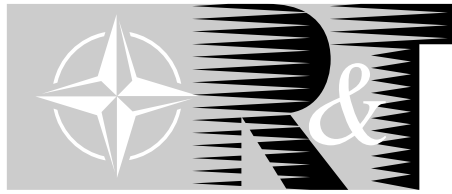


NORTH ATLANTIC TREATY ORGANISATION

RTO-MP-089



RESEARCH AND TECHNOLOGY ORGANISATION

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RTO MEETING PROCEEDINGS 89

Reduction of Military Vehicle Acquisition Time and Cost through Advanced Modelling and Virtual Simulation

(La réduction des coûts et des délais d'acquisition des
véhicules militaires par la modélisation avancée et la
simulation de produit virtuel)

*Papers presented at the RTO Applied Vehicle Technology Panel (AVT) Symposium
held in Paris, France, 22-25 April 2002.*



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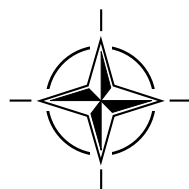
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The Research and Technology Organisation (RTO) of NATO

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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Reduction of Military Vehicle Acquisition Time and Cost through Advanced Modelling and Virtual Simulation

(RTO MP-089 / AVT-090)

Executive Summary

The defense of NATO requires a new paradigm in the development and deployment of weapon systems. This paradigm is driven by the hard realities of diminishing defense budgets and the emerging threats of unconventional attacks typified by 11 September 2001. Design simulation tools and advanced modeling techniques and processes, coupled with a maturing set of virtual manufacturing tools, are now being applied to this development and deployment. Both military and commercial companies are rapidly lowering the cost and design cycle times of their products from both a design/development and recurring manufacturing perspective through this application. Applying these tools to the development of affordable weapon systems from concept to operation, as envisioned by both the RTO MSG and AVT Panels, is essential to achieving the cost and time reductions needed to meet the emerging threats that NATO faces. The multidisciplinary composition and applied vehicle technology focus of AVT provides an excellent framework for the further development, deployment and integration of this digital environment, which has tremendous potential to reduce cost and cycle time of weapon system development. AVT is performing a vital service to NATO by fostering this new paradigm of development based on electronic simulation by encouraging and enabling technical information exchange between the Nations.

The Applied Vehicle Technology Panel (AVT) of the Research and Technology Organization (RTO) of NATO conducted a highly successful Symposium on "Reduction of Military Vehicle Acquisition Time and Cost through Advanced Modeling and Virtual Product Simulation" on 22 through 25 April 2002. The objective of the symposium was to determine the state-of-the-art and future direction of virtual design, simulation, and manufacturing tools that dramatically reduce the cost and design cycle time to develop or upgrade NATO systems. The symposium included 62 presentations focused on recent and current research and developments in design, simulation, and virtual manufacturing tools. Modeling and simulation has been successfully applied to Design Synthesis, Qualification by Analysis, Manufacturing Simulation, Aerodynamics, Turbo-machinery, Hydrodynamics, Aero-elasticity, Flight Control, Mesh Generation & Adaptation, and Geometry Fidelity. Specialized topics related to computational fluid dynamics (CFD) were included in the symposium to address the persistence of cost overruns and schedule delays that occur with aerodynamic or hydrodynamic performance validation. This included specific examples of application of the technology to vehicle platforms, space systems, propulsion, power, and weapon systems by industry and government. Emerging simulation tools offer the promise of producing more accurate and powerful analyses from the perspectives of manufacturing, vehicle performance, support systems, and system operations. This will enable the industry to shift the emphasis on physical tests from a certification role, to a secondary and less costly role of benchmarking the computational tools needed to certify by analysis.

Three common themes permeated the symposium. First, that modeling and simulation have been applied to dramatically reduce the cost and cycle times associated with military acquisition. While a remarkable cross-section of the industry was presented, the symposium did not include as much simulation in virtual manufacturing, historically an area of significant AVT interest, as expected. Those papers that addressed the application of Virtual Reality to development and deployment (such as the CAVE system for US Army TACOM) demonstrated the tremendous integration potential of the technology to address historically subjective issues, such as ergonomics. Consistent application of these technologies to product development has resulted in reduced costs and cycle time with the

potential of achieving an overall 50% reduction. It is important to recognize that the most successful applications used Virtual Reality as the integration tool, both for the simulations and for the team. Second, that a number of new technologies, such as Knowledge-Based Engineering, are only just becoming available in the commercial marketplace and hold remarkable promise to enable further reductions in cost and cycle. Third, that while remarkable strides have been made in the application of modeling and simulation to replace physical testing, there is much work that remains to be done before widespread acceptance. The framework for this continued development would be much more powerful if it leverages both the existing successful examples and the new technologies mentioned herein.

A number of detailed recommendations were made to RTO as a part of the discussion at the end of the symposium and technical evaluation. These are discussed in depth in the full technical evaluation report.

La réduction des coûts et des délais d'acquisition des véhicules militaires par la modélisation avancée et la simulation de produit virtuel

(RTO MP-089 / AVT-090)

Synthèse

La défense des pays membres de l'OTAN rend nécessaire la définition d'un nouveau paradigme pour le développement et le déploiement des systèmes d'armes. Ce paradigme doit répondre à la dure réalité des budgets de défense en diminution et aux nouvelles menaces d'attaques peu conventionnelles mises en lumière par celle du 11 septembre 2001. Des outils de conception virtuels, des techniques et des processus de modélisation avancés, associés à des outils de fabrication virtuels en plein développement, sont actuellement appliqués à ce développement et à ce déploiement. Les compagnies militaires et civiles s'efforcent de réduire les coûts et les délais du cycle de conception de leurs produits, tant du point de vue de la conception/du développement que de celui de la fabrication en série, à l'aide de cette application. L'adaptation de ces outils au développement de systèmes d'armes abordables, telle qu'envisagée par les commissions MSG et AVT de la RTO, du stade de la conception jusqu'à l'exploitation, est indispensable pour atteindre les réductions de coûts et de délais demandées pour faire face aux menaces émergentes auxquelles l'OTAN se trouve confrontée. La composition pluridisciplinaire et l'importance accordée par AVT aux technologies appliquées aux véhicules, fournit un excellent cadre pour le développement, l'intégration et le déploiement plus poussés de cet environnement numérique, qui offre des possibilités extraordinaires de réduction des coûts et des délais de développement des systèmes d'armes. AVT rend un service essentiel à l'OTAN en encourageant le lancement de ce nouveau paradigme du développement basé sur la simulation électronique, par le biais de l'échange d'informations techniques entre les pays membres de l'organisation.

Du 22 au 25 avril 2002, la commission sur la technologie appliquée aux véhicules (AVT) de l'Organisation pour la recherche et la technologie de l'OTAN (RTO) a organisé un symposium très réussi sur le thème de « La réduction des coûts et des délais d'acquisition des véhicules militaires par le biais de la modélisation avancée et la simulation du produit virtuel ». L'objectif de ce symposium était de déterminer l'état actuel des connaissances et l'orientation future de la conception virtuelle, de la simulation, et des outils de fabrication susceptibles de réduire de façon considérable les coûts et les délais de conception, permettant de développer et de moderniser les systèmes de l'OTAN. Il a donné lieu à 62 communications sur les travaux de recherche et de développement actuels ou récents dans les domaines de la conception, la simulation et les outils de fabrication virtuels. La modélisation et la simulation ont été appliquées avec succès dans les domaines de la synthèse de la conception, la qualification par l'analyse, la simulation de la fabrication, l'aérodynamique, les turbomachines, l'hydrodynamique, l'aéroélasticité, le pilotage, la génération des maillages et l'adaptation, ainsi que la fidélité de la géométrie. Des questions spécialisées concernant l'aérodynamique numérique (CFD) ont été incluses afin d'examiner la persistance des dépassements de coûts et des retards dans les programmes qui se produisent dans le domaine de l'évaluation des performances aérodynamiques et hydrodynamiques. Ces questions comprenaient des exemples spécifiques d'applications technologiques aux véhicules, aux systèmes spatiaux, aux propulseurs, aux génératrices, et aux systèmes d'armes, réalisées par l'industrie et par les gouvernements. Les nouveaux outils de simulation promettent la réalisation d'analyses plus performantes et plus précises en ce qui concerne la fabrication, les performances, les systèmes de soutien et l'exploitation. De tels développements permettront aux industriels de changer la priorité qui était accordée aux essais physiques dans leur rôle de certification vers un rôle secondaire et moins coûteux qui sera l'identification des outils informatiques requis pour la certification par analyse.

Le symposium a été dominé par trois thèmes communs. Le premier a pour origine le constat que l'application de la modélisation et la simulation a eu pour effet de réduire considérablement les coûts et les délais associés à l'acquisition militaire. Bien que l'industrie ait été bien représentée, il y avait moins de contributions que prévu sur la simulation de la fabrication virtuelle, un domaine d'intérêt traditionnel pour AVT. Les communications concernant l'application de la réalité virtuelle au développement et au déploiement (comme le système CAVE du TACOM de l'US Army), ont démontré les possibilités d'intégration extraordinaires offertes par cette technologie pour la résolution de problèmes considérés jusqu'ici comme étant spécifiques à ce domaine, tels que l'ergonomie. L'application systématique de ces technologies au développement du produit a permis une réduction globale des coûts et les délais du cycle de fabrication, pouvant atteindre 50%. Il est important de savoir que les applications les plus réussies ont utilisé la réalité virtuelle en tant qu'outil d'intégration, tant pour les simulations que pour l'équipe. Le deuxième thème concerne un certain nombre de nouvelles technologies, telles que l'ingénierie basée sur la connaissance, qui viennent de paraître sur le marché et qui promettent des réductions de coûts et de délais encore plus remarquables. En troisième lieu, le symposium a conclu que bien que des progrès importants avaient été faits dans l'application de la modélisation et la simulation pour remplacer les essais physiques, il reste encore du chemin à faire avant que ces technologies ne soient généralement reconnues. Le développement futur devrait être basé sur les exemples existants et les nouvelles technologies mentionnées ci-dessus. Une importance particulière doit être accordée à la réalité virtuelle, et AVT devrait créer un groupe de travail sur l'application de cette technologie à la fabrication et aux mesures de soutien. Un certain nombre de recommandations plus détaillées ont été proposées à la RTO dans le cadre des discussions et des évaluations techniques qui ont clôturé le symposium. Ces recommandations sont détaillées dans le rapport d'évaluation technique.

De nombreuses recommandations détaillées ont été faites à la RTO pendant la discussion à la fin du symposium et de l'évaluation technique. Elles sont largement commentées dans le rapport d'évaluation technique.

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Theme

The defence of NATO requires a new paradigm in the development and deployment of weapon systems. The development and integration of weapon systems modelling and simulation from concept to operation are essential to achieving the cost and time reductions needed to field new and improved weapon systems. Improved design simulation tools and advanced modelling methods, coupled with a maturing set of virtual manufacturing tools, are now being applied by air, land and sea vehicle companies to lower the cost and design cycle times of their products from both a design/development and recurring manufacturing perspective. The application of these advanced technologies across all aspects of the product development cycle can reduce these costs by as much as 50%. For example, the early identification and avoidance of problems currently downstream of the main design processes can dramatically reduce manufacturing costs, streamline manufacturing and assembly processes, increase supportability and maintainability, and avoid many operational problems that delay the time and cost effective deployment of modern weapon systems. AVT can perform a vital service in fostering this new paradigm because of its multidisciplinary composition and applied vehicle technology focus.

Part A of the Symposium emphasizes the use of advanced simulation to design, manufacture, and support new and existing NATO systems with reduced total cost and cycle time. This includes methods that allow us to reduce testing through the application of simulation, as well as methods that help us integrate toolsets together to produce an overarching concept-to-product simulation capability.

Part B of the Symposium is included to address the persistence of cost overruns and schedule delays that occur with aerodynamic or hydrodynamic performance validation. Emphasis is given to how CFD analysis and wind tunnel / hydrodynamic testing can be used together to most effectively reduce costs and developmental risk.

The Symposium will bring together specialists from Industry, Universities and Research Laboratories to review and report on the state-of-the-art in advanced modelling and virtual simulation. Keynote addresses will highlight the current use of tools and processes on military systems.

Thème

La défense des pays membres de l'OTAN rend nécessaire la définition d'un nouveau paradigme pour le développement et le déploiement des systèmes d'armes. Il est indispensable de développer et d'intégrer la modélisation et la simulation dans le cycle de fabrication des systèmes d'armes, de la conception jusqu'à l'exploitation, afin d'obtenir les diminutions de coûts et de délais qui permettront de mettre en service des systèmes d'armes nouveaux et améliorés. De nouveaux outils de simulation et des méthodes de modélisation avancées, associés à des outils de fabrication virtuelle de plus en plus performants, sont désormais mis en œuvre par les fabricants de véhicules aériens, terrestres et maritimes dans le but de réduire les coûts et les délais de conception de leurs produits tant du point de vue de leur conception/développement que de celui des cycles de fabrication. La mise en œuvre de ces technologies avancées pendant tout le cycle de développement du produit permettrait de réduire ces coûts jusqu'à 50%. Par exemple, l'identification rapide et l'évitement des problèmes actuellement rencontrés en aval des principaux processus de conception peuvent permettre de réduire les coûts de fabrication de façon considérable, de simplifier les processus de fabrication et de montage, d'améliorer la capacité de soutien et de maintenance, et d'éviter bon nombre des problèmes opérationnels qui entravent le déploiement rapide et rentable des systèmes d'armes modernes. AVT peut rendre un service essentiel en promouvant ce nouveau paradigme, en raison de sa composition pluridisciplinaire et de ses activités dans le domaine de la technologie appliquée aux véhicules.

La session A de ce symposium mettra en valeur l'utilisation de la simulation avancée qui permet de réduire coûts et délais lors de la conception, la fabrication et le soutien de systèmes OTAN nouveaux et existants. Elle traitera également des méthodes permettant de réduire le nombre d'essais par l'utilisation de la simulation, ainsi que des méthodes qui permettent de combiner des « boîtes à outils » pour réaliser une installation de simulation du type « du concept au produit ».

La session B examinera la persistance des dépassements de coûts et des retards dans les programmes lors de l'évaluation des performances aérodynamiques et hydrodynamiques. L'accent sera mis sur l'adéquation de l'association de l'analyse CFD et des essais en soufflerie ou hydrodynamiques pour la diminution des coûts et des risques de développement.

Le symposium rassemblera des spécialistes de l'industrie, des universités et des laboratoires de recherche, qui feront le point et rendront compte de l'état actuel des connaissances dans le domaine de la modélisation avancée et de la simulation virtuelle. Des discours d'ouverture mettront en lumière l'emploi actuel d'outils et de processus dans les systèmes militaires.

Publications of the RTO Applied Vehicle Technology Panel

MEETING PROCEEDINGS (MP)

Reduction of Military Vehicle Acquisition Time and Cost through Advanced Modelling and Virtual Simulation
MP-089, March 2003

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), March 2003

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

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14. Abstract					
<p>Integrated weapon systems modelling and simulation from concept to operation were treated as essential tool for achieving cost and time reductions which are needed to field new systems. Such tools are being applied to lower the cost and design cycle times from both a design/development and recurring manufacturing perspective. Early identification of problems dramatically reduces costs and improves procurement as well as operations, increasing performance as well as cost effectiveness. The maturing of virtual manufacturing tools led to the review of the various approaches in the NATO framework.</p> <p>Advanced simulation in design, manufacture, and support were treated in four sessions on:</p> <ul style="list-style-type: none"> - Virtual Prototyping and Simulation - Tool Integration - Qualification by Analysis - Design Synthesis <p>Avoiding cost overruns and schedule delays connected to aerodynamic or hydrodynamic performance was treated in three sessions:</p> <ul style="list-style-type: none"> - Cfd Modelling Of Non-Linear Phenomena - Cfd Validation Procedures And Error Evaluation - Dynamically Coupled Cfd 					

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