RTO-EN-12
AC/323(HFM)TP/32

RTO-EN-12

NORTH ATLANTIC TREATY ORGANIZATION

RESEARCH AND TECHNOLOGY ORGANIZATION

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

RTO LECTURE SERIES 220

Human Consequences of Agile Aircraft

(Cycle de conférences sur les facteurs humains liés au pilotage des avions de combat très manoeuvrants)

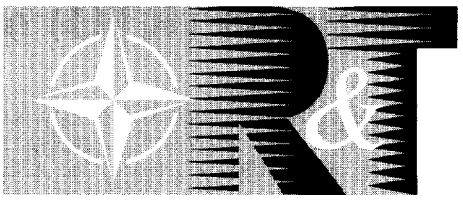
The material in this publication was assembled to support a Lecture Series under the sponsorship of the Human Factors and Medicine Panel (HFM) of RTO presented on 20-21 March 2000 in Neubiberg, Germany, on 23-24 March 2000 in Preston, UK and on 19-20 October 2000 at WPAFB Ohio, USA.

Published March 2000

Distribution and Availability on Back Cover

RTO-EN-12
AC/323(HFM)TP/32

NORTH ATLANTIC TREATY ORGANIZATION



RESEARCH AND TECHNOLOGY ORGANIZATION

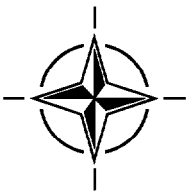
BP 25, 7 RUE ANCELLE, F-92201 NEUILLY-SUR-SEINE CEDEX, FRANCE

RTO LECTURE SERIES 220

Human Consequences of Agile Aircraft

(Cycle de conférences sur les facteurs humains liés au pilotage des avions de combat très manoeuvrants)

The material in this publication was assembled to support a Lecture Series under the sponsorship of the Human Factors and Medicine Panel (HFM) of RTO presented on 20-21 March 2000 in Neubiberg, Germany, on 23-24 March 2000 in Preston, UK and on 19-20 October 2000 at WPAFB Ohio, USA.



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
- MSG 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.

Printed on recycled paper

Published March 2000

ISBN 92-837-1036-3

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

Human Consequences of Agile Aircraft

(RTO EN-12)

Executive Summary

While historically agile flight was first seen as an issue of airframe agility with a consequent emphasis on acceleration issues, there has been an evolution in the understanding of agility. WG 27 adopted WG 19's recommendations that airframe agility is only one aspect of agility which when combined with weapons agility and systems agility results in "operational agility." The experienced pilots that we interviewed saw a real operational need for aircraft agility. They consistently rated both high angle-of-attack/nose pointing and off-boresight missiles/helmet-mounted display/sight systems as very important capabilities. They denied physiological problems related to acceleration or spatial disorientation, although their sorties to date have been with a clear sky, in active control. Also, experts predict an increase in spatial disorientation mishaps in super-manoeuvrable aircraft. In particular, there are significant gaps in our understanding of the effects of multi-axis accelerations.

With minimal constraints on angle-of-attack and expanded weapon launch envelopes, novel displays will be required that enable pilots to fly with references well beyond conventional fields-of-view. Decision aids, intelligent interfaces, and automated subsystems will be required to help pilots cope with the dramatic increase in the tempo of the tactical situation, while also maintaining situational awareness. Efficient controls are also needed to enable pilots to command and operate equipment quickly and accurately. The thrust-vectoring and post-stall operations should be fully integrated into the flight control system. Pilots still prefer controlling aircraft functions via HOTAS (hands-on-throttle-and-stick) although alternative controllers (e.g., voice and gaze-based control) may be worthwhile in the future. Current pilot protection systems will be inadequate in an unconstrained flight envelope and during ejection. The seat position relative to the aircraft's center of gravity will also impact the acceleration effects experienced by pilots.

The main aim of this Lecture Series is to provide a review of the physiological and psychological consequences of agile flight, as well as address considerations for the pilot vehicle interface design, pilot selection, training and simulation. These lectures are especially appropriate for scientific researchers and engineers involved in human-machine interaction and the design of crew stations for future aeronautical applications.

The material in this publication was assembled to support a Lecture Series under the sponsorship of the Human Factors and Medicine Panel (HFM) and the Consultant and Exchange Programme of RTO presented on 20-21 March 2000 in Neubiberg, Germany, on 23-24 March 2000 in Preston, UK and on 19-20 October, 2000 at the Wright Patterson Air Force Base, Ohio in USA.

Cycle de conférences sur les facteurs humains liés au pilotage des avions de combat très manoeuvrants

(RTO EN-12)

Synthèse

Au départ, la manoeuvrabilité des systèmes aériens militaires n'a été étudiée que sous l'aspect de la souplesse de la cellule, avec, par conséquent, un accent mis plus particulièrement sur les problèmes d'accélération. L'approche du problème a maintenant considérablement évolué. Le groupe de travail WG 27 a adopté les recommandations du WG 19, à savoir qu'il y a lieu de prendre en compte également la manoeuvrabilité des armements et des systèmes et de parler d'agilité opérationnelle. Interrogés sur la manoeuvrabilité, des pilotes militaires expérimentés en ont confirmé la nécessité opérationnelle. Ils ont systématiquement accordé une grande importance aux caractéristiques d'angles d'incidence élevés/pointage du nez et de missiles dépointés/viseurs montés sur casque. Pour eux, rien ne laisse présager que les accélérations et la désorientation spatiale puissent entraîner des problèmes physiologiques majeurs, même s'il faut noter que la plupart de leurs missions avec des taux élevés de manoeuvrabilité ont été effectuées en ciel clair, le pilote disposant de tous les repères visuels habituels. Pourtant, les spécialistes du domaine prévoient une augmentation des incidents de désorientation spatiale en vol lors du pilotage des avions de combat à très grande manoeuvrabilité. En particulier il existe des lacunes considérables dans nos connaissances des effets des accélérations multiaxiales.

L'augmentation des domaines de tir des armements et la diminution des contraintes liées aux fortes incidences, rendra nécessaire l'emploi de nouveaux visuels, permettant aux équipages de piloter à l'aide de références se trouvant largement en dehors des champs de vision classiques. Des aides à la décision, ainsi que des interfaces élaborés et des sous-systèmes automatisés seront nécessaires pour permettre aux pilotes de faire face à l'évolution rapide de la situation tactique, tout en gardant pleinement conscience de la situation globale. Des contrôles efficaces sont également demandés pour s'assurer de la commande et de l'exploitation rapides et efficaces des équipements par les pilotes. Les opérations d'orientation de la poussée et de post-décrochage devraient être entièrement intégrées au système de pilotage. A l'heure actuelle, les pilotes privilégient le contrôle HOTAS (commande manuelle), mais admettent que les nouvelles technologies (vocales et visuelles) pourraient être intéressantes à l'avenir. De plus, il faudra tenir compte de l'inadaptation de certains systèmes actuels de protection des équipages dans des domaines de vol aussi étendus ou lors d'une éjection. La position du siège par rapport au centre de gravité de l'avion est un aspect important de la conception, qui aura une incidence directe sur les accélérations subies par le pilote.

Ce cycle de conférences a pour objectif principal de faire le point des effets physiologiques et psychologiques des vols avec des taux de manoeuvrabilité élevés, ainsi que des problèmes en matière de conception des interfaces homme-machine, de sélection et d'entraînement des équipages, y compris les moyens de simulation. Les présentations sont plus particulièrement destinées aux chercheurs et aux ingénieurs impliqués dans les interfaces homme-machine et dans la conception des postes de pilotage des futurs systèmes aériens.

Cette publication a été rédigée pour servir de support de cours pour le Cycle de conférences 220, organisé par la Commission des Facteurs Humains et Médecine (HFM) dans le cadre du programme des consultants et des échanges de la RTO du 20 au 21 mars 2000, à Neubiberg, Allemagne, du 23 au 24 mars 2000 à Preston, Royaume Uni et 19 au 20 octobre 2000 à Wright Patterson Air Force Base, Ohio, (Etats-Unis).

Contents

Preface/Forward

Working Group #27 was formed under the former Advisory Group for Aerospace Research and Development (AGARD) in January 1997 to study the human factors implications of agile flight. As the Group was formed, it was believed that its focus would be aircraft maneuverability with a consequent emphasis on human physiologic issues related to the acceleration environment. Initially group members were chosen from the acceleration and vestibular research communities. Representatives from each of the nations with new fighter aircraft being developed were included as well as military pilot-physicians and acrobatic pilots. It was also planned to invite aeromedical input from Russian experts.

It soon became evident that the issue was much broader in scope. Among experts in the FMP Working Group #19 of AGARD, the definition of agility had evolved from one involving primarily aircraft maneuverability, to one including weapons and systems agility as well. It became evident that cognitive, control, and display issues also needed to be addressed. So additional representation from the human factors and psychology disciplines were added to the group. Also Mr. Patrick LeBlaye was included as a technical liaison to the engineering community.

Meeting sites were chosen to facilitate communication between the Working Group and aircraft designers, test pilots, and operational pilots. Because we wanted to base our work on real operational needs and realities, we had extensive interactions with NATO pilots from several nations. We interviewed pilots at our formal meetings; we asked them to fill our questionnaires; we were formally briefed by pilots on their concept of agility; we visited operational and test squadrons; we asked them to critique our briefings; and throughout the two and one-half years we consulted with pilots extensively. These pilots from France, the United States (USAF & NASA), Sweden, Germany, and the United Kingdom were indispensable contributors to the Working Group.

Conference Organization: During the first morning, both the pilot's and the engineer's views of agility will be discussed. Basic concepts of agility as well as history and definitions will be covered. During the afternoon of the first day potential physiological and psychological consequences of agility will be presented. Gaps in our scientific knowledge of agility and multi-axis accelerations will be highlighted. The second day will outline potential areas for intervention in the design of future aircraft and pilot-vehicle interface. Design considerations for displays and controls will be emphasised. During the last afternoon aircraft ejection, aircrew selection, and training considerations will be discussed. Finally we would like to discuss recommendations for design of agile aircraft and identify requirements for further research.

Terence J. Lyons, M.D., M.P.H.
Associate Clinical Professor
Wright State University School of Medicine
and
Program Manager, Asian Office of
Aerospace Research and Development, Air
Force Office of Scientific Research

Acknowledgements

The members of Working Group #27 would like to thank our hosts at the six different locations where we met for their excellent support and hospitality:

Colonel LasCourreges at LAMAS
Istres Flight Test Center, France

LtCol Chris Knapp at the Air Warfare Center, Nellis Air Base, U.S.
Lt.Col. Marc Jouas, Commander 422nd Test and Evaluation Squadron, USAF

Major Ken Lindberg, Magnus, and Captain Michael Seidl, FMV Testing Directorate, Sweden
Colonel Krister Backryd and Major Anders Linner, F-7 Wing, Sweden

Mr. Credet at the DASA Test and Manufacturing Center, Manching Air Base
Mr. Schmidt, Director WTD 61 (German OTC), Manching Air Base

Lt.Col. James Little at the Flight Test Center, Edwards Air Base, U.S.
Lt.Col James Mueller (USAF) at NASA Ames, California, U.S.

Mr. William Albery at the Air Force Research Laboratory, Wright-Patterson Air Base, Ohio, U.S.

For sharing their expertise and technical consultation we would like to thank Dr. Michael Haas and Dr. Grant MacMillan for their contributions in the areas of displays and controls. For tireless typing and administrative support we would like to thank Mrs Rosey Rodriguez from Brooks Air Base.

Our grateful appreciation to the following pilots for their insightful briefings to our Group:

Mr. Jon Beesley, Lockheed
Mr. Vance Brandt, NASA
Lt.Col (ret.) Richard Calwer, Daimler Chrysler Benz
Major Magnus Fredriksson, Swedish Air Force
Lt.Col. Robert Hierl, German Air Force
Lt.Col. Quirin Kim, German Air Force
Mr. Fred Knox, Rockwell-Boeing
Lt.Col. Johan Koeck, German Air Force
Colonel Lascourreges, French Air Force
Mr. Reino Lidvik, Swedish Air Force
Maj. Thomas Pitschmann, German Air Force
Lt.Col (ret.) Wolfgang Schirdewahn, Daimler Chrysler Benz
Captain Michael Seidl, Swedish Air Force
Mr. Rogers Smith, NASA
Mr. Marc Stuckey, NASA

We would also like to thank the many other pilots who shared their valuable insights with us.

List of Authors/Lecturers

Lecture Series Director: Dr. T.J. Lyons
Asian Office of Aerospace
Research and Development (AFOSR)
Unit 45002, Box 316
APO AP (96337-5002)
UNITED STATES

Ms. GLORIA CALHOUN
Engineering Research Psychologist
AFRL/HECP
2255 H Street, bldg 33
Wright Patterson AFB, OH 45433-7022
UNITED STATES

MEDECIN EN CHEF J.Y. GRAU
Institut de Medecine Aerospatiale
BP 73
91223 Bretigny sur Orge Cedex
FRANCE

Mr. P. LEBLAYE
Engineer
ONERA
BA-701
13661 Salon-Air
FRANCE

COLONEL J. LINDER
Chief Flight Surgeon
Swedish Armed Force Headquarters
S-107 85 Stockholm
SWEDEN

COL DR. H. WELSCH
Flugmedizinisches Institut des Luftwaffe
Abteilung II- Flugphysiologie
Steinborner Strasse 43
D-01936 Konigsbruck
GERMANY

CO-AUTHORS

Dr. R.D. BANKS (Author)
Biodynamics Research Corporation
San Antonio, Texas
UNITED STATES

MR. J.L. FIRTH
University Hospital
Queens Medical Centre
Nottingham NG7 2UH
UNITED KINGDOM

DR. W. ALBERY
AFRL/HESA
2800 Q Street, bldg 824
Wright Patterson AFB, OH 45433-7901
UNITED STATES

DR. W. C.M. TIELEMANS
RNLAF/SGO
Postbus 20703, Binckhorstlaan 135
2500 ES DEN HAAG
NETHERLANDS

REPORT DOCUMENTATION PAGE

1. Recipient's Reference	2. Originator's References	3. Further Reference	4. Security Classification of Document
	RTO-EN-12 AC/323(HFM)TP/32	ISBN 92-837-1036-3	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
Human Consequences of Agile Aircraft

7. Presented at/sponsored by
the Human Factors and Medicine Panel (HFM) of RTO presented on 20-21 March 2000 in Neubiberg, Germany, on 23-24 March 2000 in Preston, UK and on 19-20 October 2000 at WPAFB Ohio, USA.

8. Author(s)/Editor(s)	9. Date
Multiple	March 2000
10. Author's/Editor's Address	**11. Pages**
Multiple	92

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

Fighter aircraft	Flight crews
Aerodynamic characteristics	Pilots (personnel)
Design	Pilot training
Human factors engineering	Simulation
Stress (physiology)	Personnel selection
Stress (psychology)	Ejection
Situational awareness	Maneuverability
Man computer interface	Acceleration tolerance

14. Abstract

This Lecture Series evaluates the human factors implications for pilots of "superagile flight", specifically with regard to agile airframes, agile weapons, and rapidly configurable systems. During interviews, experienced pilots have confirmed the operational need for military aircraft agility. Although pilots have noted that their experiences to date have not caused them any major concerns regarding the potential for physiological problems, significant gaps remain in our understanding of the effects of multi-axis accelerations. Human consequences are also anticipated in the area of situational awareness. Presentation of aircraft attitude and energy state in a helmet mounted display will be a design challenge. The minimal constraints on aircraft incidence angles and the expanded weapon launch envelopes anticipated with the forthcoming and next generations of air systems requires the provision of novel displays to enable pilots to effectively operate such air systems. Decision aids, intelligent interfaces and automated subsystems are required to enable pilots to maintain situational awareness whilst coping with dramatic increases in the tempo of the tactical situation and the 'data deluge'. Moreover, many of the current pilot protection systems will be inadequate for everyday use in such an unconstrained flight envelope and during ejection. Additional challenges in selection, simulation, and training are also anticipated.

NORTH ATLANTIC TREATY ORGANIZATION

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
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. (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 documentazione tecnico-scientifica della Difesa
Via Marsala 104
00185 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
VTÚL a PVO Praha /
Air Force Research Institute Prague
Národní informační středisko obranného výzkumu (NISČR)
Mladoboleslavská ul., 197 06 Praha 9

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

TURQUIE
Millî Savunma Başkanliği (MSB)
ARGE Dairesi Başkanliği (MSB)
06650 Bakanliklar - 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 le Groupe Communication Canada Inc.
(membre de la Corporation St-Joseph)
45, boul. Sacré-Cœur, Hull (Québec), Canada K1A 0S7

NORTH ATLANTIC TREATY ORGANIZATION

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

CZECH REPUBLIC
VTÚL a PVO Praha /
Air Force Research Institute Prague
Národní informační středisko
obranného výzkumu (NISČR)
Mladoboleslavská ul., 197 06 Praha 9

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
Bunderswehr, (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 documentazione
tecnico-scientifica della Difesa
Via Marsala 104
00185 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, 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 Başkanliği (MSB)
ARGE Dairesi Başkanliği (MSB)
06650 Bakanliklar - 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

ISBN 92-837-1036-3