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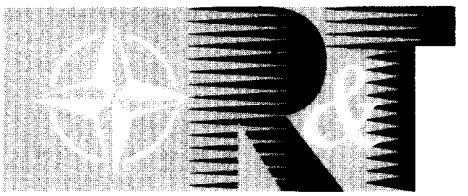

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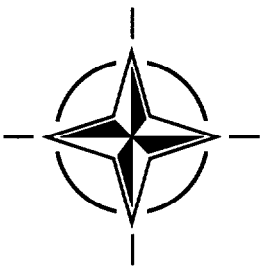
Fluid Dynamics Problems of Vehicles Operating Near or in the Air-Sea Interface

(Problèmes de dynamique des fluides des véhicules évoluant dans ou près de l'interface air-mer)

Papers presented and discussions recorded at the RTO Applied Vehicle Technology Panel (AVT) Symposium (organised by the former AGARD Fluid Dynamics Panel), held in Amsterdam, The Netherlands, 5-8 October 1998.



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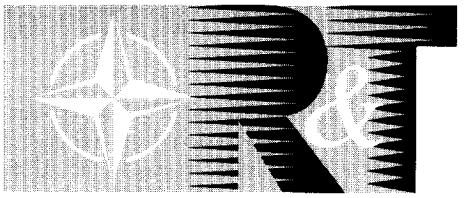

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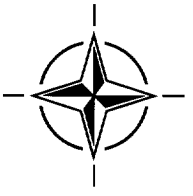

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Fluid Dynamics Problems of Vehicles Operating Near or in the Air-Sea Interface

(RTO MP-15)

Executive Summary

This Symposium concentrated on issues associated with vehicles operating near the sea surface, issues common to aeronautics and hydrodynamics, issues involving air-sea interactions; and on providing the opportunity of bringing together scientists and engineers from Western Europe, North America, Australia, Russia, and Ukraine.

One-third of the papers were authored by scientists from Russia and Ukraine. The two major topics covered during the Symposium included: Aerodynamics around Ships, and Non-Classical Aircraft flying near the air-sea interface i.e. Ekranoplanes. In addition, there were papers on Surface Effect Ships, Ship Stabilization, Hydrofoil Boats, Underwater Missile Launch, and Ship Bow Waves and Water Entry.

Aerodynamics around ships is militarily important because ship superstructures create highly unsteady 3-D flows with massive regions of flow separation behind them, and this situation can create severe problems for the landing of helicopters on the deck. It was very apparent from the presented papers that current means of calculating these flows are developing, but they are currently very limited. Many research opportunities exist involving unstable and separated flows and their simulation.

Several papers covered ground effect aerodynamics, specifically Russian technology in this area, as evidenced by the development of Ekranoplanes. By utilizing ground effect, the gap between slow and inexpensive ships and fast but expensive aircraft can possibly be filled. However, economic studies, which include sea state operability, need to be performed. An innovative means of reducing drag during take-off and thus enabling a reduction in engine power requirements was presented. There were proposals to use Ekranoplanes in a grand air/sea rescue system, and also a proposal for a future Symposium on "Marine Vehicles for Rapid Disaster Response".

For vehicles operating in the air-sea interface, load control and vertical control are very difficult and extraordinarily important. It is necessary to keep vertical accelerations very small, under 1/10th of a G and, therefore, expectations of 1/4 of a G for some Surface Effect Ships and Hydrofoils present a very serious problem. A new implementation of an automated moving weight scheme together with sophisticated fins, which reduced ship motions on an Air Craft Carrier, while ensuring navigational capability, was presented.

The material assembled in this report was prepared under the combined sponsorship of the NATO Partnership for Peace Program, the RTO Applied Vehicles and Technology Panel, the United States Office of Naval Research International Field Office - Europe, and the United States Air Force European Office of Aerospace Research and Development.

Problèmes de dynamique des fluides des véhicules évoluant dans ou près de l'interface air-mer

(RTO MP-15)

Synthèse

Ce symposium a porté essentiellement sur l'exploitation de véhicules évoluant à proximité de la surface de la mer. Il s'agit de questions relevant à la fois de l'aéronautique et de l'hydrodynamique, avec des interactions air-mer. Des scientifiques et des ingénieurs de l'Europe occidentale, de l'Amérique du nord, de l'Australie, de la Russie et de l'Ukraine ont pu être réunis à cette occasion.

Un tiers des communications a été présenté par des scientifiques russes et ukrainiens. Les deux principaux sujets couverts par le symposium comprenaient : l'aérodynamique à proximité des navires et les aéronefs non-conventionnels évoluant à proximité de la surface de la mer, c'est à dire les ekranoplanes. En outre, des communications ont été présentées sur les navires à effet de surface, sur la stabilisation des navires, sur les navires hydroptères, le lancement de missiles à partir de sous-marins, les vagues d'étrave et la pénétration dans l'eau.

Les conditions aérodynamiques à proximité des navires sont d'un grand intérêt militaire, car les superstructures créent, en aval, des écoulements tridimensionnels fortement instationnaires avec des zones de décollement très importantes, ce qui pose parfois de sérieux problèmes pour l'appontage des hélicoptères. Des communications présentées, il est apparu très clairement que des méthodes de calcul de ces écoulements sont en cours de développement mais restent très limitées. De nombreuses possibilités de recherche existent, centrées autour des écoulements instationnaires et décollés et autour de leur simulation.

L'aérodynamique des effets de sol a fait l'objet de nombreuses communications. La technologie russe a bien été mise en évidence avec le développement des ekranoplanes. Par le biais des effets de sol, il se pourrait que l'écart qui existe entre les navires lents mais peu coûteux, et les avions rapides mais chers, puisse être éliminé. Cependant, cela impliquerait la réalisation d'études économiques, entre autres sur la tenue à la mer. Un moyen novateur de réduire la traînée au décollage, permettant ainsi de réduire les besoins en propulsion, a été présenté. Des projets ont également été proposés visant l'utilisation d'ekranoplanes dans un vaste système de sauvetage en mer, ainsi qu'une proposition de symposium sur « les véhicules maritimes pour une réaction rapide en situation de catastrophe ».

Pour les véhicules à proximité de la surface de la mer, le contrôle de la charge et le contrôle vertical sont extrêmement difficiles et importants. Il faut réduire les accélérations verticales au minimum (moins d'un dixième de g) et, par conséquent, les prévisions d'un quart de g, pour certains navires et hydroptères à effets de surface, posent un problème sérieux. Une nouvelle configuration a été présentée, comprenant un système automatisé de poids amovible, comportant des dérives sophistiquées, qui permet de réduire les mouvements d'un porte-avions, tout en conservant l'aptitude à la navigation.

Ce rapport a été élaboré sous l'égide conjointe du Programme OTAN de Partenariat pour la paix, de la Commission RTO de technologies appliquées aux véhicules, du bureau extérieur international - Europe, du Directorat des États-Unis de la recherche navale, et du Bureau européen de recherche et développement aérospatial de l'armée de l'air américaine.

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Hydrofoils
Hydrofoil craft
Ground effect machines
Hydrodynamics

14. Abstract

The papers prepared for the RTO Applied Vehicle Technology (AVT) Symposium on "Fluid Dynamics Problems of Vehicles Operating Near or in the Air-Sea Interface" which was held 5-8 October 1998 in Amsterdam, The Netherlands, are contained in this report. In addition, a Technical Evaluator's 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.

In addition to presentations from the NATO Countries, this Symposium included several presentations by Russian and Ukrainian authors. In total, 30 papers were presented during sessions on the following subjects:

- Aerodynamics and Flight Dynamics around Ships
- Stabilization and Control Techniques for Ships
- Non-Classical Aircraft Flying Near the Air-Sea Interface

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