RTO-MP-37
AC/323(AVT)TP/16

RTO-MP-37

NORTH ATLANTIC TREATY ORGANIZATION

RESEARCH AND TECHNOLOGY ORGANIZATION

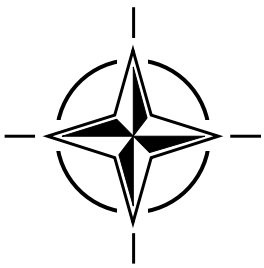
BP 25, 7 RUE ANCELLE, F-92201 NEUILLY-SUR-SEINE CEDEX, FRANCE

RTO MEETING PROCEEDINGS 37

Design for Low Cost Operation and Support

(la Conception en vue d'une exploitation et d'un soutien à coût réduit)

Papers presented at the RTO Applied Vehicle Technology Panel (AVT) Specialists' Meeting, held in Ottawa, Canada, 21-22 October 1999.



Published September 2000

Distribution and Availability on Back Cover

RTO-MP-37
AC/323(AVT)TP/16

NORTH ATLANTIC TREATY ORGANIZATION

RESEARCH AND TECHNOLOGY ORGANIZATION

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

RTO MEETING PROCEEDINGS 37

Design for Low Cost Operation and Support

(la Conception en vue d'une exploitation et d'un soutien à coût réduit)

Papers presented at the RTO Applied Vehicle Technology Panel (AVT) Specialists' Meeting, held in Ottawa, Canada, 21-22 October 1999.

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.

Published September 2000

ISBN 92-837-0012-0

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

Design for Low Cost Operation and Support

(RTO MP-37)

Executive Summary

Affordability and reliability are essential requirements of all military equipment and many NATO nations now consider life cycle costs (LCC) to be of equal importance to the performance of the weapon system. The military customer needs to establish methodologies that allow investment at the design stage to produce weapon systems with lower operational support costs. LCC must be tackled early in the design and acquisition of military systems, since 90% of LCC may be fixed by the early decisions made before production commences. This Specialist Meeting offered a forum for the NATO nations to discuss where the major LCC are incurred and the applicability of LCC models developed for existing and future systems.

About 50 delegates attended the formal presentations. Discussions confirmed that NATO forces are under great financial pressure. The life cycle cost of defence systems is under close scrutiny and the service life of equipment is being extended. This emphasises the importance of logistic support and the selection of the most cost-effective approach. Cost-modelling tools are available to aid this selection, although full model validation may not be available until equipment has been in service for many years.

Close co-operation between the manufacturer and the end-user is vital to achieve the most cost-effective solutions. The civil aircraft industry has exploited this partnership by including airline customers at all stages of the design process. This needs to be extended to military equipment and the support systems. Cost benefits can accrue from the shift towards a 2-level maintenance system where industry co-operation ensures a rapid turn around of parts in peacetime. However, there must be sufficient flexibility in the system to ensure full support during conflicts and remote deployment. It may be necessary for military personnel to work alongside industry in peacetime, so that they have the required skills to support active deployments.

The greatest problem for fleet managers and cost-effective logistics is unplanned maintenance. This hits system availability and jeopardises mission success. Reliability and predictability are key goals of current projects. Manufacturers and end-users need to co-operate to achieve the long-term goal of no unplanned maintenance. Greater use of prognostic and health monitoring systems will play a major role in achieving this objective. Much of the basic technology is already available, so the new challenge is to apply the techniques in selective, cost effective application. This requires a deeper understanding of the system and the failure processes, which are inherent in the design.

Finally, there is a cost associated with equipment disposal at the end of its life. This cost is both financial and environmental and at the moment does not play a major part in the design process. Equipment in the design phase now is not due for disposal until the middle of the 21st century. Following current trends, it is expected that future disposal and re-cycling requirements will be very stringent. More thought should be given to the effects that this will have on life cycle cost.

la Conception en vue d'une exploitation et d'un soutien à coût réduit

(RTO MP-37)

Synthèse

Le caractère acceptable du coût d'acquisition et la fiabilité sont des critères essentiels pour tout matériel militaire et aujourd'hui, bon nombre de pays membres de l'OTAN considèrent que les coûts globaux de possession (LCC) d'un systèmes d'armes sont tout aussi importants que ses performances. Le client militaire doit établir des méthodologies permettant d'investir au stade de la conception dans le but de réaliser des systèmes d'armes dont les coûts de soutien opérationnel soient réduits. Les LCC doivent être évalués très tôt lors de la conception et l'acquisition des systèmes militaires, puisque 90% des LCC peut être figé si les décisions appropriées sont prises avant le lancement de la production. Cette réunion de spécialistes a servi de forum aux pays membres de l'OTAN pour discuter de la manière dont les principaux coûts LCC sont encourus et de l'applicabilité des modèles LCC développés pour systèmes existants et futurs.

Environ 50 délégués ont assisté aux présentations officielles. Les discussions qui ont eu lieu ont confirmé l'importance de la pression financière subie par les forces de l'OTAN à l'heure actuelle. Les coûts globaux de possession des systèmes de défense sont surveillés de très près et des efforts sont faits pour prolonger la durée de vie des équipements. Ces efforts ne font que souligner l'importance du soutien logistique et du choix de l'approche la plus rentable. Des outils de modélisation des coûts sont disponibles pour faciliter ce choix, même si la modélisation complète du modèle n'est souvent pas réalisable avant que les équipements n'aient été en service pendant plusieurs années.

Une coopération étroite doit impérativement être établie entre le fabricant et l'utilisateur afin de parvenir aux solutions les plus rentables. L'industrie aéronautique civile a su exploiter ce partenariat en consultant les clients des compagnies aériennes à chaque étape du processus de conception. Cette approche doit être étendue au matériel militaire et aux systèmes de soutien. Pourvu que le partenaire industriel fasse preuve de coopération en assurant des délais d'exécution courts en temps de paix, l'adoption d'un système de maintenance à deux niveaux peut générer des gains en matière de coûts. Cependant, le système doit être suffisamment souple pour assurer le soutien nécessaire en cas d'éventuels conflits nécessitant le déploiement de troupes et de matériels à distance. Le personnel militaire pourrait être appelé à travailler aux côtés du personnel civil dans l'industrie au temps de paix, afin de lui permettre d'acquérir les compétences nécessaires au soutien des déploiements actifs.

La maintenance non-prévue représente le plus grand problème qui se pose pour les gestionnaires de flottes aériennes, ainsi que pour le maintien d'une logistique rentable. En outre, elle met en cause la disponibilité des systèmes et la réussite des missions. Les projets en cours à l'heure actuelle privilégient la fiabilité et la prévisibilité. Une coopération étroite entre fabricants et utilisateurs est essentielle pour espérer atteindre l'objectif à long terme d'une disparition de la maintenance non-planifiée. L'utilisation généralisée de systèmes de pronostic et de contrôle de l'état des matériels sera l'un des facteurs majeurs dans la réalisation de cet objectif. Bon nombre des éléments technologiques de base sont déjà disponibles. Par conséquent, le nouveau défi à relever consiste à mettre en oeuvre ces techniques de façon sélective et rentable. Cette mise en oeuvre passe par une meilleure compréhension du système ainsi que de l'origine des pannes, qui sont liées à la conception.

Enfin, la liquidation du matériel en fin de vie entraîne un coût supplémentaire. Ce coût, qui est à la fois financier et environnemental, ne joue pas un rôle majeur dans le processus de conception. Le matériel en cours de conception aujourd'hui ne sera liquidé qu'au milieu du 21ème siècle. Si la tendance actuelle se maintient, les modalités régissant la liquidation et le recyclage à l'avenir seront très strictes. Il y a lieu de réfléchir dès à présent aux conséquences de ces procédures pour les coûts globaux de possession.

Click inside the blue boxes or on the titles to view the corresponding section

Contents

† Paper not available at time of printing.

Theme

Affordability and reliability are essential requirements of all military equipment and many NATO nations now consider life cycle costs (LCC) to be of equal importance to the performance of the weapon system. The military customer needs to establish methodologies that allow investment at the design stage to produce weapon systems with lower operational support costs. LCC must be tackled early in the design and acquisition of military systems, since 90% of LCC may be fixed by the early decisions made before production commences.

This meeting offered a forum for the NATO nations to discuss where the major LCC are incurred and the applicability of LCC models developed for existing and future systems. Most examples were taken from the air environment but the principles apply equally to other systems. Critical parameters include reliability targets, mission specifications and the logistics system adopted by the operator. These will be dependent on existing facilities, fleet sizes and the mode of operation. Modelling techniques can quantify how simplified designs with fewer parts and improved maintainability reduce overhaul time and cost. This permits the design engineer to make informed trade-off decisions between the ultimate system performance and the cost. The concept of fault free operating periods offers the possibility of more effective fleet management with associated cost benefits. The new concept of prognostics and intelligent monitoring systems was discussed to show how they allow more flexible management of the fleet and increased system availability, while simultaneously reducing the in-service support costs. The sharing of experiences and difficulties encountered in LCC estimation during the design process will contribute to the acquisition of more cost effective systems in the future.

Thème

Pour tout matériel militaire, coût d'acquisition et fiabilité sont des critères essentiels et aujourd'hui, nombreux sont les pays de l'OTAN qui considèrent que pour un système d'armes les coûts globaux de possession (LCC) d'un système d'armes sont aussi importants que les performances. Le client militaire doit établir des méthodologies dès le stade de la conception afin de pouvoir réaliser des systèmes d'armes dont les coûts de soutien opérationnel sont réduits. Les LCC doivent être abordés très tôt dans la conception et l'acquisition des systèmes militaires, puisque 90% de ces coûts peuvent être maîtrisés grâce à la prise rapide de décisions avant le lancement de la production.

La réunion a servi de forum aux pays membres de l'OTAN pour discuter de l'origine des coûts LCC et de l'applicabilité des modèles LCC développés pour les systèmes existants et futurs. La plupart des exemples proviennent du milieu aéronautique mais les principes en jeu s'appliquent également à d'autres systèmes. Les paramètres critiques comprennent les objectifs en matière de fiabilité, les spécifications de mission et le système logistique adopté par l'opérateur. Ces paramètres dépendront de la nature des installations existantes, de l'importance des flottes aériennes et du mode d'exploitation choisi. Les techniques de modélisation peuvent être utilisées pour quantifier la diminution des coûts et des délais de révision en fonction d'une simplification de la conception, avec moins de pièces et plus de facilité d'entretien. Ceci permet à l'ingénieur concepteur de prendre des décisions en connaissance de cause lorsqu'il s'agit de choisir entre les performances définitives d'un système et ses coûts. Le concept d'exploitation sans pannes offre la possibilité d'une gestion de flotte aérienne plus efficace associée à des avantages en matière de coûts. Le nouveau concept de pronostics et de systèmes de contrôle intelligents était discuté afin de démontrer sa capacité de créer une gestion plus souple de la flotte aérienne, avec une disponibilité accrue du système, et une diminution des coûts de soutien en service. L'échange d'expériences et la discussion des difficultés rencontrées dans l'estimation des LCC lors de la phase de conception contribuera à l'acquisition de systèmes plus rentables à l'avenir.

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, Fall 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

Programme Committee

Chairman
Dr. M. Winstone
Technical Manager, SM2, Structural Materials Center
Room 2008, Griffith Building (A7), DERA, Ively Road
Farnborough, Hampshire, GU14 0XL, UK

BELGIUM
Prof. Dr. J. Vantomme
Royal Military Academy (RMA)
Department of Civil Engineering
avenue de la Renaissance, 30
B-1040 Brussels

CANADA
Mr. D. Simpson
Structure, Materials & Propulsion Lab.
IAR, NRC, Montreal Road,
Ottawa, Ontario K1A 0R6

FRANCE
ICA P. Armando
DGA/DSA/SPAe
Adjoint Cellule Mobilité, Systèmes
et Techniques Aéronautiques
00460 Armées

Mr. D. Chaumette
Dassault Aviation
78, quai Marcel Dassault-Cedex 300
92552 St. Cloud Cedex

GERMANY
Prof. Dr. O. Sensburg
DaimlerChrysler Aerospace AG
Militaerflugzeuge LME2
Postfach 80 11 60, 81663 Munich

ITALY
Prof. M. Marchetti
University La Sapienza, Aerospace Department, via Eudossiana
11-16, 00189 Roma

Lt. Col. G. Zennaro
c/o D.G.C.A.A.A.S.
13 Div., viale dell' Universita 4
00185 Roma

NETHERLANDS
Ir. W. Van der Hoeven
National Aerospace Laboratory NLR
P.O. Box 153, 8300 AD Emmerloord

UNITED KINGDOM
WG CDR S.Chamberlain
SM17 (RAF), B Block Room B009
RAF Wyton, P.O.Box 70, Huntington
Cambridgeshire PE17 2EA

Prof. R.T. Potter
Room G030 A1 Building, DERA,
Farnborough, Hants GU14 0LX

UNITED STATES
Mr. J. Coyle
The Boeing Company, P.O. Box 516
Saint Louis, Missouri 63166-0515

Dr. D. Paul
Air Vehicles, Air Force Research Lab.
2130 8th Street, Suite 1, WPAFB,
OH 45433-7524

Dr. S.G.Sampath
Aeronautics & Mechanics Branch, US Army - ERO
Edison House, 223-231 Old Marylebone Road,
London NW15, UK

REPORT DOCUMENTATION PAGE

1. Recipient's Reference	2. Originator's References	3. Further Reference	4. Security Classification of Document
	RTO-MP-37 AC/323(AVT)TP/16	ISBN 92-837-0012-0	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

Design for Low Cost Operation and Support

7. Presented at/sponsored by

the Applied Vehicle Technology Panel (AVT) Specialists' Meeting, held in Ottawa, Canada, 21-22 October 1999.

8. Author(s)/Editor(s)	9. Date
Multiple	September 2000
10. Author's/Editor's Address	**11. Pages**
Multiple	160

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

Life cycle costs	Defense systems
Military operations	NATO forces
Cost effectiveness	Reliability
Mathematical models	Benefit cost analysis
Operating costs	Maintenance
Logistics support	Weapon systems
NATO logistics	Design
Economic analysis	Cost models

14. Abstract

The Specialists' Meeting discussed the Life Cycle Costs (LCC) of all military equipment and the applicability of LCC models developed for existing and future systems.

There were four sessions covering the following topics:
- Introduction to Operation and Support Costs
- Life Cycle Cost Modelling
- Applications of Cost Modelling
- Techniques for Reduced Logistic Support Costs

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 di Documentazione Tecnico-Scientifica della Difesa
Via 20 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
Distribuční a informační středisko R&T
VTÚL a PVO Praha
Mladoboleslavská ul.
197 06 Praha 9-Kbely AFB

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 St-Joseph Ottawa/Hull
(Membre de la Corporation St-Joseph)
45, boul. Sacré-Cœur, Hull (Québec), Canada J8X 1C6

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
Distribuční a informační středisko R&T
VTÚL a PVO Praha
Mladoboleslavská ul.
197 06 Praha 9-Kbely AFB

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 20 Settembre 123a
00187 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 St. Joseph Ottawa/Hull
(A St. Joseph Corporation Company)
45 Sacré-Cœur Blvd., Hull (Québec), Canada J8X 1C6

ISBN 92-837-0012-0