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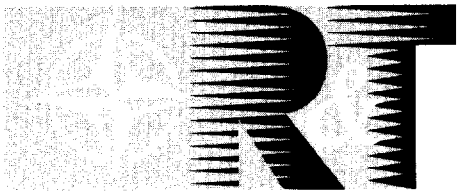

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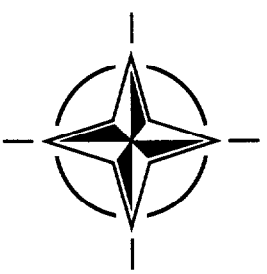
Missile Aerodynamics

(Aérodynamique des Missiles)

Papers presented and discussions recorded at the Applied Vehicle Technology Panel Symposium held in Sorrento, Italy, 11-14 May 1998.



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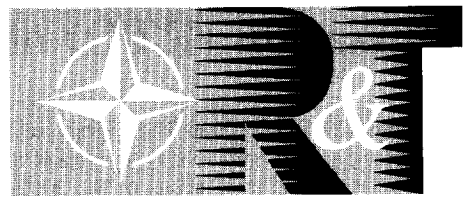

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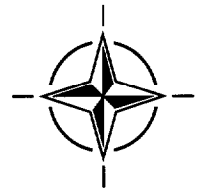

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RTO reports both to the Military Committee of NATO and to the Conference of National Armament Directors. It comprises a Research and Technology Board (RTB) as the highest level of national representation and the Research and Technology Agency (RTA), 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 6 Panels, dealing with:

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- IST Information Systems Technology
- AVT Applied Vehicle Technology
- HFM Human Factors and Medicine

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.

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Missile Aerodynamics

(RTO MP-5)

Executive Summary

This symposium was dedicated to the memory of Dr. Jack Nielsen, who was one of the fathers of missile aerodynamics.

The end of the Cold War has brought us lower production rates of missiles, and therefore, less money for new developments. New types of international conflicts demand new kinds of missiles and a higher flexibility to react to different scenarios. The new missiles have to be of higher modularity and the complete defense system that includes the missile has to be easily transportable. In addition, the design process has to become faster and cheaper. In the future, there will probably by fewer basic missile types but with a higher modularity and closer international standardization. All these trends will, of course, influence the aerodynamic design. One can expect that it will become more complex and that interdisciplinary activities will be of higher importance.

This was the third NATO Symposium on Missile Aerodynamics. At the first Symposium in 1982, the major subjects were vortex shedding, aerodynamic aspects of stealth configurations, and rolling missiles. The use of Computational Fluid Dynamics (CFD) codes was thought to be too costly for practical use. At the second Symposium in 1990, unsteady phenomena played a major role, the problems of stealth design were highlighted, and Panel Methods were the standard prediction code. CFD codes were still quoted as too costly, but promising. In the last 8 years, there has been a lot of progress in experimental techniques and in prediction codes. It is now standard to apply CFD methods to standard problems. Thus, numerical tools have experienced major progress during each of the intermediate periods. However, CFD methods still need better standards and insights into turbulence modeling and faster grid generation.

Aérodynamique des Missiles

(RTO-MP-5)

Synthèse

Ce symposium a été dédié à la mémoire du Dr Jack Nielsen, l'un des fondateurs de l'aérodynamique des missiles.

Avec la fin de la guerre froide la production des missiles a baissé, avec pour conséquence une diminution des budgets de développement. Les nouveaux types de conflits internationaux requièrent de nouveaux types de missiles, associés à une plus grande souplesse face aux différents scénarios qui se présentent. Les nouveaux missiles devront être plus modulaires et facilement transportables par les systèmes complets de défense qu'ils équipent. En outre, il faudra réduire les délais et les coûts de conception. Il est vraisemblable qu'à l'avenir il y aura moins de types de missiles, mais plus de modularité et une plus grande standardisation internationale. Naturellement, toutes ces tendances auront un impact sur la conception aérodynamique. Selon toute probabilité elle deviendra plus complexe avec plus d'importance accordée aux activités interdisciplinaires.

Il s'agit du troisième symposium OTAN sur l'aérodynamique des missiles. Les principaux sujets examinés lors du premier symposium organisé en 1982 étaient l'échappement tourbillonnaire, les aspects aérodynamiques des configurations de furtivité et le roulis des missiles. A cette époque, les codes de calcul CFD étaient considérés comme trop coûteux pour permettre une utilisation pratique. Lors du deuxième symposium en 1990, les phénomènes instationnaires ont joué un rôle important, ainsi que les problèmes de furtivité. Les méthodes de discrétisation avaient été adoptées comme norme pour les codes de prévision, mais les codes de calcul CFD étaient encore considérés comme trop coûteux, quoique prometteurs. Les huit dernières années ont vu des progrès considérables dans le domaine des techniques expérimentales et les codes de prévision. Il est désormais courant d'appliquer les méthodes CFD aux problèmes classiques et des avancés considérables ont été réalisées pendant chacune des périodes intermédiaires. Néanmoins, il ya lieu d'améliorer les normes en matière de méthodes CFD, de mieux comprendre la modélisation des tourbillons et d'écourter les délais de génération des maillages.

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Computerized simulation
Mathematical models
Jet flow
Jet effects

14. Abstract

Contains the papers prepared for the Symposium on 'Missile Aerodynamics' organised by the RTO Applied Vehicle Technology Panel (AVT), which was held 11-14 May 1998 in Sorrento, Italy. In addition, a Technical Evaluation Report aimed at assessing the success of the Symposium in meeting its objectives, and an edited transcript of the General Discussion held at the end of the Symposium are also included.

This Symposium was dedicated to the memory of Dr. Jack Nielsen and a keynote paper addressed his contributions to Missible Aerodynamics. An additional keynote paper was presented on Future Missile System Trends and their Impact on Aerodynamics. In addition to the keynote presentations, 38 Papers were presented during sessions on the following subjects:

- Aerodynamic Design
- Unconventional Configurations
- Jet Effects
- Flows Physics and Turbulence Modeling
- Prediction Methodology

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