

Enhanced Aircraft Platform Availability Through Advanced Maintenance Concepts and Technologies

(RTO-MP-AVT-144)

Executive Summary

Immense changes in aircraft maintenance/support have been introduced over the past forty years in some NATO Nations with the objectives of reducing costs and improving aircraft platform availability. It is likely that comparable changes have been introduced to varying degrees in most NATO and partner countries. The importance and scope of the changes have challenged the minds of many capable individuals from heads of governments downwards. Therefore, there is considerable knowledge and experience throughout NATO on the use of advanced maintenance concepts and advanced technologies to improve aircraft availability and reduce life-cycle costs. The AVT-144 Technical Team has attempted to capture this collective experience and present information and conclusions on what maintenance/support concepts and technologies are likely to be particularly effective in improving aircraft platform availability.

In accordance with the task issued by the AVT Panel, a Workshop of invited specialists was held and a report has been written. The current document is the Workshop Proceedings. It includes some supplementary papers invited after the Workshop to fill important gaps in information. The final report of the AVT-144 Technical Team includes a substantial amount of edited information from the Workshop. It also contains additional material from separate research, and proposes managerial and technical goals and strategies for improving aircraft availability and mission reliability. It is being published as a separate document (RTO-TR-AVT-144).

The Workshop was held in Vilnius, Lithuania, from 3 to 5 October 2006. It was attended by over eighty invited specialists from thirteen NATO Nations and two partner Nations (Sweden and Australia). Participation was by invitation only. Most of the participants were senior engineers and managers with relevant hands-on experience from industry, the Armed Forces, and other government organisations. Thirty-four invited authors made formal presentations, and most of them submitted manuscript papers for these Workshop Proceedings. The papers in these proceedings are unedited except for formatting. The Workshop was larger and wider in scope than is normally envisaged for RTO workshops; nevertheless, it included considerable time for discussions and the sharing of ideas and experience. In view of the wide scope, the Workshop was organised into four sessions and the topics addressed by the invited authors were pre-arranged. The sessions were as follows:

- National perspectives on the evolution of aircraft maintenance/support concepts with particular reference to their relevance to aircraft availability.
- Metrics, key performance indicators, and modelling of aircraft availability.
- Maintenance/support management concepts and technologies for improving aircraft availability and mission reliability.
- Aircraft, support equipment, and supply system technologies for improving aircraft availability and mission reliability.

Amélioration de la disponibilité des plateformes d'aéronefs au moyen de concepts de maintenance et de technologies évolués (RTO-MP-AVT-144)

Synthèse

D'immenses modifications dans la maintenance et le soutien des aéronefs ont été entreprises ces quarante dernières années par certaines nations de l'OTAN avec pour objectifs de réduire les coûts et d'améliorer la disponibilité des plateformes aériennes. Il est probable que des modifications comparables ont été introduites à différents degrés dans la plupart des pays de l'OTAN et de ses partenaires. L'importance et l'étendue des modifications ont frappé l'esprit de nombreux individus éclairés depuis les chefs de gouvernement jusqu'aux plus humbles. En conséquence, il existe une connaissance et une expérience considérables au sein de l'OTAN concernant l'utilisation des concepts de maintenance et des technologies avancées pour améliorer la disponibilité des aéronefs et réduire le coût du cycle de vie. L'équipe technique AVT-144 a tenté de capter cette expérience collective et de présenter les informations et les conclusions sur ce en quoi les concepts et les technologies de maintenance et de soutien sont susceptibles d'être particulièrement efficaces pour améliorer la disponibilité des plateformes aériennes.

Dans la ligne du travail fourni par la commission AVT, un atelier de spécialistes invités a été organisé et un rapport a été rédigé. Le document actuel est le compte rendu de l'atelier. Il inclut quelques documents supplémentaires ajoutés après l'atelier pour combler d'importantes lacunes d'informations. Le rapport final de l'équipe technique AVT-144 inclut un nombre substantiel de publications issues de l'atelier. Il contient aussi des éléments complémentaires provenant de recherches indépendantes, et propose des objectifs et des stratégies pour améliorer la disponibilité des aéronefs et la fiabilité des missions. Il est publié dans un document séparé (RTO-TR-AVT-144).

L'atelier s'est tenu à Vilnius, Lituanie du 3 au 5 octobre 2006. Plus de quatre-vingt spécialistes invités de treize nations de l'OTAN et de deux nations partenaires (la Suède et l'Australie) y ont participé. La participation s'est faite uniquement sur invitation. De nombreux participants étaient des ingénieurs cadres supérieurs et des responsables ayant une expérience pratique importante dans l'industrie, dans les forces armées et dans d'autres organismes gouvernementaux. Trente-quatre auteurs invités ont fait des présentations officielles et la plupart d'entre eux ont proposé des documents manuscrits pour ces comptes rendus ateliers. Les articles de ces comptes rendus n'ont pas été modifiés, exception faite de leurs formatages. Le champ couvert par l'atelier a été plus important et plus large que celui normalement prévu pour un atelier RTO ; néanmoins, cet atelier a consacré un temps considérable aux débats et aux échanges d'idées et d'expériences. Compte tenu de cette largeur de champ, l'atelier a été organisé en quatre sessions et les sujets traités par les auteurs invités ont été fixés à l'avance. Les sessions ont été organisées de la manière suivante :

- Perspectives nationales sur l'évolution des concepts de maintenance/soutien des aéronefs avec des références particulières à leur pertinence concernant la disponibilité avion.
- Systèmes de mesure, indicateurs des performances clés et modélisation de la disponibilité avion.
- Concepts et technologies de gestion de la maintenance/du soutien pour l'amélioration de la disponibilité avion et de la fiabilité des missions.
- Technologies des aéronefs, des équipements de soutien et des systèmes d'approvisionnement pour l'amélioration de la disponibilité avion et de la fiabilité des missions.



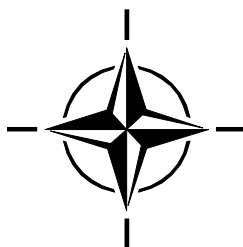
RTO MEETING PROCEEDINGS

MP-AVT-144

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

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

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

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

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

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

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Welcome Address – Official Welcome to the Workshop on Behalf of the Applied Vehicle Technology (AVT) Panel.

Hastings, R.

Mr. Robert Hastings – AVT Panel Member (Director Gas Turbine Laboratory, Institute for Aerospace Research, National Research Council, Ottawa, Ontario, Canada)

Paper 1 – Evolution of Aircraft Maintenance/Support Concepts with Particular Reference to Aircraft Availability – Polish Air Force Perspective

Szczepanik, R.; Leski, A.

Dr. Ryszard Szczepanik (Director General Air Force Institute of Technology, Warsaw, Poland), and Major (Dr.) Andrzej Leski (Team Leader, Division for Aeronautical Systems Reliability & Safety, Air Force Institute of Technology, Warsaw, Poland)

Paper 2 – Evolution of Aircraft Maintenance and Support Concepts – French Armed Forces Perspectives

Joubert, P.

Colonel Patrick Joubert (Structure Intégrée du Maintien en condition opérationnelle des Matériels Aéronautiques du ministère de la Défense – SIMMAD, Ministère de la défense, France)

Paper 3 – Evolution of Aircraft Maintenance/Support Concepts with Particular Reference to Aircraft Availability – Czech Air Force Perspective

Bulanek, J.; Kvetina, L.; Tesar, F.

Ing. Jaroslav Bulanek (Logistics Manager, Aero Vochody, Prague, Czech Republic), Lieutenant Colonel Ing. Libor Kvetina (Support Policy Section, Ministertstvo obrany – Ministry of Defence, Prague, Czech Republic), and Mr. Ferdinand Tesar (Logistics Manager, VTULaPVO, Prague, Czech Republic)

Paper 4 – Improvements of Aircraft Availability Within the Royal Netherlands Air Force

Andela, C.

Drs. Ing. Carla Andela (Collaborative Engineering and Systems, National Aerospace Laboratory NLR, Amsterdam, Netherlands)

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Barbici, S.

Mr. Sorin Barbici (Technical Expert Dependability Design, Logistics Division, Defence Material Administration – FMV, Stockholm, Sweden)

Paper 6 – The Evolution of Aircraft Support Concepts Within the UK MoD's Defence Logistics Transformation Programme

Elford, D.G.

Captain David Elford (Defence Logistics Transformation Programme, MOD DPA-DLO, UK)

Paper 7 – Metrics, Key Performance Indicators, and Modeling of Long Range Aircraft Availability and Readiness

Andresen, G.; Williams, Z.

Mr. Gerrod Andresen and Mr. Zachary Williams (IVHM Solution Center, Boeing Phantom Works, The Boeing Company, Aledo, USA)

Paper 8 – Achieving Organizational Accountability for Aircraft Operational Availability – Systems Engineering and Contracting Strategies in the Canadian Forces

Béland, P-P.; Hollick, L.J. (both presenters)

Lieutenant Colonel Pierre-Paul Béland and Mr. L.J.(Ludy) Hollick (Integrated Logistics Support, Maritime Helicopter Program, Aerospace Equipment Program Management Division, DND, Ottawa, Ontario, Canada)

Paper 9 – The Management of Reliability and Maintainability and the Choice of Maintenance Concept to Optimize Aircraft Availability and Life Cycle Cost

Buderath, M.

Dipl. Ing. Matthias Buderath (Chief Engineer Product Support Technologies, EADS Military Air Systems, Munich, Germany)

Paper 10 – Availability Improvements in New Transport Aircraft – The Case of the A400M

Heuinckx, B.

Mr. Baudouin Heuinckx (Logistic Support Officer, A400M Program Division, Organisation for Joint Armament Cooperation – OCCAR, Toulouse, France)

Paper 11 – Non-Destructive Evaluation (NDE) and Aircraft Availability

Bruce, D.A.; Buynak, C.F.; Lindgren, E.

Dr. David Bruce (Defence Sciences and Technology Laboratory, MOD, Salisbury, UK), and Mr. Charles Buynak and Dr. Eric Lindgren (NDE Branch, USAF Air Force Research Laboratory, Wright Patterson AFB, USA)

Paper 12 – The Use of Advanced NDI to Reduce the Duration and/or Frequency of Preventative Maintenance – German Air Force Experience

Manzke, H.; Grauvogl, E.

Dipl. Ing. Holger Manzke and Dipl. Ing. Ernst Grauvogl (Material Testing, EADS Military Air Systems, Manching, Germany)

Paper 13 – Corrosion Sensors to Reduce Aircraft Maintenance

Harris, S.J.; Mishon, M.; Hebbbron, M.

Dr. Steve Harris (Group Leader Materials Engineering, Advanced Technology Centre, BAE Systems, Bristol, UK), Dr. Matt Mishon (Corrosion Control Leader, Materials Integrity Group, Technical Enabling Services, MOD DPA-DLO, Gosport, UK), and Mr. M. Hebbbron, (Advanced Technology Centre, BAE Systems, Bristol, UK)

Paper 14 – Advances in Avionics Testing to Improve Aircraft Readiness and Mission Reliability

Ross, W.A.

Mr. William Ross (Deputy Program Manager for Automatic Test Systems and Member of DoD Automatic Test Systems Executive Directorate, Naval Air Systems Command, Patuxent River, USA)

Paper 15 – Advanced Diagnostics in the SNECMA M-88 Engine of the Rafale Fighter

Banet, E.; Brousse, C.; Massé, J.-R.. (presenter)

M. Erick Banet (M88 ILS Manager, Snecma, SAFRAN Group, Courcouronnes, France); Mme. Carole Brousse (M88 Electronic Control System Technical and Project Manager, Hispano-Suiza, SAFRAN Group, Systems Division, Moissy Cramayel, France); Dr. Jean-Rémi Massé (Dependability Engineering Senior Expert, also Strand 7400 Leader for TATEM European Project, Hispano-Suiza, SAFRAN Group, Systems Division, Moissy Cramayel, France)

Paper 16 – The Insertion of Advanced Diagnostic Technologies in an Ageing Fleet of Engines, to Improve Engine/Aircraft Availability and Mission Reliability

Wicks, B.; Eustace, R.

Dr. Bryon Wicks and Mr. Richard Eustace (Propulsion Systems Life Management Group, Air Vehicles Division, Platform Sciences Laboratory, Defence Science and Technology Organisation (DSTO), Fisherman's Bend, Australia)

Paper 17 – Improving the Diagnosis of Mechanical Systems, and Structure to Reduce Aircraft Downtime at 1st Line and Improve Mission Reliability

Schmidt, R.K.

Mr. Kyle Schmidt (Senior Research Engineer, Messier-Dowty, SAFRAN Group, Ajax, Canada)

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Mr. H.G. (Greg) Cook (Prognostic Health Management Division, Materials Integrity Group, Technical Enabling Services, MOD DPA-DLO, Gosport, UK)

Paper 19 – Integrating Experience with Built-In Test (BIT) to Improve First-Time-Fix Performance

D'Eon, P.; Hastings, R. (presenter)

Mr. Phil D'Eon (President and Chief Technology Officer, CaseBank Technologies Inc., Toronto, Ontario, Canada) and Mr. Robert Hastings (Director Gas Turbine Laboratory, Institute for Aerospace Research, National Research Council, Ottawa, Ontario, Canada)

Paper 20 – The Use of Integrated Reasoning with Flight and Historical Maintenance Data to Diagnose Faults and Improve Prognosis

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Dr. Sylvain Létourneau and Mr. Michael Halasz (Institute for Information Technology, National Research Council, Ottawa, Ontario, Canada)

Paper 21 – The Use of Prognostic Systems to Reduce the Duration and Frequency of Helicopter Maintenance

Cook, J.

Dr. Jonathan Cook (Head of the Prognostic Health Management Division, Materials Integrity Group, Technical Enabling Services, MOD DPA-DLO, Gosport, UK)

Paper 22 – The Use of On-Board Condition Monitoring, Usage Monitoring, Diagnostics, Prognosis, and Integrated Vehicle Health Management to Improve Aircraft Availability and Mission Reliability

Dunsdon, J.

Dr. Jonathan Dunsdon (Manager of Technologies for New Maintenance Concepts, also Technical Manager of TATEM European project, Smiths Aerospace Electronic Systems, Cheltenham, UK)

Paper 23 – Maintenance Free Periods of Operation – The Holy Grail?

Hockley, C.J.

Wing Commander (Rtd.) Chris Hockley (Lecturer, Defence College of Management and Technology, MOD Defence Academy, Shrivenham, UK)

Paper 24 – Rapid Salvage and Repair Strategies for Aircraft Disabled or Damaged in Action

Absi, F.; Lemaignan, L.

Mr. Frédéric Absi (Rafale Maintenance Manager, Military Customer Support Division, Dassault Aviation, St. Cloud, France) and Mr. Louis Lemaignan (Head of Future Support Studies, Military Customer Support Division, Dassault Aviation, St. Cloud, France)

Paper 25 – Aircraft Corrosion Control and Maintenance

Agarwala, V.S.

Dr. Vinod Agarwala (Associate Director for Materials Science & Engineering, US Office of Naval Research Global, London, UK)

Paper 26 – Use of Dehumidification to Reduce Preventive and Corrective Maintenance of Aircraft Due to Corrosion

Schweitz, H.

Lieutenant Colonel (Retd.) Hakan Schweitz (Dehumidification and Storage Expert, Competence Centre for Logistics, FMV, Stockholm, Sweden)

Paper 27 – Galvanic Sensor for Monitoring Structural Damage

Aiello, L.; Colavita, M.; Agarwala, V.

Major Lorenzo Aiello (Aeronautica Militare, Centro Sperimentale di Volo (Flight Test Centre), Pomezia, Italy), Major Mario Colavita (Aeronautica Militare, Agenzia Nazionale per la Sicurezza del Volo ANSV, Rome, Italy), and Dr. Vinod Agarwala (Associate Director for Materials Science & Engineering, US Office of Naval Research Global, London, UK)

Paper 28 – Defending Our Aging Fleets: Defining the Impacts of Aging Aircraft Sustainment on Warfighting Capability

Hart, K.A.

Mr. Karl A. Hart (Senior Engineer/Analyst, Alion Science & Technology Inc., Wright Patterson Air Force Base, Ohio, USA)

Paper 29 – State of Development of Advanced Sensory Systems for Structural Health Monitoring Applications

Mrad, N.

Dr. Nezhir Mrad (Research Scientist, Defence R&D Canada, Department of National Defence, Ottawa, Ontario, Canada)

Paper 30 – Physics of Failure Modelling at the Microstructural Level for Prognostics of Creep Failure in an Engine Turbine Blade

Koul, A.K.; Tiku, A.; Bhanot, S.; Junkin, B.

Dr. Ashok K. Koul, Mr. Ajay Tiku, and Mr. Saurabh Bhanot (Life Prediction Technologies Inc., Ottawa, Ontario, Canada), and Mr. Brent Junkin (Standard Aero Limited, Winnipeg, Manitoba, Canada)

Paper 31 – Operational Availability Modeling for Risk and Impact Analysis

Hurst, D.J.

Mr. David J. Hurst (Manager Accreditation and Audits, Aerospace Engineering and Project Management Division, Department of National Defence, Ottawa, Ontario, Canada)

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Closing Remarks – Observations by Reviewer at Close of Workshop.

Bird, J.

Mr. Jeff Bird (Senior Research Officer, NRC Institute for Aerospace Research, Ottawa, Ontario, Canada)

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Corrosion prevention	Maintenance	Usage monitoring																			
14. Abstract	Aircraft availability is a key component of military capability and an important measure of the readiness and effectiveness of a force. For years, NATO accepted trade-offs between reliability and technical performance in tactical systems because it was compelled to pursue technological superiority over the Soviet Union during the Cold War. There is now a need to place more emphasis on availability, together with an enduring ability to provide it in tactical deployments with a small logistics footprint. Therefore, a Workshop was held in Vilnius, Lithuania, from 3 to 5 October 2006, to identify advanced maintenance/support concepts and technologies which could help to improve aircraft availability. It was attended by over eighty invited specialists from thirteen NATO Nations and two partner Nations. The topics of the papers were individually prearranged to ensure the widest possible coverage of this large topic, and fell into four main categories: national perspectives; metrics and key performance indicators; maintenance/support management concepts and technologies; and aircraft and support equipment technologies. Most speakers provided manuscript papers, which are contained in these proceedings. The AVT-144 Technical Team has also prepared a report which blends information from the Workshop with additional research. This has been published separately as RTO-TR-AVT-144.																				





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