

NORTH ATLANTIC TREATY ORGANIZATION



RESEARCH AND TECHNOLOGY ORGANIZATION

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

RTO TECHNICAL REPORT 31

NATO East-West Workshop on Magnetic Materials for Power Applications

(Atelier OTAN Est-Ouest sur les matériaux magnétiques pour applications propulsives)

Papers presented at the Workshop with Partnership for Peace Countries, sponsored by the RTO Applied Vehicle Technology Panel (AVT), organised by the US Air Force Office of Scientific Research, Arlington, VA, USA and held in Marathon, Greece, 25-30 June 2000.



Published August 2001

Distribution and Availability on Back Cover

This page has been deliberately left blank



Page intentionnellement blanche

NORTH ATLANTIC TREATY ORGANIZATION



RESEARCH AND TECHNOLOGY ORGANIZATION

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

RTO TECHNICAL REPORT 31

NATO East-West Workshop on Magnetic Materials for Power Applications

(Atelier OTAN Est-Ouest sur les matériaux magnétiques pour applications propulsives)

Papers presented at the Workshop with Partnership for Peace Countries, sponsored by the RTO Applied Vehicle Technology Panel (AVT), organised by the US Air Force Office of Scientific Research, Arlington, VA, USA and held in Marathon, Greece, 25-30 June 2000.



The Research and Technology Organization (RTO) of NATO

RTO is the single focus in NATO for Defence Research and Technology activities. Its mission is to conduct and promote cooperative research and information exchange. The objective is to support the development and effective use of national defence research and technology and to meet the military needs of the Alliance, to maintain a technological lead, and to provide advice to NATO and national decision makers. The RTO performs its mission with the support of an extensive network of national experts. It also ensures effective coordination with other NATO bodies involved in R&T activities.

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 the following 7 bodies:

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

These bodies are made up of national representatives as well as generally recognised 'world class' scientists. They 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.

The content of this publication has been reproduced directly from material supplied by RTO or the authors.

Published August 2001

Copyright © RTO/NATO 2001
All Rights Reserved

ISBN 92-837-1060-6



*Printed by St. Joseph Ottawa/Hull
(A St. Joseph Corporation Company)
45 Sacré-Cœur Blvd., Hull (Québec), Canada J8X 1C6*

NATO East-West Workshop on Magnetic Materials for Power Applications

(RTO TR-031 / AVT-060)

Executive Summary

The Partners for Peace (PfP) NATO Workshop on Advanced Magnetic Materials for More Electric Vehicles and Electric Pulse Power Weapons (AVT-060) was organized with the aim of assessing the need for improved magnetic materials primarily in future generations of more electric vehicles and (to a lesser extent) in electric pulse power weapons. Knowledgeable scientists from 8 NATO countries were represented (Canada, France, Germany, Greece, Hungary, Poland, UK and USA), as were 3 non-NATO Eastern European countries (Bulgaria, Romania and Russia), plus Austria and Cyprus. The participants discussed recent advancements in relevant magnetic materials and how further improvements can be made to achieve the goals stated for military applications.

The first full day of this Workshop was devoted to an exposition of the needs of the user communities, with the focus on applications for military vehicles, primarily tanks and aircraft. Researchers presented electric vehicle and weapon concepts and configurations along with potentially enhanced features such as electric drives, power supplies for external consumers, electric braking and auxiliary subsystems. These advanced concepts are based on utilizing electric power to drive subsystems that are currently driven by a complex combination of hydraulic, pneumatic, electric and mechanical power transfer systems. The lack of hydraulics, homogeneous power supplies, automation and remote control options, and high reliability are system level benefits that arise from electric air and ground vehicle configurations. The first day of the workshop ended with a group discussion on the needs of military vehicle and electric weapon system applications. Table I (page 3) is a compilation of that open discussion.

The succeeding three and a half days were devoted primarily to reports on a number of recent materials development programs that have resulted in some significant advances in both hard (permanent) and soft magnetic materials that function reasonably well at somewhat elevated temperatures. Nevertheless, there is a continuing need to improve upon the recent successes to produce even higher temperature materials with higher energy products or higher saturation magnetization, and high mechanical strength. Additionally, some Workshop participants stressed the need for more advanced measurement techniques as a key to understanding what really needs to be done. It was generally concluded that while there has been substantial progress made in magnetics over the last four years, as reflected in the remainder of this report, there is still a need for higher temperature materials capable of higher energy products or saturation levels. Corrosion resistance and the need for higher strength were also emphasized along with the need for improved fabrication and processing techniques.

Atelier OTAN Est-Ouest sur les matériaux magnétiques pour applications propulsives

(RTO TR-031 / AVT-060)

Synthèse

L'atelier AVT 060 de l'OTAN ouvert aux partenaires pour la paix (PpP) sur « Les matériaux magnétiques avancés pour le développement de véhicules militaires exploitant davantage l'énergie électrique des génératrices à impulsions électriques », a été organisé dans le but d'évaluer les besoins en matériaux magnétiques améliorés, principalement pour de futures générations de véhicules à plus fort composant électrique et (dans une moindre mesure) pour génératrices à impulsions électriques. Étaient présents : des scientifiques éminents de 8 pays de l'OTAN (le Canada, la France, l'Allemagne, la Grèce, la Hongrie, la Pologne, le Royaume-Uni et les États-Unis), ainsi que des représentants de 3 pays non-NATO de l'Europe de l'Est (la Bulgarie, la Roumanie et la Russie) et de l'Autriche et de Chypre. Les participants ont discuté des derniers progrès réalisés dans le domaine des matériaux magnétiques et de l'approche à adopter pour atteindre les objectifs annoncés pour les applications militaires.

La première journée de l'atelier a été consacrée à un exposé des besoins des différents utilisateurs, l'accent étant mis sur les applications pour les véhicules militaires, et principalement les chars et les avions. Les chercheurs ont présenté des concepts et configurations de véhicules électriques et de systèmes d'armes incorporant des éléments améliorés tels que les commandes électriques, les alimentations électriques pour consommateurs externes, les systèmes de freinage électriques et leurs sous-systèmes auxiliaires. Ces concepts avancés sont basés sur l'utilisation de l'électricité pour alimenter des sous-systèmes actuellement mus par une combinaison complexe de systèmes de transfert d'énergie hydrauliques, pneumatiques, électriques et mécaniques. L'absence d'hydraulique, d'alimentations homogènes, d'automatisation et de télécommandes et une grande fiabilité sont autant d'avantages offerts au niveau systèmes par des configurations électriques de véhicules aériens et terrestres. La première journée de l'atelier s'est terminée par une discussion de groupe sur les besoins en matière d'applications pour les véhicules militaires et les systèmes d'armes.

Les trois jours et demi qui ont suivi ont été principalement consacrés à l'examen d'un certain nombre de rapports sur des programmes récents de développement de matériaux qui ont permis de réaliser des progrès importants dans le domaine des matériaux magnétiques rigides (permanents) et souples se comportant de façon satisfaisante à des températures relativement élevées. Cependant, il faudra encore améliorer les réalisations récentes pour obtenir des matériaux résistant à des températures plus élevées avec des produits à plus haute énergie, une magnétisation à plus grande saturation et une résistance mécanique plus élevée. Aussi, certains participants ont souligné le besoin de disposer de techniques de mesure plus avancées afin de mieux cerner le problème. Les participants étaient unanimes à reconnaître que malgré les progrès considérables réalisés dans le domaine du magnétisme au cours des quatre dernières années, comme en témoigne ce rapport, le besoin existe toujours de disposer de matériaux résistant à des températures plus élevées et capables de fournir des produits à plus haute énergie ou des niveaux de saturation plus élevés. Une plus grande résistance à la corrosion, une plus grande résistance mécanique, ainsi que des techniques améliorées de fabrication et de traitement ont également été soulignées comme nécessaires.

Contents

	Page
Executive Summary	iii
Synthèse	iv
Foreword	vi
Publications of the RTO Applied Vehicle Technology Panel	vii
Members of the AVT-060 Workshop	viii
1. Introduction	1
2. Technical Presentations	1
2.1 Applications	1
2.2 Fundamental and Technical Magnetism	3
2.3 Characterization	3
2.4 Materials	4
2.5 Novel Processing	5
3. Magnetic Material Needs	5
4. Potential Collaborations	7
4.1 Mikhov-Niarchos	7
4.2 McHenry-Varga	8
4.3 Chelluri-Varga	8
4.4 Hadjipanayis-Ermolenko	8
4.5 Chiriac-McHenry	8
4.6 Menushenkov-Fingers	9
Appendix A – Presentation Abstracts	A
Appendix B – Participant Listing	B

Foreword

The Partners for Peace (PfP) NATO Workshop on Advanced Magnetic Materials for More Electric Vehicles and Electric Pulse Power Weapons (AVT-060) was held at Marathon, Greece, 25-30 June 2000. It was organized with the aim of assessing the need for improved magnetic materials primarily in future generations of more electric vehicles and (to a lesser extent) in electric pulse power weapons. Moreover, after assessing that need, the Workshop was designed to both review the status of recent advances in relevant magnetic materials and to discuss how further improvements can be made, e.g., via compositional and/or processing changes, to achieve the desired magnetic and mechanical properties required at elevated temperatures. Finally, by bringing together knowledgeable scientists from numerous NATO countries and Eastern Europe, it was hoped that collaborations would be formed that could hasten the development of the new magnetic materials that are required to optimize future military and commercial systems. The stated goals for temperatures at which these materials would operate successfully are 600°C for soft materials and 450°C for hard materials.

The first full day of this Workshop was devoted to an exposition of the needs of the user communities, with the focus on applications for military vehicles, primarily tanks and aircraft. The succeeding three and a half days were devoted primarily to reports on a number of recent materials development programs that have resulted in some significant advances in both hard (permanent) and soft magnetic materials that function reasonably well at somewhat elevated temperatures. Nevertheless, there is a continuing need to improve upon the recent successes to produce even higher temperature materials with higher energy products or higher saturation magnetization, and high mechanical strength. Additionally, some Workshop participants stressed the need for more advanced measurement techniques as a key to understanding what really needs to be done, and it was stated that the interaction of microstructure and domain structure would go a long way to determining the ultimate limits that can be attained.

Among the 27 participants in the Workshop, 8 NATO countries were represented (Canada, France, Germany, Greece, Hungary, Poland, UK and USA), as were 3 non-NATO Eastern European countries (Bulgaria, Romania and Russia), plus Austria and Cyprus. The discussions could be considered primarily in the realm of basic research in the physics, chemistry and materials engineering of magnetic materials. Participants were mostly from academia and national or defense laboratories, although 2 were from industrial organizations. Over the 5-day period there was ample opportunity for both formal and informal discussion, and it is anticipated that a few strong bi-national research collaborations will result.

The program was formulated through a joint effort of Professor George Hadjipanayis of the University of Delaware and myself, with most of the effort falling on his shoulders. Dr. Dimitris Niarchos of "Demokritos," the Greek National Center for Scientific Research, ably handled local arrangements. Funds for the 5 Eastern European scientists were made available through the NATO PfP Workshop program under the direction of Mr. Dimitris Stamatopoulos. The bulk of the funding for this Workshop results from grant support from 3 US Department of Defense organizations located in London: the European Research Office of the Army, the Office of Naval Research European Office, and the European Office of Aerospace Research and Development. Additional funding was provided by the Greek Ministry of Defense. We are indebted to all these individuals and organizations for making this Workshop possible. Finally, it is a pleasure to acknowledge the tremendous effort made by Dr. Richard (Rick) Fingers in distilling the information presented at the Workshop and preparing the report you are about to read.

Dr. Harold Weinstock
US Air Force Office of Scientific Research
Physics and Electronics
801 N. Randolph St., Room 732
Arlington, VA 22203-1977
Tel: 1-703-696-8572
Fax: 1-703-696-8481
harold.weinstock@afosr.af.mil

Publications of the RTO Applied Vehicle Technology Panel

MEETING PROCEEDINGS (MP)

Design for Low Cost Operation and Support

MP-37, September 2000

Gas Turbine Operation and Technology for Land, Sea and Air Propulsion and Power Systems (Unclassified)

MP-34, September 2000

Aerodynamic Design and Optimization of Flight Vehicles in a Concurrent Multi-Disciplinary Environment

MP-35, June 2000

Structural Aspects of Flexible Aircraft Control

MP-36, May 2000

New Metallic Materials for the Structure of Aging Aircraft

MP-25, April 2000

Small Rocket Motors and Gas Generators for Land, Sea and Air Launched Weapons Systems

MP-23, April 2000

Application of Damage Tolerance Principles for Improved Airworthiness of Rotorcraft

MP-24, January 2000

Gas Turbine Engine Combustion, Emissions and Alternative Fuels

MP-14, June 1999

Fatigue in the Presence of Corrosion

MP-18, March 1999

Qualification of Life Extension Schemes for Engine Components

MP-17, March 1999

Fluid Dynamics Problems of Vehicles Operation Near or in the Air-Sea Interface

MP-15, February 1999

Design Principles and Methods for Aircraft Gas Turbine Engines

MP-8, February 1999

Airframe Inspection Reliability under Field/Depot Conditions

MP-10, November 1998

Intelligent Processing of High Performance Materials

MP-9, November 1998

Exploitation of Structural Loads/Health Data for Reduced Cycle Costs

MP-7, November 1998

Missile Aerodynamics

MP-5, November 1998

EDUCATIONAL NOTES (EN)

Measurement Techniques for High Enthalpy and Plasma Flows

EN-8, April 2000

Development and Operation of UAVs for Military and Civil Applications

EN-9, April 2000

Planar Optical Measurements Methods for Gas Turbine Engine Life

EN-6, September 1999

High Order Methods for Computational Physics, Published jointly with Springer-Verlag, Germany

EN-5, March 1999

Fluid Dynamics Research on Supersonic Aircraft

EN-4, November 1998

Integrated Multidisciplinary Design of High Pressure Multistage Compressor Systems

EN-1, September 1998

TECHNICAL REPORTS (TR)

Verification and Validation Data for Computational Unsteady Aerodynamics

TR-26, October 2000

Recommended Practices for Monitoring Gas Turbine Engine Life Consumption

TR-28, April 2000

A Feasibility Study of Collaborative Multi-facility Windtunnel Testing for CFD Validation

TR-27, December 1999

Members of the AVT-060 Workshop

Chairman

Dr. Harold Weinstock
US Air Force Office of Scientific Research
Physics and Electronics
801 N. Randolph St., Room 732
Arlington, VA 22203-1977
Tel: 1-703-696-8572
Fax: 1-703-696-8481
harold.weinstock@afosr.af.mil

THE NETHERLANDS

Col. Ir. Willem Kauw
DMKLu/MXS
P.O. Box 20703
2500 ES The Hague
Tel: 31 70 339 6039
Fax: 31 70 339 6424
woklu@dmklu.af.dnet.miindex.nl

UNITED STATES

Dr. Richard McClelland
US Army Tank-Automotive & Armaments Command
Tank Automotive Res. Dev. & Eng. Ctr.
Attn: AMSTA-TR-R
Mail Stop 202
Warren, Michigan 48397-5000
Tel: 1 810 574 5494
Fax: 1 810 574 6013
mcclellr@tacom.army.mil

WORKSHOP ORGANIZERS

Harold Weinstock
Air Force Office of Scientific Research
Washington D.C., USA

George Hadjipanayis
University of Delaware
Newark, Delaware, USA

Dimitris Niarchos
NCSR Demokritos
Athens, Greece

PROCEEDINGS EDITOR

Richard Fingers
Air Force Research Lab
Wright-Patterson AFB, Ohio, USA

REPORT DOCUMENTATION PAGE

1. Recipient's Reference	2. Originator's References RTO-TR-031 AC/323(AVT-060)TP/36	3. Further Reference ISBN 92-837-1060-6	4. Security Classification of Document UNCLASSIFIED/ UNLIMITED														
5. Originator Research and Technology Organization North Atlantic Treaty Organization BP 25, 7 rue Ancelle, F-92201 Neuilly-sur-Seine Cedex, France																	
6. Title NATO East-West Workshop on Magnetic Materials for Power Applications																	
7. Presented at/sponsored by the Applied Vehicle Technology Panel (AVT), organised by the US Air Force Office of Scientific Research, Arlington, VA, USA and held in Marathon, Greece, 25-30 June 2000.																	
8. Author(s)/Editor(s) Multiple			9. Date August 2001														
10. Author's/Editor's Address Multiple			11. Pages 58														
12. Distribution Statement There are no restrictions on the distribution of this document. Information about the availability of this and other RTO unclassified publications is given on the back cover.																	
13. Keywords/Descriptors <table style="width: 100%; border: none;"> <tr> <td style="width: 50%;">Magnetic materials</td> <td>Electric power</td> </tr> <tr> <td>Electric vehicles</td> <td>Electric drives</td> </tr> <tr> <td>Magnetic properties</td> <td>Electric brakes</td> </tr> <tr> <td>Power supplies</td> <td>Weapon systems</td> </tr> <tr> <td>Electromagnetic pulses</td> <td>High temperature</td> </tr> <tr> <td>International cooperation</td> <td>Mechanical properties</td> </tr> <tr> <td>Military vehicles</td> <td>Novel processing</td> </tr> </table>				Magnetic materials	Electric power	Electric vehicles	Electric drives	Magnetic properties	Electric brakes	Power supplies	Weapon systems	Electromagnetic pulses	High temperature	International cooperation	Mechanical properties	Military vehicles	Novel processing
Magnetic materials	Electric power																
Electric vehicles	Electric drives																
Magnetic properties	Electric brakes																
Power supplies	Weapon systems																
Electromagnetic pulses	High temperature																
International cooperation	Mechanical properties																
Military vehicles	Novel processing																
14. Abstract <p>The NATO Workshop with Partners for Peace on Advanced Magnetic Materials for More Electric Vehicles and Electric Pulse Power Weapons (AVT-060) was organised with the aim of assessing the need for improved magnetic materials primarily in future generations of more electric vehicles and (to a lesser extent) in electric pulse power weapons. Scientists from eight NATO countries and five non NATO countries participated. Recent advancements and further improvements were discussed:</p> <p>Applications Fundamental and Technical Magnetism Characterisation Materials Novel Processing</p> <p>and foundations for future co-operation were established.</p>																	

This page has been deliberately left blank



Page intentionnellement blanche



RESEARCH AND TECHNOLOGY ORGANIZATION

BP 25 • 7 RUE ANCELLE

F-92201 NEUILLY-SUR-SEINE CEDEX • FRANCE

Télécopie 0(1)55.61.22.99 • E-mail mailbox@rta.nato.int

DIFFUSION DES PUBLICATIONS

RTO NON CLASSIFIEES

L'Organisation pour la recherche et la technologie de l'OTAN (RTO), détient un stock limité de certaines de ses publications récentes, ainsi que de celles de l'ancien AGARD (Groupe consultatif pour la recherche et les réalisations aérospatiales de l'OTAN). Celles-ci pourront éventuellement être obtenues sous forme de copie papier. Pour de plus amples renseignements concernant l'achat de ces ouvrages, adressez-vous par lettre ou par télécopie à l'adresse indiquée ci-dessus. Veuillez ne pas téléphoner.

Des exemplaires supplémentaires peuvent parfois être obtenus auprès des centres nationaux de distribution indiqués ci-dessous. Si vous souhaitez recevoir toutes les publications de la RTO, ou simplement celles qui concernent certains Panels, vous pouvez demander d'être inclus sur la liste d'envoi de l'un de ces centres.

Les publications de la RTO et de l'AGARD sont en vente auprès des agences de vente indiquées ci-dessous, sous forme de photocopie ou de microfiche. Certains originaux peuvent également être obtenus auprès de CASI.

CENTRES DE DIFFUSION NATIONAUX

ALLEMAGNE

Streitkräfteamt / Abteilung III
Fachinformationszentrum der
Bundeswehr, (FIZBw)
Friedrich-Ebert-Allee 34
D-53113 Bonn

BELGIQUE

Coordinateur RTO - VSL/RTO
Etat-Major de la Force Aérienne
Quartier Reine Elisabeth
Rue d'Evère, B-1140 Bruxelles

CANADA

Services d'information scientifique
pour la défense (SISD)
R et D pour la défense Canada
Ministère de la Défense nationale
Ottawa, Ontario K1A 0K2

DANEMARK

Danish Defence Research Establishment
Ryvangs Allé 1, P.O. Box 2715
DK-2100 Copenhagen Ø

ESPAGNE

INTA (RTO/AGARD Publications)
Carretera de Torrejón a Ajalvir, Pk.4
28850 Torrejón de Ardoz - Madrid

ETATS-UNIS

NASA Center for AeroSpace
Information (CASI)
Parkway Center
7121 Standard Drive
Hanover, MD 21076-1320

FRANCE

O.N.E.R.A. (ISP)
29, Avenue de la Division Leclerc
BP 72, 92322 Châtillon Cedex

GRECE (Correspondant)

Hellenic Ministry of National
Defence
Defence Industry Research &
Technology General Directorate
Technological R&D Directorate
D.Soutsou 40, GR-11521, Athens

HONGRIE

Department for Scientific
Analysis
Institute of Military Technology
Ministry of Defence
H-1525 Budapest P O Box 26

ISLANDE

Director of Aviation
c/o Flugrad
Reykjavik

ITALIE

Centro di Documentazione
Tecnico-Scientifica della Difesa
Via XX Settembre 123a
00187 Roma

LUXEMBOURG

Voir Belgique

NORVEGE

Norwegian Defence Research
Establishment
Attn: Biblioteket
P.O. Box 25, NO-2007 Kjeller

PAYS-BAS

NDRCC
DGM/DWOO
P.O. Box 20701
2500 ES Den Haag

POLOGNE

Chief of International Cooperation
Division
Research & Development Department
218 Niepodleglosci Av.
00-911 Warsaw

PORTUGAL

Estado Maior da Força Aérea
SDFA - Centro de Documentação
Alfragide
P-2720 Amadora

REPUBLIQUE TCHEQUE

DIC Czech Republic-NATO RTO
VTÚL a PVO Praha
Mladoboleslavská ul.
Praha 9, 197 06, Česká republika

ROYAUME-UNI

Defence Research Information Centre
Kentigern House
65 Brown Street
Glasgow G2 8EX

TURQUIE

Millî Savunma Başkanlığı (MSB)
ARGE Dairesi Başkanlığı (MSB)
06650 Bakanlıklar - Ankara

AGENCES DE VENTE

NASA Center for AeroSpace

Information (CASI)
Parkway Center
7121 Standard Drive
Hanover, MD 21076-1320
Etats-Unis

The British Library Document

Supply Centre
Boston Spa, Wetherby
West Yorkshire LS23 7BQ
Royaume-Uni

Canada Institute for Scientific and

Technical Information (CISTI)
National Research Council
Document Delivery
Montreal Road, Building M-55
Ottawa K1A 0S2, Canada

Les demandes de documents RTO ou AGARD doivent comporter la dénomination "RTO" ou "AGARD" selon le cas, suivie du numéro de série (par exemple AGARD-AG-315). Des informations analogues, telles que le titre et la date de publication sont souhaitables. Des références bibliographiques complètes ainsi que des résumés des publications RTO et AGARD figurent dans les journaux suivants:

Scientific and Technical Aerospace Reports (STAR)

STAR peut être consulté en ligne au localisateur de ressources uniformes (URL) suivant:
<http://www.sti.nasa.gov/Pubs/star/Star.html>
STAR est édité par CASI dans le cadre du programme NASA d'information scientifique et technique (STI)
STI Program Office, MS 157A
NASA Langley Research Center
Hampton, Virginia 23681-0001
Etats-Unis

Government Reports Announcements & Index (GRA&I)

publié par le National Technical Information Service
Springfield
Virginia 2216
Etats-Unis
(accessible également en mode interactif dans la base de données bibliographiques en ligne du NTIS, et sur CD-ROM)



Imprimé par St-Joseph Ottawa/Hull
(Membre de la Corporation St-Joseph)

45, boul. Sacré-Cœur, Hull (Québec), Canada J8X 1C6



RESEARCH AND TECHNOLOGY ORGANIZATION

BP 25 • 7 RUE ANCELLE

F-92201 NEUILLY-SUR-SEINE CEDEX • FRANCE

Telefax 0(1)55.61.22.99 • E-mail mailbox@rta.nato.int

DISTRIBUTION OF UNCLASSIFIED

RTO PUBLICATIONS

NATO's Research and Technology Organization (RTO) holds limited quantities of some of its recent publications and those of the former AGARD (Advisory Group for Aerospace Research & Development of NATO), and these may be available for purchase in hard copy form. For more information, write or send a telefax to the address given above. **Please do not telephone.**

Further copies are sometimes available from the National Distribution Centres listed below. If you wish to receive all RTO publications, or just those relating to one or more specific RTO Panels, they may be willing to include you (or your organisation) in their distribution.

RTO and AGARD publications may be purchased from the Sales Agencies listed below, in photocopy or microfiche form. Original copies of some publications may be available from CASI.

NATIONAL DISTRIBUTION CENTRES

BELGIUM

Coordinateur RTO - VSL/RTO
Etat-Major de la Force Aérienne
Quartier Reine Elisabeth
Rue d'Evère, B-1140 Bruxelles

CANADA

Defence Scientific Information
Services (DSIS)
Defence R&D Canada
Department of National Defence
Ottawa, Ontario K1A 0K2

CZECH REPUBLIC

DIC Czech Republic-NATO RTO
VTÚL a PVO Praha
Mladoboleslavská ul.
Praha 9, 197 06, Česká republika

DENMARK

Danish Defence Research
Establishment
Ryvangs Allé 1, P.O. Box 2715
DK-2100 Copenhagen Ø

FRANCE

O.N.E.R.A. (ISP)
29 Avenue de la Division Leclerc
BP 72, 92322 Châtillon Cedex

GERMANY

Streitkräfteamt / Abteilung III
Fachinformationszentrum der
Bundeswehr, (FIZBw)
Friedrich-Ebert-Allee 34
D-53113 Bonn

GREECE (Point of Contact)

Hellenic Ministry of National
Defence
Defence Industry Research &
Technology General Directorate
Technological R&D Directorate
D.Soutsou 40, GR-11521, Athens

HUNGARY

Department for Scientific
Analysis
Institute of Military Technology
Ministry of Defence
H-1525 Budapest P O Box 26

ICELAND

Director of Aviation
c/o Flugrad
Reykjavik

ITALY

Centro di Documentazione
Tecnico-Scientifica della Difesa
Via XX Settembre 123a
00187 Roma

LUXEMBOURG

See Belgium

NETHERLANDS

NDRCC
DGM/DWO0
P.O. Box 20701
2500 ES Den Haag

NORWAY

Norwegian Defence Research
Establishment
Attn: Biblioteket
P.O. Box 25, NO-2007 Kjeller

POLAND

Chief of International Cooperation
Division
Research & Development
Department
218 Niepodleglosci Av.
00-911 Warsaw

PORTUGAL

Estado Maior da Força Aérea
SDFA - Centro de Documentação
Alfragide
P-2720 Amadora

SPAIN

INTA (RTO/AGARD Publications)
Carretera de Torrejón a Ajalvir, Pk.4
28850 Torrejón de Ardoz - Madrid

TURKEY

Millî Savunma Başkanlığı (MSB)
ARGE Dairesi Başkanlığı (MSB)
06650 Bakanlıklar - Ankara

UNITED KINGDOM

Defence Research Information
Centre
Kentigern House
65 Brown Street
Glasgow G2 8EX

UNITED STATES

NASA Center for AeroSpace
Information (CASI)
Parkway Center
7121 Standard Drive
Hanover, MD 21076-1320

SALES AGENCIES

**NASA Center for AeroSpace
Information (CASI)**

Parkway Center
7121 Standard Drive
Hanover, MD 21076-1320
United States

**The British Library Document
Supply Centre**

Boston Spa, Wetherby
West Yorkshire LS23 7BQ
United Kingdom

**Canada Institute for Scientific and
Technical Information (CISTI)**

National Research Council
Document Delivery
Montreal Road, Building M-55
Ottawa K1A 0S2, Canada

Requests for RTO or AGARD documents should include the word 'RTO' or 'AGARD', as appropriate, followed by the serial number (for example AGARD-AG-315). Collateral information such as title and publication date is desirable. Full bibliographical references and abstracts of RTO and AGARD publications are given in the following journals:

Scientific and Technical Aerospace Reports (STAR)

STAR is available on-line at the following uniform resource locator:

<http://www.sti.nasa.gov/Pubs/star/Star.html>

STAR is published by CASI for the NASA Scientific and Technical Information (STI) Program
STI Program Office, MS 157A
NASA Langley Research Center
Hampton, Virginia 23681-0001
United States

Government Reports Announcements & Index (GRA&I)

published by the National Technical Information Service
Springfield
Virginia 22161
United States
(also available online in the NTIS Bibliographic Database or on CD-ROM)



Printed by St. Joseph Ottawa/Hull
(A St. Joseph Corporation Company)
45 Sacré-Cœur Blvd., Hull (Québec), Canada J8X 1C6