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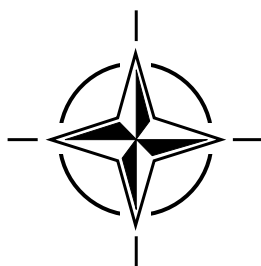
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RTO EDUCATIONAL NOTES 9

Development and Operation of UAVs for Military and Civil Applications

(Développement et utilisation des avions sans pilote (UAV) pour des applications civiles et militaires)

This report is a compilation of the edited proceedings of the “Development and Operation of UAVs for Military and Civil Applications” course held at the von Kármán Institute for Fluid Dynamics (VKI) in Rhode-Saint-Genèse, Belgium, 13-17 September 1999.



Published April 2000

Distribution and Availability on Back Cover

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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.

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- SAS Studies, Analysis and Simulation
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- SET Sensors and Electronics Technology
- IST Information Systems Technology
- AVT Applied Vehicle Technology
- HFM Human Factors and Medicine
- MSG Modelling and Simulation

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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Published April 2000

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ISBN 92-837-1033-9



*Printed by Canada Communication Group Inc.
(A St. Joseph Corporation Company)
45 Sacré-Cœur Blvd., Hull (Québec), Canada K1A 0S7*

Development and Operation of UAVs for Military and Civil Applications

(RTO EN-9)

Executive Summary

This international Special Course brought together 60 engineers and scientists (47 observers and 13 lecturers) from 14 different countries. It was a full five-day course organized from 13th to 17th September 1999.

The first lecture, "UAVs: Overview of the Current Situation and Potential for the Future", emphasized UAV classification with respect to the mission, vehicle performance, (range, altitude, endurance), the type of payload and the launch and recovery requirements. Problems related to "Airspace Policy and Air Traffic Management" were the subject of the second lecture. These are challenges for which effective solutions are urgently required in the next few years, especially in Europe where the airspace is already very crowded. The first day ended with a lecture on C3, highlighting the issues arising when the crew are removed from the aircraft.

The second day started with a lecture on "Tools for Optimization and Validation of System Architecture and Software", addressing the need for optimization and the techniques already available today. The lecture on "Design and Airworthiness Requirements for Unmanned Air Vehicle Systems" examined the safety implications and factors to be considered for the procurement of a UAV and identified the design requirements to be used as a guide to produce an air vehicle specification. Aspects of vehicle and payload control were dealt with during the lecture on "UAV Datalinks: Tasks, Types, Techniques and Examples".

On Wednesday a lecture was given on "The Developmental and Operational Challenges of UAV and UCAV Airbreathing Propulsion". Benefits, advantages and disadvantages of various types of UAV propulsion technologies were reviewed. Case histories on Pioneer, Predator and Global Hawk were presented. The afternoon was dedicated to micro aerial vehicles. A lecture entitled "Microflyers and Aerial Robots: Missions and Design Criteria" provided an overview of the issues surrounding the design and choice of appropriate missions for this class of unmanned flying vehicles.

"Aerodynamic Measurements at Low Reynolds Numbers for Fixed Wing Micro Air Vehicles" was the subject of a half day lecture given on Thursday. The results of a study of the methods that can be used to obtain reliable force and moment data on thin wings in wind and water tunnels were presented as well as balance characteristics and validation. During the lecture on "Tactical Payloads for UAVs" various imaging and non-imaging sensors were described.

On Friday the main subject of the lecture on "Various sensors aboard UAVs" was Synthetic Aperture Radar (SAR). The working principles, challenges and future developments of this complex imaging sensor were translated into understandable words for observers not familiar with the subject. The lecture on "Use Case Analysis and the Formulation of Functional Requirements for Complex Systems: A Case Study for UAVs" gave an example on how modern mathematical tools can be applied for the elaboration of a Request for Proposal (RFP). Finally, the last lecture entitled "The B-Hunter UAV System" illustrated some modifications and upgrades of the Hunter UAV to fulfill the requirements of the RFP issued by the Belgian Army.

Développement et utilisation des avions sans pilote (UAV) pour des applications civiles et militaires

(RTO EN-9)

Synthèse

Ce cours spécial international a rassemblé 60 ingénieurs et scientifiques (47 observateurs et 13 conférenciers) ressortissants de 14 pays différents pour une période de cinq jours, du 13 au 17 septembre 1999.

Le premier cours, «Les UAV, tour d'horizon de la situation actuelle et perspectives d'avenir» a mis l'accent sur la classification des UAV par rapport à la mission, aux performances (portée, altitude, endurance), au type de charge utile et aux besoins en matière de lancement et de récupération. Les problèmes relatifs à «La politique de gestion de l'espace aérien et la gestion du trafic aérien» ont fait l'objet du deuxième cours. Il s'agissait des défis pour lesquels des solutions efficaces doivent être rapidement trouvées au cours des prochaines années, surtout en Europe où l'espace aérien est déjà très encombré. Le premier jour s'est achevé par un cours sur le C3 qui a mis en relief les problèmes qui se posent dès qu'il est fait abstraction de l'équipage.

La deuxième journée a débuté par un cours sur «Les outils d'optimisation et de validation des architectures et des logiciels des systèmes» qui a souligné le besoin d'optimisation, ainsi que les techniques déjà disponibles. Le cours sur «Les spécifications de conception et d'aptitude au vol des systèmes UAV», a ensuite examiné les conséquences pour la sécurité et les facteurs à prendre en considération lors de l'achat d'un UAV. Les spécifications de conception à suivre lors de l'établissement des spécifications techniques d'un véhicule aérien ont été décrites. Enfin, certains aspects du contrôle des véhicules et de leurs charges utiles ont été traités lors du cours sur «Les UAV et les liaisons de données : Tâches, types, techniques et exemples».

Le mercredi, un cours a été donné sur «Les défis liés au développement et à l'utilisation opérationnelle de la propulsion aérobique des UAV et UCAV». L'intérêt, les avantages et les désavantages de différents types de technologies de propulsion pour UAV ont été étudiés. Des études de cas concernant les Pioneer, Predator et Global Hawk ont été présentées. L'après-midi a été consacré aux micro-véhicules aériens. Une communication intitulée «Les micro-avions et les robots aériens : Missions et critères de conception» a fait un tour d'horizon des questions d'actualité concernant la conception et le choix de missions appropriées pour cette catégorie de véhicules aériens sans pilote.

«Les mesures aérodynamiques aux faibles nombres de Reynolds pour les micro-véhicules aériens à voilure fixe» a été le sujet d'un cours d'une demi-journée le jeudi. Les résultats d'une étude sur les méthodes d'obtention de données fiables sur les forces et les moments exercés sur les voilures minces en soufflerie et en tunnel hydrodynamique ont été présentés, ainsi que les caractéristiques de centrage et leur validation. La communication sur «Les charges utiles tactiques pour UAV» a décrit différents types de capteurs d'images et autres.

Le vendredi, les radars à synthèse d'ouverture SAR ont été le principal sujet de la communication sur «Les différents capteurs embarqués sur UAV». Les principes de fonctionnement, les défis et le développement de ce capteur complexe ont été exprimés d'une manière claire et compréhensible même pour l'observateur inexpérimenté. La communication sur «L'analyse des cas d'utilisation et la définition des caractéristiques fonctionnelles des systèmes complexes : Une étude de cas pour les UAV» a présenté un exemple de mise en oeuvre d'outils mathématiques modernes pour l'élaboration d'un appel d'offre (RFP). Enfin, la dernière communication sur «Le système UAV B-Hunter», a illustré certaines modifications et améliorations apportées à l'UAV Hunter afin de répondre aux exigences du RFP émis par l'armée Belge.

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Publications of the RTO Applied Vehicle Technology Panel

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Design for Low Cost Operation and Support

MP-37, Spring 2000

Structural Aspects of Flexible Aircraft Control

MP-36, Spring 2000

Aerodynamic Design and Optimization of Flight Vehicles in a Concurrent Multi-Disciplinary Environment

MP-35, Spring 2000

Gas Turbine Operation and Technology for Land, Sea and Air Propulsion and Power Systems (Unclassified)

MP-34, Spring 2000

New Metallic Materials for the Structure of Aging Aircraft

MP-25, Spring 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

Qualification of Life Extension Schemes for Engine Components

MP-17, March 1999

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

MP-15, February 1999

Design Principles and Methods for Aircraft Gas Turbine Engines

MP-8, February 1999

Airframe Inspection Reliability under Field/Depot Conditions

MP-10, November 1998

Intelligent Processing of High Performance Materials

MP-9, November 1998

Exploitation of Structural Loads/Health Data for Reduced Cycle Costs

MP-7, November 1998

Missile Aerodynamics

MP-5, November 1998

EDUCATIONAL NOTES

Measurement Techniques for High Enthalpy and Plasma Flows

EN-8, Spring 2000

Development and Operation of UAVs for Military and Civil Applications

EN-9, April 2000

Planar Optical Measurements Methods for Gas Turbine Engine Life

EN-6, September 1999

High Order Methods for Computational Physics, Published jointly with Springer-Verlag, Germany

EN-5, March 1999

Fluid Dynamics Research on Supersonic Aircraft

EN-4, November 1998

Integrated Multidisciplinary Design of High Pressure Multistage Compressor Systems

EN-1, September 1998

TECHNICAL REPORT

Recommended Practices for Monitoring Gas Turbine Engine Life Consumption

TR-28, Spring 2000

Verification and Validation Data for Computational Unsteady Aerodynamics

TR-26, Spring 2000

A Feasibility Study of Collaborative Multi-facility Windtunnel Testing for CFD Validation

TR-27, December 1999

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REPORT DOCUMENTATION PAGE

1. Recipient's Reference	2. Originator's References RTO-EN-9 AC/323(AVT)TP/24	3. Further Reference ISBN 92-837-1033-9	4. Security Classification of Document UNCLASSIFIED/ UNLIMITED																						
5. Originator Research and Technology Organization North Atlantic Treaty Organization BP 25, 7 rue Ancelle, F-92201 Neuilly-sur-Seine Cedex, France																									
6. Title Development and Operation of UAVs for Military and Civil Applications																									
7. Presented at/sponsored by the Applied Vehicle Technology Panel (AVT) and held at the von Kármán Institute for Fluid Dynamics (VKI) in Rhode-Saint-Genèse, Belgium, 13-17 September 1999.																									
8. Author(s)/Editor(s) Multiple			9. Date April 2000																						
10. Author's/Editor's Address Multiple			11. Pages 308																						
12. Distribution Statement There are no restrictions on the distribution of this document. Information about the availability of this and other RTO unclassified publications is given on the back cover.																									
13. Keywords/Descriptors <table border="0"><tr><td>UAV (Unmanned Aerial Vehicle)</td><td>Data links</td></tr><tr><td>Airspace</td><td>Remotely operated vehicles</td></tr><tr><td>Air traffic control</td><td>Robots</td></tr><tr><td>Command and control</td><td>Detectors</td></tr><tr><td>Optimization</td><td>Reynolds number</td></tr><tr><td>Systems analysis</td><td>Aerodynamic characteristics</td></tr><tr><td>Computer architecture</td><td>Synthetic aperture radar</td></tr><tr><td>Design</td><td>Drone aircraft</td></tr><tr><td>Airworthiness</td><td>Command control communications</td></tr><tr><td>Payloads</td><td>Airbreathing propulsion</td></tr><tr><td>Control equipment</td><td></td></tr></table>				UAV (Unmanned Aerial Vehicle)	Data links	Airspace	Remotely operated vehicles	Air traffic control	Robots	Command and control	Detectors	Optimization	Reynolds number	Systems analysis	Aerodynamic characteristics	Computer architecture	Synthetic aperture radar	Design	Drone aircraft	Airworthiness	Command control communications	Payloads	Airbreathing propulsion	Control equipment	
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14. Abstract Lecture Notes for the RTO Applied Vehicle Panel (AVT) Special Course on "Development and Operation of UAVs for Military and Civil Applications" have been assembled in this report. The following topics were covered: Overview of current UAV systems and potential for the future, Design and airworthiness requirements, Propulsion systems, Airbreathing propulsion for UAVs, Microflyers, Experimental research at low Reynolds numbers, Payloads and sensors, Datalinks, Airspace policy, Air traffic management and Tools for software and system architecture validation. The material assembled in this report was prepared under the combined sponsorship of the RTO Applied Vehicle Technology Panel, the Consultant and Exchange Programme of RTO, the von Kármán Institute for Fluid Dynamics (VKI), and the NATO Partnership for Peace Programme.																									



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Printed by Canada Communication Group Inc.
(A St. Joseph Corporation Company)
45 Sacré-Cœur Blvd., Hull (Québec), Canada K1A 0S7