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STO TECHNICAL REPORT **TR-AVT-202**

Extensions of Fundamental Flow Physics to Practical MAV Aerodynamics

(Elargissement de la physique fondamentale
des écoulements à l'aérodynamique
pratique des MAV)

AVT-202 Final Report.

Published May 2016

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The NATO Science and Technology Organization

Science & Technology (S&T) in the NATO context is defined as the selective and rigorous generation and application of state-of-the-art, validated knowledge for defence and security purposes. S&T activities embrace scientific research, technology development, transition, application and field-testing, experimentation and a range of related scientific activities that include systems engineering, operational research and analysis, synthesis, integration and validation of knowledge derived through the scientific method.

In NATO, S&T is addressed using different business models, namely a collaborative business model where NATO provides a forum where NATO Nations and partner Nations elect to use their national resources to define, conduct and promote cooperative research and information exchange, and secondly an in-house delivery business model where S&T activities are conducted in a NATO dedicated executive body, having its own personnel, capabilities and infrastructure.

The mission of the NATO Science & Technology Organization (STO) is to help position the Nations' and NATO's S&T investments as a strategic enabler of the knowledge and technology advantage for the defence and security posture of NATO Nations and partner Nations, by conducting and promoting S&T activities that augment and leverage the capabilities and programmes of the Alliance, of the NATO Nations and the partner Nations, in support of NATO's objectives, and contributing to NATO's ability to enable and influence security and defence related capability development and threat mitigation in NATO Nations and partner Nations, in accordance with NATO policies.

The total spectrum of this collaborative effort is addressed by six Technical Panels who manage a wide range of scientific research activities, a Group specialising in modelling and simulation, plus a Committee dedicated to supporting the information management needs of the organization.

- AVT Applied Vehicle Technology Panel
- HFM Human Factors and Medicine Panel
- IST Information Systems Technology Panel
- NMSG NATO Modelling and Simulation Group
- SAS System Analysis and Studies Panel
- SCI Systems Concepts and Integration Panel
- SET Sensors and Electronics Technology Panel

These Panels and Group are the power-house of the collaborative model and are made up of national representatives as well as recognised world-class scientists, engineers and information specialists. In addition to providing critical technical oversight, they also provide a communication link to military users and other NATO bodies.

The scientific and technological work is carried out by Technical Teams, created under one or more of these eight bodies, for specific research activities which have a defined duration. These research activities can take a variety of forms, including Task Groups, Workshops, Symposia, Specialists' Meetings, Lecture Series and Technical Courses.

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AVT-202 Membership List

CO-CHAIRS

Dr. Michael OL
Air Force Research Lab, AFRL/VAAA
2130 8th Street, Building 45
Wright-Patterson AFB, OH 45433-7542
UNITED STATES
Email: michael.ol@us.af.mil

Prof. Holger BABINSKY
University of Cambridge, Engineering Department
Trumpington Street
Cambridge CB2 1PZ
UNITED KINGDOM
Email: hb@eng.cam.ac.uk

MEMBERS

AUSTRALIA

Mr. Jan DROBIK
DSTO
506 Lorimer Street
Fishermans Bend, Victoria 3207
Email: jan.drobik@dsto.defence.gov.au

Dr. Jennifer L. PALMER
DSTO, Air Vehicles Division, GPO Box 4331
Melbourne, Victoria 3001
Email: jennifer.palmer@dsto.defence.gov.au

CANADA

Dr. David RIVAL
Queen’s University, McLaughlin Hall
130 Stuart Street
Kingston, Ontario K7L 3N6
Email: d.e.rival@queensu.ca

FRANCE

Dr. Jean-Bernard PAQUET
ONERA
5 Bd. Painlevé
59045 Lille Cedex
Email: jean-bernard.paquet@onera.fr

GERMANY

Dr.-Ing. Rainer HAIN
Universitaet der Bundeswehr Muenchen
Institute of Fluid Mechanics and Aerodynamics
Werner-Heisenberg-Weg 39
D-85577 Neubiberg
Email: rainer.hain@unibw.de

Dr. Ing. Robert KONRATH
DLR
Institute für Aerodynamk under Stroemungstechnik
Experimentelle Verfahren
Bunsenstrasse 10
D-37073 Goettingen
Email: robert.konrath@dlr.de

Prof. Dr.-Ing. Rolf Ernst RADESPIEL
Technische Universitaet Braunschweig
Institut für Strömungsmechanik
Technische Universität Braunschweig
Hermann-Blenk-Str. 37
D-38108 Braunschweig
Email: r.radespiel@tu-bs.de

ISRAEL

Prof. Gil IOSILEVSKII
Israel Institute of Technology
Aerospace Engineering
Technion City, Haifa 32000
Email: igil@aerodyne.technion.ac.il

TURKEY

M.Sc. Mustafa PERCIN
TU Delft
Delft University of Technology
Faculty of Aerospace Engineering
Aerodynamics Group, Building 64
Kluyverweg 2
2629 HT Delft
Email: m.percin@tudelft.nl

NETHERLANDS

Dr. Ir. Bas VAN OUDHEUSDEN
Delft University of Technology
Dept. of Aerospace Engineering
Kluyverweg 1
2629 HS Delft
Email: b.w.vanoudheusden@tudelft.nl

POLAND

PhD. Dr. Tomasz KOZLOWSKI
Wroclaw University of Technology
Wybrzeze Wyspianskiego 27
50-370 Wroclaw
Email: tomasz.kozlowski@pwr.wroc.pl

Prof. Hernyk KUDELA
Wroclaw University of Technology
Wybrzeze Wyspianskiego 27
50-370 Wroclaw
Email: henryk.kudela@pwr.wroc.pl

Prof. Krzysztof SIBILSKI
Air Force Institute of Technology
Ks Boleslawa 6, P.O. Box 96
01-494 Warsaw
Email: sibilski@hot.pl

TURKEY

Dr. N.L. Oksan CETINER-YILDIRIM
Istanbul Technical University
Faculty of Aeronautics and Astronautics
34469 Maslak, Istanbul
Email: cetiner@itu.edu.tr

Mr. Arif Cem GOZUKARA
Aselsan Inc. MGEO Division
Cankiri yolu 7. km Akyurt
06750 Ankara
Email: cgozukar@mgeo.aselsan.com.tr

Asst. Prof. Dr. Dilek Funda KURTULUS
Middle East Technical University
Aerospace Engineering Department
06531 Ankara
Email: dfunda@ae.metu.edu.tr

Prof. Mehmet SAHIN
Istanbul Technical University
Faculty of Aeronautics and Astronautics
34469 Maslak, Istanbul
Email: msahin@itu.edu.tr

UNITED KINGDOM

Prof. Kwing-So CHOI
University of Nottingham
Faculty of Engineering, University Park
Nottingham NG7 2RD
Email: kwing-so.choi@nottingham.ac.uk

UNITED STATES

Prof. Luis BERNAL
University of Michigan
1320 Beal Avenue
Ann Arbor, MI 48109-2140
Email: lpb@umich.edu

Dr. Kenneth GRANLUND
Universal Technologies Corporation
Air Force Research Lab.
Air Vehicles Directorate
2130 8th Street, Building 45
Wright-Patterson AFB, OH 45433-7542
Email: kenneth.granlund@wpafb.af.mil

Dr. Anya JONES
University of Maryland
Department of Aerospace Engineering
3154 Martin Hall
College Park, MD 20942
Email: arjones@umd.edu

Dr. Matthew MUNSON
US Army Research Laboratory
Autonomous Systems Division
RDRL-VTA (Building 1120B)
Aberdeen Proving Ground, MD 21005
Email: matthew.j.munson6.civ@mail.mil

Dr. Douglas SMITH
Air Force Office of Scientific Research
875 N. Randolph Street
Suite 325, Room 3122
Arlington, VA 22203
Email: douglas.smith.67@us.af.mil

Dr. Gregg ABATE
Air Force Office of Scientific Research (AFOSR)
European Office of Aerospace Research and Development (EOARD)
86 Blenheim Crescent
Ruislip HA4 7HB
UNITED KINGDOM
Email: gregg.abate@us.af.mil

CONTRIBUTORS

CANADA

Prof. Dominique POIREL
Royal Military College of Canada
Department of Mechanical Engineering
P.O. Box 17000, Stn Forces
Kingston, Ontario K7K 7B4
Email: poirel-d@rmc.ca

Dr.-Ing. Weixing YUAN
National Research Council of Canada
Institute for Aerospace Research (Uplands, U66)
Ottawa, Ontario K1A 0R6
Email: weixing.yuan@nrc-cnrc.gc.ca

FRANCE

Mr. Olivier MARQUET
ONERA, French Aerospace Laboratory
Chalais Meudon Center
Fundamental and Experimental Aerodynamic Department
8, rue des Vertugadins
92190 Meudon
Email: olivier.marquet@onera.fr

GERMANY

Prof. Dr. Andreas DILLMANN
German Aerospace Center
Institute of Aerodynamics and Flow Technology
D-37073 Göttingen
Email: Andreas.Dillmann@dlr.de

M.Sc. Hauke EHLERS
German Aerospace Center
Bunsenstraße 10
D-37073 Göttingen
Email: hauke.ehlers@dlr.de

Prof. Dr. Cameron TROPEA
Technische Universität Darmstadt
Fachgebiet Strömungslehre und Aerodynamik
Petersenstr. 30
D-64287 Darmstadt
Email: ctropea@sla.tu-darmstadt.de

Mr. Alexander WIDMANN
TU Darmstadt
Karolinenplatz 5
D-64289 Darmstadt
Email: awidmann@sla.tu-darmstadt.de

ISRAEL

Dr. Yossef ELIMELECH
Technion – Israel Institute of Technology
Haifa 32000
Email: meitalyossi.elimelech@gmail.com

ITALY

Dr. Flavio NOCA
Hepia – University of Applied Sciences Western
Rue de la Prairie 4
1202 – Geneva
SWITZERLAND
Email: flavio.noca@hesge.ch

TURKEY

Mr. Muhittin GOCER
TAI – Turkish Aerospace Industries Inc.
Fethiye Mah.Havacilik Blv.No. 17
06980 Kazan-Ankara
Email: mugocer@tai.com.tr

UNITED KINGDOM

Dr. Richard BOMPHREY
University of Oxford, Department of Zoology
South Parks Road
Oxford OX1 3PS
Email: richard.bomphrey@zoo.ox.ac.uk

Dr. Kevin KNOWLES
Cranfield University
DCMT
Shrivenham, Wiltshire SN6 8LA
Email: K.Knowles@cranfield.ac.uk

Dr. Nathaniel PHILLIPS
University of Oxford
Department of Zoology
The Tinbergen Building
South Parks Road
Oxford OX1 3PS
Email: nathan.phillips@zoo.ox.ac.uk

Mr. Charles PITT FORD
University of Cambridge
Trumpington Street
Cambridge CB2 1PZ
Email: cwp24@cam.ac.uk

UNITED KINGDOM (cont'd)

Mr. Patrick, Robert (Robbie), James STEVENS
University of Cambridge
Engineering Department
Trumpington Street
Cambridge CB2 1PZ
Email: prrjs2@cam.ac.uk

UNITED STATES

Prof. Carlos CESNIK
University of Michigan
Department of Aerospace Engineering
1320 Beal Avenue, 3024 FXB
Ann Arbor, MI 48109-2140
Email: cesnik@umich.edu

Prof. Jeff ELDREDGE
UCLA
48-121A Engineering IV
420 Westwood Plaza
Los Angeles, CA 90095-1597
Email: eldredge@seas.ucla.edu

Dr. Ray GORDNIER
Air Force Research Lab
AFRL/VAAC
Computational Sciences Branch
2210 8th Street, Building 146
Wright-Patterson AFB, OH 45433-7512
Email: raymond.gordnier@wpafb.af.mil

Mr. Adam HART
University of Florida REEF
1350 N. Poquito Road
Shalimar, FL 32579
Email: darock@ufl.edu

Mr. Field MANAR
University of Maryland
College Park, MD 20742
Email: fmanar@umd.edu

Mr. Peter MANCINI
University of Maryland
College Park, MD 20742
Email: petri1123@gmail.com

Mr. Ryan RANDALL
The University of Arizona
Aerospace and Mechanical Engineering
P.O. Box 210119
Tucson, AZ 85721-0119
Email: Ryan18rmr@yahoo.com

Dr. Matthew RINGUETTE
State University of New York at Buffalo
318 Jarvis Hall
Buffalo, NY 14260
Email: ringum@buffalo.edu

Prof. Sergey SHKARAYEV
University of Arizona
Aerospace and Mechanical Engineering Department
1130 N. Mountain Avenue
Tucson, AZ 85721-0119
Email: svs@Email.arizona.edu

Mr. Lawrence UKEILEY
University of Florida
REEF Dept. of Mechanical and Aerospace Eng.
1350 N. Poquito Road
Shalimar, FL 32579
Email: ukeiley@reef.ufl.edu

Dr. Miguel R. VISBAL
Air Force Research Lab.
Air Vehicles Directorate, AFRL/VAAC
2210 8th Street, Building 146B
Wright-Patterson AFB, OH 45433-7521
Email: miguel.visbal@wpafb.af.mil

AVT PANEL MENTOR

Dr. Siva S. BANDA
US Air Force Research Lab, AFRL/RQ
2130 8th Street
Wright-Patterson AFB, OH 45433
UNITED STATES
Email: siva.banda@us.af.mil

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14. Abstract

In massively unsteady wing-flows, organized flow-separation may increase lift well above steady-state. We explore imposed rotations and rectilinear translations of rigid flat plates in incompressible flow, comparing a linear-ramp angle of attack change with streamwise acceleration (surge). In rotation, the plate revolves about an axis inboard of its inboard tip, notionally representative of a flapping-wing. Experiment, computation and analysis culminated in a two-dimensional lumped-vortex model for physics-based accounting of lift history. Rotation was found to stabilize the leading edge vortex, at least for inboard spanwise locations; the vortex sheds after saturation for the translational case. However, no advantage in peak lift or lift to drag ratio was found in rotation during the manoeuvre itself. Pitching causes a large force transient, both for rotation and translation, relative to surging; this is due to pitch-rate effects, predicted by unsteady aerofoil theory, which also accurately handles apparent-mass effects. For translation, > 10 convective times are needed for the post-manoeuvre lift transient to relax; the rotational case reaches a steady lift value in ~ 5 convective times, and this steady value is higher than for translation. Thus rotation offers a steady-state advantage in lift, but not a transient one, owing to leading-edge vortex behaviour.

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CANADA
DGSIST
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101 Colonel By Drive, 6 CBS
Ottawa, Ontario K1A 0K2

DANEMARK
Danish Acquisition and Logistics Organization
(DALO)
Lautrupbjerg 1-5
2750 Ballerup

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Área de Cooperación Internacional en I+D
SDGPLATIN (DGAM)
C/ Arturo Soria 289
28033 Madrid

ESTONIE
Estonian National Defence College
Centre for Applied Research
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Tartu 51013

ETATS-UNIS
Defense Technical Information Center
8725 John J. Kingman Road
Fort Belvoir, VA 22060-6218

FRANCE
O.N.E.R.A. (ISP)
29, Avenue de la Division Leclerc
BP 72
92322 Châtillon Cedex

GRECE (Correspondant)
Defence Industry & Research General
Directorate, Research Directorate
Fakinos Base Camp, S.T.G. 1020
Holargos, Athens

HONGRIE
Hungarian Ministry of Defence
Development and Logistics Agency
P.O.B. 25
H-1885 Budapest

ITALIE
Centro Gestione Conoscenza
Secretariat General of Defence
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LUXEMBOURG
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Norwegian Defence Research
Establishment
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Akadémia ozbrojených síl gen.
M.R. Štefánika, Distribučné a
informačné stredisko STO
Demänová 393
031 06 Liptovský Mikuláš 6

SLOVENIE
Ministry of Defence
Central Registry for EU & NATO
Vojkova 55
1000 Ljubljana

TURQUIE
Milli Savunma Bakanlığı (MSB)
ARGE ve Teknoloji Dairesi
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Ministry of Defence
Defence Institute "Prof. Tsvetan Lazarov"
"Tsvetan Lazarov" bul no.2
1592 Sofia

CANADA
DSTKIM
Defence Research and Development Canada
101 Colonel By Drive, 6 CBS
Ottawa, Ontario K1A 0K2

CZECH REPUBLIC
Vojenský technický ústav s.p.
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DENMARK
Danish Acquisition and Logistics Organization (DALO)
Lautrupbjerg 1-5
2750 Ballerup

ESTONIA
Estonian National Defence College
Centre for Applied Research
Riia str 12
Tartu 51013

FRANCE
O.N.E.R.A. (ISP)
29, Avenue de la Division Leclerc – BP 72
92322 Châtillon Cedex

GERMANY
Streitkräfteamt / Abteilung III
Fachinformationszentrum der Bundeswehr (FIZBw)
Gorch-Fock-Straße 7
D-53229 Bonn

GREECE (Point of Contact)
Defence Industry & Research General Directorate, Research Directorate
Fakinos Base Camp, S.T.G. 1020
Holargos, Athens

HUNGARY
Hungarian Ministry of Defence
Development and Logistics Agency
P.O.B. 25
H-1885 Budapest

ITALY
Centro Gestione Conoscenza
Secretariat General of Defence
National Armaments Directorate
Via XX Settembre 123/A
00187 Roma

LUXEMBOURG
See Belgium

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Royal Netherlands Military Academy Library
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Norwegian Defence Research Establishment, Attn: Biblioteket
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Centralna Biblioteka Wojskowa
ul. Ostrobramska 109
04-041 Warszawa

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Estado Maior da Força Aérea
SDFA – Centro de Documentação
Alfragide
P-2720 Amadora

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Romanian National Distribution Centre
Armaments Department
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Sector 6
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031 06 Liptovský Mikuláš 6

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Ministry of Defence
Central Registry for EU & NATO
Vojkova 55
1000 Ljubljana

SPAIN
Área de Cooperación Internacional en I+D
SDGPLATIN (DGAM)
C/ Arturo Soria 289
28033 Madrid

TURKEY
Milli Savunma Bakanlığı (MSB)
ARGE ve Teknoloji Dairesi Başkanlığı
06650 Bakanliklar – Ankara

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Dstl Porton Down, Salisbury SP4 0JQ

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