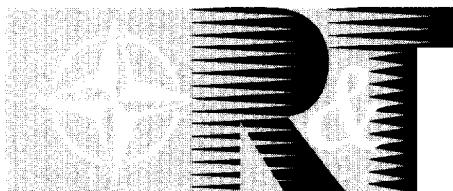


NORTH ATLANTIC TREATY ORGANIZATION



RESEARCH AND TECHNOLOGY ORGANIZATION

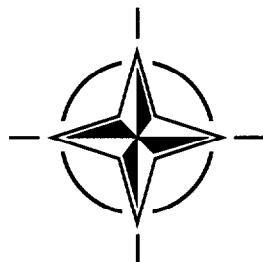
BP 25, 7 RUE ANCELLE, F-92201 NEUILLY-SUR-SEINE CEDEX, FRANCE

---

**RTO AGARDograph 339**

## **Optical Gyros and their Application** (Gyrosopes optiques et leurs applications)

*This AGARDograph has been sponsored by the Systems Concepts and Integration Panel (SCI) of RTO.*

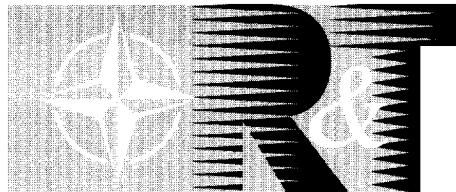


---

Published May 1999

*Distribution and Availability on Back Cover*

NORTH ATLANTIC TREATY ORGANIZATION



RESEARCH AND TECHNOLOGY ORGANIZATION

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

---

**RTO AGARDograph 339**

**Optical Gyros and their Application**

(Gyrosopes optiques et leurs applications)

edited by

D. Loukianov  
R. Rodloff  
H. Sorg  
B. Stieler

*This AGARDograph has been sponsored by the Systems Concepts and Integration Panel (SCI) of RTO.*



# 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 7 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
- NSPG NATO Simulation Policy Group (Modelling and Simulation)

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.

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



*Printed on recycled paper*

Published May 1999

Copyright © RTO/NATO 1999  
All Rights Reserved

ISBN 92-837-1014-2



*Printed by Canada Communication Group Inc.  
(A St. Joseph Corporation Company)  
45 Sacré-Cœur Blvd., Hull (Québec), Canada K1A 0S7*

# **Optical Gyros and their Application**

## **(RTO AG-339)**

### **Executive Summary**

This AGARDograph is written by experts from France, Germany, Russia and the United States. Only the radical change of the political and military situation within the last decade made it possible to have the subject Optical Gyros covered by scientists and engineers from East and West. Until this change, Optical Gyros and their research and development were mostly handled as top secret. The more it can be seen as a giant step forward that we have in our hands an unclassified and nevertheless in depth treatment of Optical Gyros from scientists from East and West.

Optical Gyros replacing the fast rotating rotor gyros as sensors for angular displacement or angular rate opened new possibilities in applications as well as in production. Especially in the field of inertial navigation, Optical Gyros replaced the mechanical gyro. Using them in Strapdown Inertial Navigation Systems in combination with Satellite Navigation Systems, offers new systems for dual usage in military and civil applications.

This volume can be divided into four main parts. The first one gives a detailed description of the laser and fiber optical gyro theory, the main sources of errors and the methods used to reduce their influence. The analysis of many types of modern laser gyros allowing various requirements to be met is presented in the second part. The reader can also find here some areas of practical applications of laser gyros. The third part is devoted to fiber optical gyros that have been developed recently. They are so successful both technologically and commercially that they are in great demand. The last part of the book considers special applications of optical gyros.

# **Gyrosopes optiques et leurs applications**

## **(RTO AG-339)**

### **Synthèse**

Cette AGARDographie a été rédigée par des spécialistes français, allemands, russes et américains. Il est à noter que seul le changement radical de la situation politique et militaire au cours de la dernière décennie a permis l'étude conjointe du sujet des gyroscopes optiques par des scientifiques et des ingénieurs des pays de l'est et des pays de l'Alliance. Avant ce changement, les gyroscopes optiques, ainsi que les activités de recherche et développement y associées, étaient classifiés très secret. D'ailleurs on peut mesurer le progrès accompli avec un tel document non-classifié, rédigé par des scientifiques des pays membres de l'OTAN et des pays de l'ancien pacte de Varsovie, traitant de façon approfondie les gyroscopes optiques.

La mise en oeuvre de gyroscopes optiques en remplacement des gyroscopes à rotation rapide en tant que capteurs de déplacement et de vitesse angulaires a ouvert de nouvelles possibilités d'application et de production. Dans le domaine de la navigation inertielle surtout, les gyroscopes optiques ont remplacé les gyroscopes mécaniques. Placés dans des centrales inertielles liées associées à des systèmes de navigation par satellite, ils sont devenus de nouveaux systèmes pour des applications militaires et civiles.

Ce volume peut être sous-divisé en quatre grandes parties. La première donne la description détaillée de la théorie des gyroscopes laser et des gyroscopes à fibres optiques, ainsi qu'une description des principales sources d'erreur et des méthodes utilisées pour les réduire. Dans la deuxième partie, les différents types de gyroscopes modernes sont analysés selon leurs différents critères d'utilisation. Le lecteur y trouvera également la description de certains domaines d'application des gyroscopes laser. La troisième partie est consacrée aux gyroscopes à fibres optiques récents. Ceux-ci sont très demandés en raison de leur grand succès technologique et commercial. La dernière partie de ce volume examine des applications spéciales relatives aux gyroscopes optiques.

# Contents

	Page
<b>Executive Summary</b>	<b>iii</b>
<b>Synthèse</b>	<b>iv</b>
<b>List of Authors/Editors</b>	<b>vi</b>
	Reference
<b>1. Introduction</b> by D. Loukianov, R. Rodloff, H. Sorg and B. Stieler	<b>1</b>
<b>2. Physical Background and Technical Realization</b> by R. Rodloff	<b>2</b>
<b>3. Fundamentals of the Ring Laser Gyro</b> by F. Aronowitz	<b>3</b>
<b>4. Multioscillator Ring Laser Gyroscopes and their Applications</b> by C.H. Volk, S.C. Gillespie, J.G. Mark and D.A. Tazartes	<b>4</b>
<b>5. Zeeman Laser Gyroscopes</b> by V.V. Azarova, Yu.D. Golyaev, V.G. Dmitriev, M.S. Drozdov, A.A. Kazakov, A.V. Melnikov, M.M. Nazarenko, V.N. Svirin, T.I. Soloviova and N.V. Tikhmenev	<b>5</b>
<b>6. Laser Gyros With Total Reflection Prisms</b> by Y.V. Bakin, G.N. Ziouzev and M.B. Lioudomirski	<b>6</b>
<b>7. Application of the Sagnac Effect in the Interferometric Fiber-Optic Gyroscope</b> by H.C. Lefèvre	<b>7</b>
<b>8. Passive All-Fiber Open Loop Gyroscope</b> by G. Trommer	<b>8</b>
<b>9. Miniature Fiber Optic Gyro. Fizoptika Implementation</b> by V. Listvin, V. Logozinski and V. Solomatin	<b>9</b>
<b>10. Progress in Fiber-Optic Gyro Development and Applications</b> by W. Auch	<b>10</b>
<b>11. Progress in Fiber-Optic Gyroscope Applications II with Emphasis on the Theory of Depolarized Gyros</b> by G.A. Sanders and B. Szafraniec	<b>11</b>
<b>12. Dynamic Ring Laser Goniometer</b> by Yu.V. Filatov, D.P. Loukianov, P.A. Pavlov, M.N. Burnashev and R. Probst	<b>12</b>
<b>13. Gyroscopic Goniometry During Quasistatic and Kinematic Conditions Using a New and Conventional Methods for Aiding</b> by B. Stieler	<b>13</b>
<b>14. Application of a Laser Gyro in Track Measuring Systems</b> by D.P. Loukianov, A.V. Mochalov and M. Rechel	<b>14</b>
<b>15. A System for Measuring Deformations of Large-Sized Objects</b> by A.V. Mochalov	<b>15</b>

# List of Authors/Editors

## Editors

Prof.Dr. D. Loukianov  
St.Petersburg Electrotechnical University  
Dept. of Navigation, Control & Mechanics  
Prof. Popov St. 5  
St.Petersburg, 197376  
Russia

Dr. R. Rodloff  
DLR  
Institut für Flugführung  
Lilienthalplatz, 7  
38108 Braunschweig  
Germany

Prof.Dr. H. Sorg  
Universität Stuttgart  
Institut A für Mechanik  
Pfaffenwaldring, 9  
70550 Stuttgart  
Germany

Prof.Dr. B. Stieler  
DLR  
Institut für Flugführung  
Lilienthalplatz, 7  
38108 Braunschweig  
Germany

## Authors

F. Aronowitz (Chapter 3)  
11430 Manzanitz Trail  
Dewey, AZ 86327  
USA

W. Auch (Chapter 10)  
SFIM Industries Deutschland  
Gottlieb-Daimler Str. 60  
71711 Murr  
Germany

V.V. Azarova, Yu.D. Golyaev, V.G. Dmitriev,  
M.S. Drozdov, A.A. Kazakov, A.V. Melnikov,  
M.M. Nazarenko, V.N. Svirin, T.I. Soloviova,  
N.V. Tikhmenev (Chapter 5)  
Research & Development Institute "Polyus"  
3 Vvendensky str.  
117342 Moscow  
Russia

Y.V. Bakin, G.N. Ziouzev,  
M.B. Lioudormirski (Chapter 6)  
Bauman Moscow State Technical University  
No. 5 2<sup>nd</sup> Baumanskaja St.  
Moscow, 107005  
Russia

Yu. V. Filatov, P.A. Pavlov,  
M.N. Burnashev (Chapter 12)  
Autonomous Navigation Department  
St. Petersburg State Electrotechnical University  
Professor Popov Str. 5  
St. Petersburg, 197376  
Russia

H.C. Lefèvre (Chapter 7)  
EuroFOG-Photonetics  
52, avenue de l'Europe, BP 39  
78160 Marly-le-Roi  
France

V. Listvin, V. Logozinski, V. Solomatin (Chapter 9)  
Fizoptika Co.  
Post Box 16  
Moscow 109387  
Russia

A.V. Mochalov (Chapters 14 & 15)  
St. Petersburg Electrotechnical University  
Professor Popov Str. 5  
St. Petersburg 197376  
Russia

R. Probst (Chapter 14)  
Physikalisch Technische Bundesanstalt  
Bundesallee 100  
38116 Braunschweig

A. Sanders, B. Szafraniec (Chapter 11)  
Honeywell Inc. HTC  
21111 N. 19<sup>th</sup> Avenue  
Phoenix, Arizona 85027  
USA

B. Stieler (Chapter 13)  
DLR  
Institut für Flugführung  
Lilienthalplatz, 7  
38108 Braunschweig  
Germany

G. Trommer (Chapter 8)  
LFK (Lenkflugköpersysteme-GmbH)  
FTE 5  
Postfach 80 11 49  
81633 München  
Germany

C.H. Volk, S.C. Gillespie, J.G. Mark,  
D.A. Tazartes (Chapter 4)  
Litton Guidance and Control Systems  
5500 Canoga Ave  
Woodland Hills, CA 91367-6698  
USA

REPORT DOCUMENTATION PAGE			
1. Recipient's Reference	2. Originator's References  RTO-AG-339 AC/323(SCI)TP/9	3. Further Reference  ISBN 92-837-1014-2	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	Optical Gyros and their Application		
7. Presented at/sponsored by	the Systems Concepts and Integration Panel (SCI) of RTO.		
8. Author(s)/Editor(s)	D. Loukianov R. Rodloff H. Sorg B. Stieler		
9. Date	May 1999		
10. Author's/Editor's Address	Multiple		
11. Pages	340		
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	Gyroscopes Laser gyroscopes Ring lasers Zeeman effect Fiber optics Accuracy Utilization Deformation Depolarization Drift (instrumentation) Dynamic range Flight control  Inertial navigation Integrated optics Manufacturing Goniometers Performance Random walk Sagnac effect Signal processing Measurement Metrology Surveying instruments Railroad tracks		
14. Abstract	<p>This AGARDograph is written by leading experts from France, Germany, Russia and the United States. It consists of 15 chapters that can be divided into four main parts. The first one gives a detailed description of the laser and fiber optical gyro theory, the main sources of errors and the methods used to reduce their influence. The analysis of many types of modern laser gyros allowing various requirements to accuracy, dimension, weight and cost is presented in the second part. The reader can also find here some areas of practical applications of laser gyros. The third part is devoted to fiber optical gyros that have been developed recently and which are very successful technologically and commercially. The last part of the book considers special applications of optical gyros for laser dynamic goniometry and metrology, fundamental and applied research (such as nuclear physics, aerodynamics, etc.), railway track surveying and estimation of deformation of objects.</p>		



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](mailto: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 télecopie 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**

Fachinformationszentrum Karlsruhe  
D-76344 Eggenstein-Leopoldshafen 2

**BELGIQUE**

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

**CANADA**

Directeur - Recherche et développement -  
Communications et gestion de l'information -  
DRDCGI 3  
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. (Direction)  
29, Avenue de la Division Leclerc  
92322 Châtillon Cedex

**GRECE**

Hellenic Air Force  
Air War College  
Scientific and Technical Library  
Dekelia Air Force Base  
Dekelia, Athens TGA 1010

**ISLANDE**

Director of Aviation  
c/o Flugrad  
Reykjavik

**ITALIE**

Aeronautica Militare  
Ufficio Stralcio RTO/AGARD  
Aeroporto Pratica di Mare  
00040 Pomezia (Roma)

**LUXEMBOURG**

Voir Belgique

**NORVEGE**

Norwegian Defence Research Establishment  
Attn: Biblioteket  
P.O. Box 25  
N-2007 Kjeller

**PAYS-BAS**

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

**PORTUGAL**

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

**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)





**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](mailto: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'Evêre, B-1140 Bruxelles

**CANADA**

Director Research & Development  
 Communications & Information  
 Management - DRDCIM 3  
 Dept of National Defence  
 Ottawa, Ontario K1A 0K2

**DENMARK**

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

**FRANCE**

O.N.E.R.A. (Direction)  
 29 Avenue de la Division Leclerc  
 92322 Châtillon Cedex

**GERMANY**

Fachinformationszentrum Karlsruhe  
 D-76344 Eggenstein-Leopoldshafen 2

**GREECE**

Hellenic Air Force  
 Air War College  
 Scientific and Technical Library  
 Dekelia Air Force Base  
 Dekelia, Athens TGA 1010

**ICELAND**

Director of Aviation  
 c/o Flugrad  
 Reykjavik

**ITALY**

Aeronautica Militare  
 Ufficio Stralcio RTO/AGARD  
 Aeroporto Pratica di Mare  
 00040 Pomezia (Roma)

**LUXEMBOURG**

*See Belgium*

**NETHERLANDS**

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

**NORWAY**

Norwegian Defence Research Establishment  
 Attn: Biblioteket  
 P.O. Box 25  
 N-2007 Kjeller

**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 Canada Communication Group Inc.*

*(A St. Joseph Corporation Company)*

*45 Sacré-Cœur Blvd., Hull (Québec), Canada K1A 0S7*