

NORTH ATLANTIC TREATY ORGANISATION



RESEARCH AND TECHNOLOGY ORGANISATION

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

RTO MEETING PROCEEDINGS 79(II)

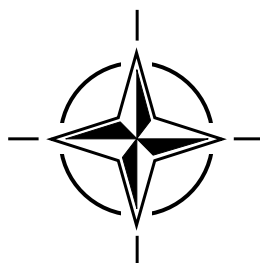
Ageing Mechanisms and Control

(Les mécanismes vieillissants et le contrôle)

Specialists' Meeting on Life Management Techniques for Ageing Air Vehicles

(Réunions des spécialistes des techniques de gestion du cycle de vie pour véhicules aériens vieillissants)

Papers presented at the RTO Applied Vehicle Technology Panel (AVT) Specialists' Meeting held in Manchester, United Kingdom, 8-11 October 2001.



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

RTO reports both to the Military Committee of NATO and to the Conference of National Armament Directors. It comprises a Research and Technology Board (RTB) as the highest level of national representation and the Research and Technology Agency (RTA), a dedicated staff with its headquarters in Neuilly, near Paris, France. In order to facilitate contacts with the military users and other NATO activities, a small part of the RTA staff is located in NATO Headquarters in Brussels. The Brussels staff also coordinates RTO's cooperation with nations in Middle and Eastern Europe, to which RTO attaches particular importance especially as working together in the field of research is one of the more promising areas of initial cooperation.

The total spectrum of R&T activities is covered by the following 7 bodies:

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

These bodies are made up of national representatives as well as generally recognised 'world class' scientists. They also provide a communication link to military users and other NATO bodies. RTO's scientific and technological work is carried out by Technical Teams, created for specific activities and with a specific duration. Such Technical Teams can organise workshops, symposia, field trials, lecture series and training courses. An important function of these Technical Teams is to ensure the continuity of the expert networks.

RTO builds upon earlier cooperation in defence research and technology as set-up under the Advisory Group for Aerospace Research and Development (AGARD) and the Defence Research Group (DRG). AGARD and the DRG share common roots in that they were both established at the initiative of Dr Theodore von Kármán, a leading aerospace scientist, who early on recognised the importance of scientific support for the Allied Armed Forces. RTO is capitalising on these common roots in order to provide the Alliance and the NATO nations with a strong scientific and technological basis that will guarantee a solid base for the future.

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Specialists' Meeting on Life Management Techniques for Ageing Air Vehicles

(RTO MP-079(II) / AVT-085)

Executive Summary

The military commanders in all NATO countries are seeing their aircraft operate well beyond the date that they were originally intended to retire. The costs of maintaining these ageing aircraft are draining the existing budgets to the point that money will not be available to modernise the fleets when obsolescence forces the retirement of the old aircraft. A possible path to reduce this economic burden is through targeted research and development. It is not always clear, however, what the best return will be when allocating funds for research and development for ageing problems.

The Specialist Meeting AVT-085 provided guidance on strategies for the development and implementation of new/existing technologies and logistic management processes, enabling the prioritisation of resources for fleet management and the research and development options. The emphasis was on military aircraft, but many of the principles could be applied to other defence systems. The papers covered the entire range of ageing problems including structural integrity, corrosion, avionics, mechanical subsystems, structures and wiring. There were also papers devoted to the role of information management as it applies to the ageing problem.

The programme contained forty-two papers addressing the needs of the manager charged with maintaining ageing systems. Papers provided an understanding of the safety and economic implications of ageing problems such as fatigue cracking, corrosion, wear and material degradation. In addition, the current status of key technologies was discussed, including non-destructive inspection, repair, modifications, prevention analysis, and health management. The shortcomings of current technology in effectively addressing the ageing problems were highlighted and the investment required was identified.

The need for research and development was clearly identified and it is recommended that these issues are pursued by the services to improve the availability of aircraft in service and to reduce the high costs associated with the maintenance of ageing aircraft. State-of-the-art technologies are available that could be adapted to ageing vehicles by additional research activity. The identified research areas should be pursued in order to reduce maintenance cost.

Under current regulations research and development resources are focused on the initial phases of new projects. This should be reviewed to facilitate the transfer and adaptation of existing technologies into ageing fleets. The services should take advantage of these possibilities to keep their fleets operational and cost effective, while maintaining a high level of safety.

It is recommended that the problems and technologies associated with ageing air vehicles should be pursued on a NATO wide basis and that RTO should continue to support the activities on ageing vehicles.

Mike Winstone

25/3/02

Réunions des spécialistes des techniques de gestion du cycle de vie pour véhicules aériens vieillissants

(RTO MP-079(II) / AVT-085)

Synthèse

Aujourd'hui, les chefs militaires de l'ensemble des pays membres de l'OTAN constatent que leurs flottes d'aéronefs sont maintenues en exploitation bien au-delà de leur durée de vie théorique. Les coûts de maintien de ces aéronefs vieillissants grèvent les budgets existants à un tel point qu'il est vraisemblable que les crédits nécessaires à la modernisation des flottes aériennes ne seront pas disponibles au moment où l'obsolescence imposera le retrait des vieux avions. La recherche et le développement ciblés sont l'un des moyens possibles d'alléger ce fardeau économique. Cependant, il n'est pas toujours facile de choisir le programme qui donnera le meilleur rendement lors de l'attribution des crédits de recherche et développement sur les problèmes de vieillissement.

La réunion de spécialistes AVT-085 a fourni des directives concernant des stratégies pour le développement et la mise en œuvre de technologies nouvelles/existantes, ainsi que de processus de gestion de la logistique, permettant l'établissement de priorités en matière de moyens de gestion des flottes aériennes, ainsi que les options de recherche et développement. L'accent a été mis sur les avions militaires, mais bon nombre des principes évoqués étaient applicables à d'autres systèmes de défense. Les communications couvraient l'éventail complet des problèmes du vieillissement, y compris l'intégrité des structures, la corrosion, l'avionique, les sous-systèmes mécaniques, les structures et le câblage. D'autres communications étaient consacrées au rôle de la gestion de l'information appliqué au problème du vieillissement.

Le programme était composé de 42 communications axées sur les besoins des responsables chargés de la maintenance de systèmes vieillissants. Les communications présentées ont permis de mieux comprendre les implications sécuritaires et économiques des problèmes de vieillissement tels que la fissuration par fatigue, la corrosion, l'usure et la dégradation matérielle. En plus, des discussions ont eu lieu sur l'état actuel des technologies clés, y compris l'inspection non destructive, la réparation, les modifications, l'analyse préventive et la gestion de l'intégrité des structures. Les lacunes des technologies actuelles vis-à-vis des problèmes de vieillissement ont été mises en évidence et l'investissement demandé a été identifié.

La nécessité de recherche et développement dans ce domaine a été clairement identifiée et il est recommandé aux armées de suivre ces questions de manière à rendre plus disponibles les aéronefs actuellement en service et de réduire les coûts élevés liés à la maintenance de flottes vieillissantes. Il existe des technologies de pointe susceptibles d'adaptation aux véhicules vieillissants, moyennant des activités de recherche supplémentaires. Il y a lieu de poursuivre les domaines de recherche identifiés afin de réduire le coût de la maintenance.

Le règlement actuellement en vigueur en matière de moyens de recherche et développement favorise les phases initiales de nouveaux projets. Cette situation est à revoir pour faciliter le transfert et l'adaptation des technologies existantes à des flottes vieillissantes. Les différents services devraient tirer profit de ces possibilités pour assurer la rentabilité et la disponibilité de leurs flottes, tout en maintenant un haut niveau de sécurité.

Il est recommandé de poursuivre les activités concernant les technologies et les problèmes des véhicules aériens vieillissants à l'échelle de l'OTAN. La RTO devrait continuer de soutenir ces activités.

Mike Winstone

25/3/02

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(As presented in the AVT Meeting Announcement)

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The conduct of this Meeting was marked by the "Events of 11 September 2001". A substantial number of authors were unable to present their paper at the meeting site, however these papers have been published in line with the schedule of the Meeting Announcement. Some replacement papers were submitted and are indicated after the "regular papers". The Specialists' Meeting on "Life Management Techniques for Ageing Air Vehicles" greatly suffered and an entirely new schedule was organised at short notice. Both the original schedule and the actual schedule have been included in the Proceedings.

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Theme

The military commanders in all NATO countries are seeing their aircraft operate well beyond the time they originally intended to retire them. The costs of maintaining these ageing aircraft are draining the existing budgets to the point that money will not be available to modernize their fleets when they will need to be retired because of obsolescence. A possible path to reduce this economic burden is through research and development. It is not always clear, however, what the best return will be when allocating funds for research and development for the ageing problem.

The specialists meeting will provide the attendees with guidance on strategies for the development and implementation of new and existing technologies, and logistic management processes. They will then be in a better position to prioritize resources for fleet management and fleet management research and development options. The emphasis will be on military aircraft, but many of the papers will apply to land vehicles as well. The topics will cover the entire range of ageing problems including avionics, mechanical subsystems, structures, and wiring. There will be papers devoted to the role of information management as it applies to the ageing problem. The forty-two papers on the agenda were written to address the needs of the manager charged with maintaining ageing systems. The technical details will be minimized in favor of providing a broad overview of the ageing issues.

The papers are designed to provide the attendees with an understanding of safety and, economic implications of ageing problems such as fatigue cracking, corrosion, wear, and material degradation. In addition, the current status of technologies such as nondestructive inspection, repair, modifications, prevention, analysis, and health management will be discussed. They will also describe the technology shortcomings for effectively addressing the ageing problems and, where possible, the investment required for attaining the needed capability.

Thème

Aujourd'hui, les chefs militaires de l'ensemble des pays membres de l'OTAN sont obligés de constater que leurs flottes d'aéronefs sont maintenues en exploitation bien au-delà de leur durée de vie théorique. Les coûts de maintenance de ces aéronefs vieillissants grèvent les budgets existants d'une telle façon que les budgets nécessaires à la modernisation des flottes pourraient être insuffisants au moment du retrait de service de ces appareils pour cause d'obsolescence. La recherche et le développement est un des moyens possibles de réduire ce fardeau économique. Cependant, en ce qui concerne le problème du vieillissement, la question de savoir, au moment de l'affectation des fonds, quel projet de recherche et développement sera le plus avantageux, est parfois délicate à résoudre.

La réunion de spécialistes fournira aux participants des orientations concernant les stratégies de développement et de mise en œuvre des technologies existantes et nouvelles, ainsi que des processus de gestion de la logistique. Ils seront alors plus à même de déterminer leurs priorités en matière de gestion des flottes, ainsi qu'en ce qui concerne les options de recherche et développement dans ce même domaine. L'accent sera mis sur les aéronefs militaires, mais de nombreuses communications porteront aussi sur les véhicules terrestres. Les sujets examinés couvriront toute la gamme des problèmes du vieillissement, avec notamment l'avionique, les sous-systèmes mécaniques, les structures et le câblage. Certaines communications seront consacrées au rôle de la gestion de l'information dans la mesure où elle s'applique au problème du vieillissement des véhicules. Les 42 communications inscrites à l'ordre du jour proposent des réponses aux besoins des personnes responsables de la maintenance des systèmes vieillissants. Les détails techniques seront réduits au minimum pour permettre un large tour d'horizon des problèmes de vieillissement.

Les participants pourront s'informer sur les implications économiques et de sécurité liées aux différents problèmes de vieillissement tels que les fissures, la corrosion, l'usure et la dégradation des matériels. De plus, la réunion fera le point de l'état actuel des connaissances dans le domaine des technologies d'inspection non-destructive, de la réparation, des modifications, de la prévention, de l'analyse et du contrôle de l'état des moteurs. Elle examinera également les lacunes technologiques dans l'approche des problèmes de vieillissement et, dans la mesure du possible, l'investissement qui serait nécessaire pour atteindre les capacités voulues.

Publications of the RTO Applied Vehicle Technology Panel

MEETING PROCEEDINGS (MP)

Advanced Flow Management: Symposium Part A – Vortex Flows and High Angle of Attack for Military Vehicles / Part B – Heat Transfer and Cooling in Propulsion and Power Systems
MP-069(I), February 2003

Low Cost Composite Structures / Cost Effective Application of Titanium Alloys in Military Platforms
MP-069(II), February 2003

Ageing Mechanisms and Control: Symposium Part A – Developments in Computational Aero- and Hydro-Acoustics / Part B – Monitoring and Management of Gas Turbine Fleets for Extended Life and Reduced Costs
MP-079(I), February 2003

Ageing Mechanisms and Control: Specialists' Meeting on Life Management Techniques for Ageing Air Vehicles
MP-079(II), February 2003

Unmanned Vehicles (UV) for Aerial, Ground and Naval Military Operations
MP-052, January 2002

Active Control Technology for Enhanced Performance Operational Capabilities of Military Aircraft, Land Vehicles and Sea Vehicles
MP-051, June 2001

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

EDUCATIONAL NOTES (EN)

Active Control of Engine Dynamics

EN-020, November 2002

Supercavitating Flows

EN-010, January 2002

Aging Aircraft Fleets: Structural and Other Subsystem Aspects

EN-015, March 2001

Aging Engines, Avionics, Subsystems and Helicopters

EN-14, October 2000

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)

Performance Prediction and Simulation of Gas Turbine Engine Operation

TR-044, April 2002

Evaluation of Methods for Solid Propellant Burning Rate Measurements

TR-043, February 2002

Design Loads for Future Aircraft

TR-045, February 2002

Ice Accretion Simulation Evaluation Test

TR-038, November 2001

NATO East-West Workshop on Magnetic Materials for Power Applications

TR-031, August 2001

Verification and Validation Data for Computational Unsteady Aerodynamics

TR-26, October 2000

Recommended Practices for Monitoring Gas Turbine Engine Life Consumption

TR-28, April 2000

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

TR-27, December 1999

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* Dr. J.W. Lincoln has since passed away.

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<table style="width: 100%; border: none;"> <tr> <td style="width: 50%; vertical-align: top;"> Aging tests (materials) Aircraft engines Aircraft maintenance Airframes Avionics Corrosion Failure analysis Fatigue (materials) Fleet management Inspection Life (durability) </td> <td style="width: 50%; vertical-align: top;"> Life cycle management Life extension Logistics management Materials science Mechanical properties Methodology Military aircraft Nondestructive tests Service life assessment Structural integrity </td> </tr> </table>				Aging tests (materials) Aircraft engines Aircraft maintenance Airframes Avionics Corrosion Failure analysis Fatigue (materials) Fleet management Inspection Life (durability)	Life cycle management Life extension Logistics management Materials science Mechanical properties Methodology Military aircraft Nondestructive tests Service life assessment Structural integrity
Aging tests (materials) Aircraft engines Aircraft maintenance Airframes Avionics Corrosion Failure analysis Fatigue (materials) Fleet management Inspection Life (durability)	Life cycle management Life extension Logistics management Materials science Mechanical properties Methodology Military aircraft Nondestructive tests Service life assessment Structural integrity				
14. Abstract					
<p>The costs of maintaining ageing aircraft are draining the existing budgets. The Specialist Meeting provided guidance on strategies for the development and implementation of technologies and logistic management processes to reduce this economic burden. The emphasis was on military aircraft, but many of the principles could be applied to other defence systems. The papers covered the entire range of ageing problems including structural integrity, corrosion, avionics, mechanical subsystems, structures and wiring as well as the role of information management.</p> <p>Forty-two papers addressed the safety and economic implications such as fatigue cracking, corrosion, wear and material degradation. Key technologies were discussed, including non-destructive inspection, repair, modifications, prevention analysis, and health management. The shortcomings of current were highlighted and the investment required was identified.</p> <p>The need for research and development was clearly identified.</p>					

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