order to provide the Alliance and the NATO nations with a strong scientific and technological basis that will guarantee a solid base for the future.

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Sensor Data Fusion and Integration of the Human Element

(RTO MP-12)

Executive Summary

Operators of future military systems in a digitised battlespace will be faced with increasing volumes of data. These data will derive from multiple sources including on-board sensors, other platforms and systems. Sensor Data Fusion (SDF) aims to integrate these data in order to present the simplest and most accurate picture to the operator. Perceived benefits include reduced operator workload, improved mission management and improved decision-making.

The prime purpose of this symposium was to provide an opportunity for the NATO community to explore and discuss the technological and operational issues raised by the need to ensure effective integration of SDF systems and the military operators.

The symposium was structured into sessions as follows:

- Characteristics of Operational Requirements
- System Design Techniques and Technologies
- Integration of Human Operators with Complex Systems
- System Applications
- Lessons learned and Future Trends

The papers presented addressed a broad spectrum of issues for a variety of different platforms and mission types. The main areas covered were:

- Development and implementation of data fusion algorithms
- Design of SDF Human Machine Interfaces
- Methods for evaluating the effectiveness of integrated SDF/crew systems
- Results of trials assessing the performance of integrated SDF/crew systems

The issue of mission responsibility was discussed: was the human or the machine to be held responsible for "decisions" made by an SDF system? What checks should systems incorporate to ensure that the operator could verify or override a fusion decision? In today's increasingly politically sensitive climate, this issue could be critical to the implementation of SDF systems.

There seemed little doubt amongst the attendees that SDF systems could significantly enhance mission effectiveness. However, it was also agreed that integration of the human element was vital. The involvement of crew in the design and prototyping process was felt to be key. The importance of adequate training was stressed. Training must ensure that crew not only understand the capabilities of the system but also trust the information generated.

Dr George E A Reid
Chairman, Technical Planning Committee

La fusion de données de senseur et l'intégration du facteur humain

(RTO MP-12)

Synthèse

Les opérateurs des futurs systèmes militaires sur un champ de bataille en environnement numérisé devront faire face à des volumes grandissants de données. Ces données proviendront de sources multiples telles que capteurs embarqués et autres plates-formes et systèmes. Le fusionnement des données capteurs (SDF) permet d'intégrer ces données afin de présenter la situation à l'opérateur de la façon la plus simple et la plus précise possible. Les avantages escomptés comprennent la diminution de la charge de travail de l'opérateur, ainsi que l'amélioration de la gestion de la mission et de la prise de décisions.

Ce symposium a eu pour objectif principal de permettre aux représentants des pays membres de l'OTAN d'examiner et de discuter des questions technologiques et opérationnelles soulevées par l'intégration effective des systèmes SDF dans l'environnement de travail des opérateurs militaires.

Le symposium a été organisé sous forme de sessions :

- Caractéristiques des besoins opérationnels
- Techniques et technologies de conception systèmes
- Intégration des opérateurs humains dans les systèmes complexes
- Applications systèmes
- Enseignements tirés et tendances

Les communications présentées ont abordé un large éventail de sujets concernant divers types de plates-formes et de missions. Les principaux domaines couverts furent :

- Le développement et la mise en oeuvre d'algorithmes de fusionnement de données
- La conception des interfaces homme-machine SDF
- Les méthodes d'évaluation de l'efficacité de l'intégration des systèmes SDF
- Les résultats des essais de performance des systèmes SDF

La question de la responsabilité de la mission a été discutée : Les « décisions » prises par un système SDF, sont-elles imputables à l'être humain ou à la machine ? Quels sont les tests intégrés à inclure pour permettre à l'opérateur de vérifier une décision de fusion, afin d'en tenir compte ou non. Etant donné la sensibilité du climat politique actuel, cette question pourrait être déterminante pour l'adoption des systèmes SDF.

La majorité des participants semblait convaincus que l'intégration des systèmes SDF pourrait améliorer de façon considérable l'efficacité des missions, en étant cependant d'accord sur le fait que l'intégration de l'élément humain était indispensable et que l'implication des membres d'équipage au stade de conception demeurerait un élément clé. Les participants ont souligné l'importance d'une formation appropriée qui devrait permettre aux équipages non seulement d'apprécier les capacités du système, mais aussi d'avoir confiance dans les informations qu'il génère.

Dr George E A Reid
Président du comité de planification technique

Contents

Theme

The theme is the effective collaboration between crew and the complex, but not entirely autonomous, systems in the context of multiple information sources such as off-board communications, other platforms and multiple sensors on board platforms. The primary components of this theme that merit particular attention are:

(a) Characteristics of operational requirements demanding difficult human-system interactions;

(b) System design and technology for the fusion of mission-related data, information and knowledge in the context of complex missions involving co-operation against multiple targets;

(c) Effective deployment of crew in supervising and interacting with such systems, taking into account cognitive issues including software psychology (addressing human-software interaction).

TOPICS

a) Characteristics of operational requirements requiring difficult human-system interaction, e.g. group operations; C^3I issues; interoperability; uncertainty; survival in battle damage; IFF: consideration of air, sea and land systems.

b) Reliance on human operators to perform the fusion task often creates a prohibitively high workload and can result in an unacceptable reduction in the timeliness of information. This applies particularly to the operation of modern aircraft where one person may be required to assimilate all the sensor information as well as flying the aircraft and managing other systems. Automating the functions of fusion and sensor management offers a potential solution to these workload and timeliness difficulties.

c) New concepts and improving techniques in the integration of crew with complex systems, including: solution of cognitive issues; model-based reasoning for human advisory systems; the psychology of human interaction with complex software systems; virtual reality; de-cluttering in information presentation; the multi-media cockpit including head-mounted, head-up and head-down displays, voice input and output; autonomous machine Vs human-assisted machine; interactions and transitions between system autonomy and human interaction; situation awareness; representation of the human operator for modelling.

Thème

Cette réunion a pour thème la collaboration effective entre des équipages et des systèmes complexes mais non totalement autonomes, dans un contexte de sources multiples d'informations telles que communications terrestres, autres plates-formes et senseurs multiples sur plates-formes. Trois éléments principaux de ce thème méritent une attention particulière à savoir :

(a) les caractéristiques des situations opérationnelles impliquant des interactions homme-système difficiles

(b) la conception systèmes et les technologies permettant le fusionnement des données de mission, des informations et des connaissances dans le contexte de missions complexes requérant des actions coopératives contre des objectifs, multiples

(c) le déploiement efficace des équipages en ce qui concerne la surveillance et l'interaction avec de tels systèmes, compte tenu des questions cognitives y compris la psychologie de l'interaction homme-logiciel.

SUJETS

a) caractéristiques des situations opérationnelles exigeant des inter actions homme-système difficiles par exemple des opérations de groupe; questions C3I; interopérabilité; incertitude; survie après avaries au combat IFF; la prise en compte de systèmes terre, air et mer.

b) le recours à des opérateurs humains pour l'exécution de la tâche de fusionnement crée souvent une charge de travail excessivement lourde et risque d'entraîner une dégradation inacceptable dans l'actualisation des informations. Ceci vaut à plus forte raison pour le pilotage de l'avion de combat moderne où, dans certains cas, un seul homme doit assimiler l'ensemble des informations fourmes par les senseurs, piloter l'avion et gérer d'autres systèmes en même temps. L'automatisation des fonctions de fusionnement et de gestion des senseurs offre une solution possible à ces problèmes de charge de travail et d'actualisation.

c) l'application de concepts nouveaux et l'amélioration des techniques d'intégration des équipages aux systèmes complexes, y compris la résolution de problèmes cognitifs; le raisonnement à partir de modèles pour des systèmes-conseil; la psychologie de l'interaction homme/logiciels complexes; la réalité virtuelle; l'élimination sélective dans la présentation des informations; le poste de pilotage multimédia y compris les viseurs de casque et les représentations tête haute et tête basse, les entrées et les sorties vocales; la machine autonome contre la machine assistée par l'homme; les interactions et transitions entre le système autonome et l'interaction humaine; l'appréciation de la situation; la représentation de l'opérateur humain pour la modélisation.

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Data displays
Command and control
Target recognition
Cognition

14. Abstract

This volume contains the Technical Evaluation Report, the Opening Address, the Keynote Address and the 20 unclassified papers, presented at the Systems Concepts and Integration (SCI) Panel Symposium held in Ottawa, Canada from 14th to 17th September 1998.

The papers presented covered the following headings:

- Characteristics of Operational Requirements
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