



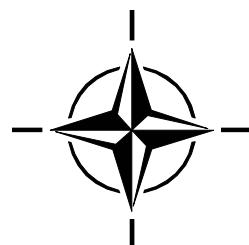
RTO TECHNICAL REPORT

TR-HFM-122

Tactile Displays for Orientation, Navigation and Communication in Air, Sea and Land Environments

(Les systèmes d'affichage tactiles pour l'orientation,
la navigation et la communication dans les
environnements aérien, maritime et terrestre)

This document is the Final Report of
Task Group RTO-TR-HFM-122.



Published August 2008





RTO TECHNICAL REPORT

TR-HFM-122

Tactile Displays for Orientation, Navigation and Communication in Air, Sea and Land Environments

(Les systèmes d'affichage tactiles pour l'orientation,
la navigation et la communication dans les
environnements aérien, maritime et terrestre)

This document is the Final Report of
Task Group RTO-TR-HFM-122.

Edited by
J.B.F. van Erp and B.P. Self

The Research and Technology Organisation (RTO) of NATO

RTO is the single focus in NATO for Defence Research and Technology activities. Its mission is to conduct and promote co-operative 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 co-ordination 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 co-ordinates RTO's co-operation 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 co-operation.

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 System Analysis and Studies 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 co-operation 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 2008

Copyright © RTO/NATO 2008
All Rights Reserved

ISBN 978-92-837-0058-6

Single copies of this publication or of a part of it may be made for individual use only. The approval of the RTA Information Management Systems Branch is required for more than one copy to be made or an extract included in another publication. Requests to do so should be sent to the address on the back cover.

Table of Contents

	Page
List of Figures/Tables	vii
HFM-122 Membership List	viii
 Executive Summary and Synthèse	ES-1
 Chapter 1 – Introduction to Tactile Displays in Military Environments	1-1
by J.B.F. van Erp and B.P. Self	
1.1 Justification for This Effort	1-2
1.1.1 Timeliness	1-2
1.1.2 Why use Tactile Displays?	1-2
1.1.2.1 Spatial Disorientation Countermeasure	1-2
1.1.2.2 Counteracting the Threat of Sensory and Cognitive Overload	1-4
1.2 Potential Applications	1-5
1.2.1 Air	1-5
1.2.2 Sea	1-6
1.2.3 Land	1-7
1.2.4 Uninhabited Vehicles	1-8
1.2.5 Additional Application Areas	1-9
1.2.5.1 Telemanipulation	1-9
1.2.5.2 Training, Simulation and Virtual Media, Gaming and Entertainment	1-9
1.2.5.3 Therapeutic Applications	1-10
1.3 Historical Aspects	1-11
1.4 Set Up of the Report	1-12
1.4.1 Definition of the Tactile Sense	1-12
1.4.2 The Remainder of This Report	1-13
1.5 References	1-13
 Chapter 2 – Anatomical, Neurophysiological and Perceptual Issues of Tactile Perception	2-1
by B. Cheung, J.B.F. van Erp and R.W. Cholewiak	
2.1 Anatomical and Morphological Characteristics of Tactile Receptors	2-1
2.2 Psychophysical Overview of Touch Sensation	2-2
2.3 Available Psychophysical Data Related Specifically to the Conditions under which Touch Sensation and Perception Arise	2-5
2.3.1 Difference Threshold	2-5
2.3.1.1 Absolute Detection Threshold	2-5
2.3.1.2 Subjective Magnitude	2-6
2.3.1.3 Spatial Summation	2-6
2.3.1.4 Psychophysics of Localization	2-6
2.3.1.5 Spatial Acuity of the Skin	2-6
2.3.1.6 Psychophysics of Temporal Events	2-7

2.3.1.7	Short Burst Duration	2-7
2.3.1.8	Temporal Difference Thresholds	2-7
2.3.1.9	Temporal Summation	2-8
2.3.1.10	Adaptation	2-8
2.3.1.11	Frequency of Stimuli	2-8
2.3.1.12	Spatiotemporal Perception	2-8
2.3.1.13	Sensory Saltation	2-8
2.3.1.14	The Cutaneous Rabbit	2-9
2.3.1.15	Apparent Motion	2-9
2.3.1.16	Pattern Recognition	2-10
2.3.1.17	Masking	2-10
2.3.1.18	Models for Spatiotemporal Processing	2-10
2.4	Concluding Remarks	2-11
2.5	References	2-11

Chapter 3 – Human Factors Issues of Tactile Displays for Military Environments 3-1

by B.P. Self, J.B.F. van Erp, L. Eriksson and L.R. Elliott

3.1	Perceptual Issues	3-1
3.1.1	Burst Duration and Timing Parameters	3-3
3.1.2	Tactile Illusions	3-3
3.2	Coding Principles	3-3
3.2.1	Tactile Characteristics	3-4
3.2.1.1	Size	3-4
3.2.1.2	Shape	3-4
3.2.1.3	Orientation	3-5
3.2.1.4	Position	3-5
3.2.1.5	Moving Pattern	3-5
3.2.1.6	Frequency	3-5
3.2.1.7	Amplitude	3-5
3.2.1.8	Rhythms	3-5
3.2.1.9	Waveform	3-6
3.2.2	Multiple Information Displays	3-6
3.2.3	Coding Standardisation	3-7
3.3	Cognitive Issues	3-7
3.3.1	Attention Tunneling	3-7
3.3.2	Cognitive Overload	3-8
3.4	Multisensory Integration	3-9
3.5	User Acceptance	3-11
3.6	Summary	3-12
3.7	References	3-12

Chapter 4 – Tactile Actuator Technology 4-1

by B. McGrath, A. McKinley, M. Duistermaat, O. Carlander, C. Brill, G. Zets and J.B.F. van Erp

4.1	Electrical	4-1
4.2	Vibro-Mechanical	4-3

4.2.1	Electro-Mechanical	4-3
4.2.1.1	Rotary Inertial	4-3
4.2.1.2	Linear Actuators	4-4
4.2.2	Pneumatic Tactors	4-5
4.3	Other Tactors	4-5
4.3.1	Static Low Frequency Tactors	4-5
4.3.1.1	Pin-Based Tactile Displays	4-5
4.3.1.2	Hydraulic	4-6
4.3.2	Piezo-Electric Based Devices	4-6
4.4	Future Technologies	4-6
4.4.1	Electro-Active Polymers	4-6
4.4.2	Micro-Electro-Mechanical Systems	4-6
4.5	Tactor Performance Measurement	4-6
4.5.1	Artificial Skin Model	4-7
4.5.2	Human Comparison Studies	4-7
4.5.3	An International Standards Organization (ISO) Standard for Tactile/Haptic Interfaces	4-8
4.6	Tactor Performance	4-8
4.7	Tactor Control Systems	4-10
4.8	Concluding Remarks	4-11
4.9	References	4-12

Chapter 5 – Integration Issues of Tactile Displays in Military Environments **5-1**

by T. Dobbins and A. McKinley

5.1	Introduction	5-1
5.2	Environment	5-1
5.2.1	Temperature	5-1
5.2.2	Underwater	5-1
5.2.3	Whole Body Vibration	5-2
5.2.4	High/Variable G	5-3
5.2.5	Space-Zero/Micro G	5-4
5.3	Tactor-Body Integration Issue	5-4
5.3.1	Skin-Tactor Contact	5-4
5.3.1.1	Skin Issues	5-4
5.3.1.2	Electromechanical Tactile Stimulation	5-4
5.3.2	Electrical Tactile Stimulation	5-6
5.4	Hardware Issues	5-6
5.4.1	Weight	5-6
5.4.2	Equipment Ditching	5-7
5.4.3	Emergency Egress	5-7
5.4.4	Comfort	5-7
5.5	Concluding Remarks	5-7
5.6	References	5-7

Chapter 6 – Applied Research Review/Lessons Learned **6-1**

by W. Ercoline and A. McKinley

6.1	Introduction	6-1
6.2	Air	6-1
6.2.1	Fixed-Wing Manned Aircraft	6-1
6.2.1.1	Self-Motion During Spatial Disorientation	6-1
6.2.1.2	T-34 Tactile Situational Awareness System (TSAS) Project	6-1
6.2.2	Rotary-Wing Manned Aircraft	6-3
6.2.2.1	Cockpit Instrument to Support Altitude Control	6-3
6.2.2.2	Tactile Display and Night Vision Goggles	6-3
6.2.2.3	The Role of Intelligent Software in Spatial Awareness Displays	6-3
6.2.2.4	Canadian Helicopter Test	6-6
6.2.3	Unmanned Aerial Vehicles	6-7
6.2.3.1	Effect of Tactile Feedback on Unmanned Aerial Vehicle Landings	6-7
6.3	Land	6-8
6.3.1	Navigation	6-8
6.3.2	Vehicle Navigation	6-8
6.3.3	Land Navigation	6-9
6.3.4	Army Platoon Leader Decision Making	6-9
6.3.5	Tactile Support of Shooting Performance in Computer-Based Army Simulation	6-9
6.3.6	Auditory and Tactile Threat Cueing in Combat Vehicle 90	6-10
6.3.7	Ground Navigation Tests	6-10
6.4	Maritime	6-10
6.4.1	Surface Operations	6-11
6.4.1.1	The Use of a Navigation Tactile Interface System in Establishing the Blind World Water Speed Record	6-11
6.4.1.2	The Use of Tactile Navigation Cues in High-Speed Craft Operations	6-11
6.4.2	Diving Operations	6-12
6.4.2.1	Enhanced Situation Awareness in Sea, Air, and Land Environments	6-13
6.4.3	Uninhabited Marine Vehicles	6-14
6.5	Space	6-14
6.5.1	Orientation Awareness in Microgravity	6-14
6.6	Conclusion	6-14
6.7	References	6-14

Chapter 7 – Tactile Displays in Military Environments: Current Status and Future Directions

by J.B.F. van Erp and B.P. Self

7.1	Introduction	7-1
7.2	Future Areas of Research	7-2
7.2.1	Coding and Standardization	7-2
7.2.2	Limitations of Intuitive Displays and Tactile Clutter	7-2
7.2.3	Multimodal Integration	7-2
7.2.4	Hardware Development	7-3
7.2.5	Miscellaneous Research Issues	7-3
7.3	Closing Remarks	7-4

List of Figures/Tables

Figure		Page
Figure 1.1	A Helicopter Pilot Showing a TNO Tactile Torso Display (TTTD), Consisting of a Matrix of Vibrating Elements Inside a Multi-Ply Garment Covering the Pilot's Torso	1-1
Figure 1.2	Spatial Orientation Retention Device (U.S. Air Force)	1-6
Figure 1.3	Diver Navigation System	1-7
Figure 1.4	Joint U.S. Army and TNO Tactile Array for Land Navigation	1-8
Figure 1.5	Sony's Playstation 2 Controller with Vibration Feedback	1-10
Figure 1.6	The Working Definitions of the Tactile Sense in Relation to Other Systems Used Throughout This Report	1-13
Figure 3.1	Example of the Use of a Tactile Display in a Military Environment	3-1
Figure 4.1	EXTENSOR Electrical Tactile Stimulation System	4-2
Figure 4.2	EXTENSOR Tactile Array Examples using Conductive Rubber	4-3
Figure 4.3	OPTEC-2890W11 Pager Motor	4-3
Figure 4.4	TNO Custom Rotary-Inertial Tactor – TNO Tactor Array Housed in Vest	4-4
Figure 4.5	FOI Sweden Tactile Belt – 12 Tactors Evenly Spaced Around Torso	4-4
Figure 4.6	C2 Tactor and Minivib-4 are two Examples of Coil Based Linear Actuators	4-5
Figure 4.7	B&K Mini-Shaker, Type 4810 is a Coil-based Actuator that has an Extremely Wide Range in Frequency, Amplitude, Force, and Displacement	4-8
Figure 5.1	US Navy SEAL Delivery Vehicle (SDV)	5-2
Figure 5.2	a) When the Vibrator Oscillates Horizontally, a Shear Wave Moves Downwards and a Longitudinal Wave Propagates Along the Surface. b) When the Vibrator Oscillates Vertically, a Longitudinal Wave Moves Downwards and a Shear Wave Propagates along the Surface	5-5
Figure 6.1	A T-34 Equipped with a Tactile Situation Awareness System during a Flight Demonstration Project	6-2
Figure 6.2	TSAS Equipped UH-60	6-5
Figure 6.3	TSAS Experiment Pilot Showing TSAS Tactor Locator System	6-5
Figure 6.4	TSAS Equipped Helicopter Performing Hover Task	6-6
Figure 6.5	Example of Navigation Track Using a Tactile Navigation System Based on a Two Tactor Display	6-12
Figure 6.6	The QinetiQ Driver Reconnaissance System (DRS) with the Display Screen Showing a Sonar Image	6-13

Table

Table 3.1	A Summary of the Properties of Nine Tactile Characteristics	3-4
Table 4.1	Summary Table (Common Tactile Actuators)	4-9
Table 6.1	Overall Performance Results of Participants by Condition (Mean ± SD)	6-8

HFM-122 Membership List

CHAIRMAN

Dr. Jan B.F. VAN ERP
Chief Scientist Department Human Interfaces
TNO Human Factors
Kampweg 5, PO Box 23
3769 ZG Soesterberg
NETHERLANDS
Email: jan.vanerp@tno.nl

Dr. William ALBERY
AFRL/HEPA
2800 Q Street, Bldg 24
Wright Patterson AFB, OH 45433-7947
USA
Email: balbery@specpro-inc.com

Asst. Prof. J. Christopher BRILL
Michigan Technological University
Dept of Cognitive and Learning Sciences
1400 Townsend Drive
Houghton, MI 49931
USA
Email: cbrill@mtu.edu

Mr. Otto W. CARLANDER
Swedish Defence Research Agency (FOI)
Division of Man System Interaction
Dept of Information Presentation
P.O. Box 1165
SE-581 11 Linköping
SWEDEN
Email: otto.carlander@foi.se

Dr. Robert CHEUNG
Defence Research & Development Canada
Leader – Performance Group
Individual Readiness Section
1133 Sheppard Ave. W.
P.O. Box 2000
Toronto, Ontario M3M 3B9
CANADA
Email: bob.cheung@drdc-rddc.gc.ca

Prof.dr. Roger W. CHOLEWIAK
Princeton University (retired)
12 Allwood Drive
Lawrenceville
NJ 08648
USA
Email: rcholewi@Princeton.edu

Dr. Trevor DOBBINS
Human Sciences and Engineering
5 The Terrace, Mill Lane, Sidlesham
Chichester, West Sussex PO20 7NA
UNITED KINGDOM
Email: trevor.dobbins@humansci-eng.com

Mrs. Maaike DUISTERMAAT
Department Human Interfaces
TNO Human Factors
Kampweg 5
3769 ZG Soesterberg
NETHERLANDS
Email: maiike.duistermaat@tno.nl

Dr. Linda ELLIOTT
Research Psychologist
Human Research and Engineering Directorate
Army Research Laboratory
US Army Infantry Center, Bldg 4, Room 33
Fort Benning, GA 31905
USA
Email: linda.r.elliott@us.army.mil

Mr. Bill ERCOLINE
Manager, San Antonio Operations
Wyle Laboratories AFRL/HEM
2485 Gilllingham Dr., Bldg 170
Brooks City-Base, TX 78235-5104
USA
Email: bill.ercoline@brooks.af.mil

Mr. Lars M. ERIKSSON
Senior Scientist
Swedish Defence Research Agency, FOI
Div. of Command and Control Systems
Dept. of MSI Man-System Interaction
P.O. Box 1165
SE-581 11 Linköping
SWEDEN
Email: lars.eriksson@foi.se

Dr. Kristen LIGGETT
Air Force Research Laboratory
Human Effectiveness Directorate AFRL/HECI
2210 Eighth Street
Wright Patterson AFB, OH 45433-7511
USA
Email: kristen.liggett@wpafb.af.mil

Dr. Braden McGRATH
Ball Solutions Group
80 Northbourne Ave
Braddon ACT 2612
AUSTRALIA
Email: bmcgrath@ballsolutions.com

Mr. Andy McKINLEY
Biomedical Engineer
Biobehavioral Performance Branch
Human Effectiveness Directorate
Air Force Research Laboratory
2215 First Street, Bldg 33
Wright-Patterson AFB, OH 45433-7947
USA
Email: Andy.McKinley@wpafb.af.mil

Dr. Brian P. SELF (Co-Editor)
Associate Professor
Mechanical Engineering Department
California Polytechnic State University
San Luis Obispo, CA 93407-0358
USA
Email: bself@calpoly.edu

Mr. Gary ZETS
Engineering Acoustics, Inc.
Email: Zets@eaiinfo.com



REPORT DOCUMENTATION PAGE																								
1. Recipient's Reference	2. Originator's References	3. Further Reference	4. Security Classification of Document																					
	RTO-TR-HFM-122 AC/323(HFM-122)TP/208	ISBN 978-92-837-0058-6	UNCLASSIFIED/ UNLIMITED																					
5. Originator	Research and Technology Organisation North Atlantic Treaty Organisation BP 25, F-92201 Neuilly-sur-Seine Cedex, France																							
6. Title	Tactile Displays for Orientation, Navigation and Communication in Air, Sea and Land Environments																							
7. Presented at/Sponsored by	This document is the Final Report of Task Group RTO-TR-HFM-122.																							
8. Author(s)/Editor(s)	J.B.F. van Erp and B.P. Self		9. Date August 2008																					
10. Author's/Editor's Address	Multiple		11. Pages 114																					
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> <tbody> <tr> <td>Attitude indicators</td> <td>Man computer interface</td> <td>Tactile displays</td> </tr> <tr> <td>Automation</td> <td>Man machine systems</td> <td>Tactile modality</td> </tr> <tr> <td>Cognitive assistance</td> <td>Military applications</td> <td>Tactile sensing</td> </tr> <tr> <td>Control equipment</td> <td>Perception</td> <td>Touch</td> </tr> <tr> <td>Display devices</td> <td>Senses</td> <td>Vibration</td> </tr> <tr> <td>Efficiency</td> <td>Situational awareness</td> <td>Visual displays</td> </tr> <tr> <td>Human factors engineering</td> <td>Stimulus (psychophysiology)</td> <td></td> </tr> </tbody> </table>			Attitude indicators	Man computer interface	Tactile displays	Automation	Man machine systems	Tactile modality	Cognitive assistance	Military applications	Tactile sensing	Control equipment	Perception	Touch	Display devices	Senses	Vibration	Efficiency	Situational awareness	Visual displays	Human factors engineering	Stimulus (psychophysiology)	
Attitude indicators	Man computer interface	Tactile displays																						
Automation	Man machine systems	Tactile modality																						
Cognitive assistance	Military applications	Tactile sensing																						
Control equipment	Perception	Touch																						
Display devices	Senses	Vibration																						
Efficiency	Situational awareness	Visual displays																						
Human factors engineering	Stimulus (psychophysiology)																							
14. Abstract	This report describes the state-of-the-art of touch-based displays in military environments: neurophysiology, psychophysics, perceptual and human factors issues, hardware and integration issues and lessons learned, and future directions. The document gives an overview of NATO activities and is useful for both end users and designers.																							





BP 25
F-92201 NEUILLY-SUR-SEINE CEDEX • FRANCE
Télécopie 0(1)55.61.22.99 • E-mail mailbox@rtt.nato.int

Les publications de l'AGARD et de la RTO peuvent parfois être obtenues 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 soit à titre personnel, soit au nom de votre organisation, sur la liste d'envoi.

Les publications de la RTO et de l'AGARD sont également en vente auprès des agences de vente indiquées ci-dessous.

Les demandes de documents RTO ou AGARD doivent comporter la dénomination « RTO » ou « AGARD » selon le cas, suivi du numéro de série. Des informations analogues, telles que le titre est la date de publication sont souhaitables.

Si vous souhaitez recevoir une notification électronique de la disponibilité des rapports de la RTO au fur et à mesure de leur publication, vous pouvez consulter notre site Web (www.rto.nato.int) et vous abonner à ce service.

DIFFUSION DES PUBLICATIONS RTO NON CLASSIFIEES



ALLEMAGNE

Streitkräfteamt / Abteilung III
Fachinformationszentrum der Bundeswehr (FIZBw)
Gorch-Fock-Straße 7, D-53229 Bonn

BELGIQUE

Royal High Institute for Defence – KHID/IRSD/RHID
Management of Scientific & Technological Research
for Defence, National RTO Coordinator
Royal Military Academy – Campus Renaissance
Renaissancelaan 30, 1000 Bruxelles

CANADA

DSIGRD2 – Bibliothécaire des ressources du savoir
R et D pour la défense Canada
Ministère de la Défense nationale
305, rue Rideau, 9^e étage
Ottawa, Ontario K1A 0K2

DANEMARK

Danish Acquisition and Logistics Organization (DALO)
Lautrupbjerg 1-5, 2750 Ballerup

ESPAGNE

SDG TECEN / DGAM
C/ Arturo Soria 289
Madrid 28033

ETATS-UNIS

NASA Center for AeroSpace Information (CASI)
7115 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)

Defence Industry & Research General
Directorate, Research Directorate
Fakinos Base Camp, S.T.G. 1020
Holargos, Athens

**NASA Center for AeroSpace
Information (CASI)**
7115 Standard Drive
Hanover, MD 21076-1320
ETATS-UNIS

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

HONGRIE

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

ISLANDE

Director of Aviation
c/o Flugrad
Reykjavik

ITALIE

General Secretariat of Defence and
National Armaments Directorate
5th Department – Technological
Research
Via XX Settembre 123
00187 Roma

LUXEMBOURG

Voir Belgique

NORVEGE

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

PAYS-BAS

Royal Netherlands Military
Academy Library
P.O. Box 90.002
4800 PA Breda

POLOGNE

Centralny Ośrodek Naukowej
Informacji Wojskowej
Al. Jerozolimskie 97
00-909 Warszawa

AGENCES DE VENTE

**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 Acquisitions
Montreal Road, Building M-55
Ottawa K1A 0S2, CANADA

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)



BP 25

F-92201 NEUILLY-SUR-SEINE CEDEX • FRANCE
Télécopie 0(1)55.61.22.99 • E-mail mailbox@rtt.nato.int



DISTRIBUTION OF UNCLASSIFIED RTO PUBLICATIONS

AGARD & RTO publications are sometimes available from the National Distribution Centres listed below. If you wish to receive all RTO reports, 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 reports may also be purchased from the Sales Agencies listed below.

Requests for RTO or AGARD documents should include the word 'RTO' or 'AGARD', as appropriate, followed by the serial number. Collateral information such as title and publication date is desirable.

If you wish to receive electronic notification of RTO reports as they are published, please visit our website (www.rto.nato.int) from where you can register for this service.

NATIONAL DISTRIBUTION CENTRES

BELGIUM

Royal High Institute for Defence – KHID/IRSD/RHID
Management of Scientific & Technological Research
for Defence, National RTO Coordinator
Royal Military Academy – Campus Renaissance
Renaissancelaan 30
1000 Brussels

CANADA

DRDKIM2 – Knowledge Resources Librarian
Defence R&D Canada
Department of National Defence
305 Rideau Street, 9th Floor
Ottawa, Ontario K1A 0K2

CZECH REPUBLIC

LOM PRAHA s. p.
o. z. VTÚLaPVO
Mladoboleslavská 944
PO Box 18
197 21 Praha 9

DENMARK

Danish Acquisition and Logistics Organization (DALO)
Lautrupbjerg 1-5
2750 Ballerup

FRANCE

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

GERMANY

Streitkräfteamt / Abteilung III
Fachinformationszentrum der Bundeswehr (FIZBw)
Gorch-Fock-Straße 7
D-53229 Bonn

GREECE (Point of Contact)

Defence Industry & Research General Directorate
Research Directorate, Fakinos Base Camp
S.T.G. 1020
Holargos, Athens

NASA Center for AeroSpace Information (CASI)

7115 Standard Drive
Hanover, MD 21076-1320
UNITED STATES

HUNGARY

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

ICELAND

Director of Aviation
c/o Flugrad, Reykjavik

ITALY

General Secretariat of Defence and
National Armaments Directorate
5th Department – Technological
Research
Via XX Settembre 123
00187 Roma

LUXEMBOURG

See Belgium

NETHERLANDS

Royal Netherlands Military
Academy Library
P.O. Box 90.002
4800 PA Breda

NORWAY

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

POLAND

Centralny Ośrodek Naukowej
Informacji Wojskowej
Al. Jerozolimskie 97
00-909 Warszawa

SALES AGENCIES

The British Library Document Supply Centre

Boston Spa, Wetherby
West Yorkshire LS23 7BQ
UNITED KINGDOM

PORUGAL

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

ROMANIA

Romanian National Distribution
Centre
Armaments Department
9-11, Drumul Taberei Street
Sector 6, 061353, Bucharest

SLOVENIA

Ministry of Defence
Central Registry for EU and
NATO
Vojkova 55
1000 Ljubljana

SPAIN

SDG TECEN / DGAM
C/ Arturo Soria 289
Madrid 28033

TURKEY

Milli Savunma Bakanlığı (MSB)
ARGE ve Teknoloji Dairesi
Başkanlığı
06650 Bakanlıklar – Ankara

UNITED KINGDOM

Dstl Knowledge Services
Information Centre
Building 247
Dstl Porton Down
Salisbury, Wiltshire SP4 0JQ

UNITED STATES

NASA Center for AeroSpace
Information (CASI)
7115 Standard Drive
Hanover, MD 21076-1320

Canada Institute for Scientific and Technical Information (CISTI)

National Research Council Acquisitions
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 2216
UNITED STATES
(also available online in the NTIS Bibliographic Database or on CD-ROM)