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RESEARCH AND TECHNOLOGY ORGANISATION

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RTO EDUCATIONAL NOTES **EN-AVT-105**

MEMS Aerospace Applications

(Les applications aérospatiales des MEMS)

The material in this publication was assembled to support a Lecture Series under the sponsorship of the Applied Vehicle Technology Panel (AVT) on 3-4 October 2002 in Montreal, Canada; on 24-25 February 2003 in Ankara, Turkey; on 27-28 February 2003 in VKI Brussels, Belgium; and on 3-4 March 2003 in Monterey, California, USA.

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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 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 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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MEMS Aerospace Applications

(RTO-EN-AVT-105)

Executive Summary

Micro-Electro-Mechanical-Systems (MEMS) are miniature devices, which integrate actuators, sensors, and a processor (controller) to form intelligent systems. They are characterized by their close relationship to integrated-circuit components both in terms of manufacturing techniques and their potential for integrations with electronics. After its emergence in the late eighties, MEMS has developed into billion $ commercial markets, in particular in the automotive, medical, and telecommunication fields. The Lecture Series will address applications in the aerospace field, which encounter unique challenges related to harsh environment conditions and reliability requirements.

After an introduction into MEMS technology, six aerospace applications are described, where MEMS will enable the development of potentially new capabilities. They will allow introduction of low-cost, high-end functionality and thereby will enhance performance and extend lifetimes. For these applications, the status, R&D needs, barriers of implementation, and insertion strategies will be discussed.

Aerospace applications include (1) active control of thin boundary layer flows with the potential to eliminate conventional flight control surfaces, reduce drag, provide lift-on-demand, and enhance aerodynamic performance of compressors, turbines and low-observable intakes, (2) complete inertial and navigation units on a single chip which offer major advantages in terms of size, weight and cost over conventional systems, (3) fuzing/safety & arming systems for torpedo applications, (4) micro power generation using micro fuel cells and micro engines for potential standalone sensors and actuators with wireless communication, and micro rockets, (5) applications in harsh environments (e.g., high temperatures, large number of vibrational cycles, erosive flows, and corrosive media), and (6) applications for autonomous inventory & storage environments monitoring and for service life predictions. Following on from these MEMS applications, Micro-Optic-Electro-Mechanical-Systems (MOEMS) are described in the context of optical communication & sensing systems.

Les applications aérospatiales des MEMS

(RTO-EN-AVT-105)

Synthèse

Les MEMS sont des dispositifs miniaturisés intégrant des actionneurs, des capteurs et un processeur (dispositif de commande) et constituant des systèmes intelligents. Ils sont caractérisés par leur parenté avec les composants des circuits intégrés tant du point de vue de leurs techniques de fabrication que par leurs possibilités d'intégration dans l'électronique. Suite à son émergence à la fin des années '80, le MEMS a trouvé sa place sur des marchés commerciaux estimés à des milliards de dollars, en particulier dans les domaines de la médecine, de l'automobile et des télécommunications. Ce cycle de conférences examinera les applications dans le domaine aérospatial, qui doivent répondre à des conditions d'environnement et à des spécifications de fiabilité difficiles.

Suite à une introduction aux technologies du MEMS, six applications sont décrites où le MEMS permettrait de développer de nouvelles capacités. Elles promettent des fonctionnalités haut de gamme à coût modique qui permettront d'améliorer les performances et augmenter la durée de vie du matériel militaire. L'état d'avancement, les besoins en R&D, les obstacles à la mise en œuvre et les stratégies d'insertion de ces applications seront discutés.

Les applications aérospatiales comprennent (1) le contrôle actif des écoulements de couches limites minces pouvant éliminer les gouvernes classiques, réduire la traînée, fournir la sustentation à la demande et améliorer les performances aérodynamiques des compresseurs, turbines et prises d'air « indétectables », (2) des centrales inertielles et de navigation sur une seule puce qui offrent des avantages majeurs d'encombrement, de masse et de coût par rapport aux systèmes classiques, (3) des systèmes d'allumage/sécurité et mécanismes d'armement pour des applications torpilles, (4) la micro-production d'énergie à l'aide de micro-piles à combustible, et des micro-moteurs pour des capteurs et actionneurs autonomes avec communication sans fil et micro-fusées, (5) des applications pour environnements difficiles (par exemple, les hautes températures, les cycles vibratoires élevés, les écoulements érosifs et les milieu corrosifs) et (6) des applications pour le contrôle autonome d'environnements d'inventaire et de stockage, ainsi que pour la prévision de la durée de vie utile. Suite à ces présentations sur le MEMS, le systèmes micro-optico-électro-mécaniques (MOEMS) sont décrits dans le contexte de systèmes de communication et de détection.

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MEMS (Micro-Electro-Mechanical System)
Microelectronics
Microminiaturization
Microsensors
Microsystems
Microtechnology
Military applications
MOEMS (Micro-Optic-Electro-Mechanical System)
Monitors
Optical equipment
Reliability
Safety and arming (ordnance)
Service life
Wireless communications

14. Abstract

This Lecture Series provides an introduction into MEMS technology and then focuses on six potential applications, namely micro-flow control, IMU, fuze/safety & arming, micro power, gas turbines applications, inventory and health monitoring of munitions. Also an introduction into MOEMS (Micro-Optical-Electro-Mechnical-Systems) will be provided.

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