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RTO TECHNICAL REPORT **TR-HFM-162**

Rotary-Wing Brownout Mitigation: Technologies and Training

(Remèdes contre le phénomène de brownout sur les appareils à voilure tournante : Technologies et entraînement)

This Report documents the findings of Task Group HFM-162 (2008 – 2011) that investigated the training and technologies employed by member NATO Nations to mitigate the impact of brownout on rotary-winged operations.

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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 System Analysis and Studies 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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List of Acronyms

2-D	Two Dimensional
3-D	Third Dimensional
AAFD	Army Aeroflightdynamics Directorate
AATD	Aviation Applied Technology Directorate
ACAH	Attitude Command Attitude Hold
AFCS	Automated Flight Control System
AFDD	Aeroflightdynamics Directorate
AFRL	Air Force Research Laboratory
AGL	Above Ground Level
ALARP	As Low As Reasonably Practical
AMRDEC	Aviation and Missile Research Development and Evaluation Centre
AUM	All Up Mass
AVS	Advanced Vision System
BOSS	Brownout Symbology System
BRU	Boresight Reticule Unit
BSAU	Brownout Situational Awareness Upgrade
CAAS	Common Avionics Architecture System
CG	Center of Gravity
CMOTS	Commercial Military Off-The-Shelf
CNS	Central Nervous System
CONOPS	Concept of Operations
CRM	Crew Resource Management
CRT	Cathode-Ray Tube
CSAR	Combat Search And Rescue
DAFCS	Digital Advanced Flight Control Systems
DARPA	Defence Advanced Research Projects Agency
DAS	Distributed Aperture System
DNVG	Display Night Vision Goggle
DoD	Department of Defense
DSTL	Defence Science and Technology Laboratory
DTED	Digital Terrain and Elevation Database
DVE	Degraded Visual Environments
EGI	Embedded GPS/Inertial system
FARP	Forward Arming and Refuel Point
FLIR	Forward-Looking Infrared
FM	Frequency Modulation
FOR	Field Of Regard
FOV	Field Of View
GHz	Gigahertz
GPS	Global Positioning System
GVE	Good Visual Environment

HALS	Helicopter Autonomous Landing System
HAT	Height Above Terrain
HDD	Head-Down Display
HFM	Human Factors and Medicine
HMD	Helmet-Mounted Display
HMI	Human Machine Interface
HMSD	Helmet-Mounted Sight and Display
HOCAS	Hands On Collective And Stick
HOGE	Hover Out of Ground Effect
HP	Handling Pilot
HRM	Hover Reference Markers
HRTF	Head-Related Transfer Function
HSD	Horizontal Situation Display
HUD	Head-Up Display
Hz	Hertz
ICR	International Collaborative Research
IED	Improvised Explosive Device
IFR	Instrument Flight Rules
IMC	Instrument Meteorological Conditions
IMU	Inertial Measurement Unit
INS	Inertial Navigation System
IR	Infrared
IRBA	Institut de Recherche Biomédicale des Armées
IRT	Immediate Response Team
KIAS	Knots Indicated Airspeed
LADAR	Laser Detection And Ranging
LCD	Liquid-Crystal Display
LED	Light-Emitting Diode
LIDAR	Light Detection And Ranging
LLLTV	Low-Light-Level Television
LLTV	Low-Light Television
LOS	Line Of Sight
LP	Landing Point
LS	Landing Site
LVL	Low-Visibility Landing
LWIR	Long-Wave Infrared
LZ	Landing Zone
MFD	Multi-Function Display
MHz	Megahertz
MMW	Millimeter Wave
MW	Medium Wave
MWIR	Mid-Wave Infrared
NATO	North Atlantic Treaty Organisation
NHP	Non-Handling Pilot
NM	Nautical Miles
NVD	Night Vision Device
NVG	Night Vision Goggle

OSW	Outside World
PFP	Partners for Peace
PhLASH	Photographic Landing Augmentation System for Helicopters
PMMW	Passive Millimeter Wave
PNVS	Panoramic Night Vision System
QRF	Quick-Reaction Force
RADAR	Radio Detection And Ranging
RNLAF	Royal Netherlands Air Force
ROD	Rate Of Decent
RTO	Research and Technology Organisation
RW	Rotary Wing
RWB	Rotary-Wing Brownout
SA	Situational Awareness
SD	Spatial Disorientation
SERE	Survive Evade Resist and Extract
SOP	Standard Operating Procedure
SV	Synthetic Vision
TA	Terrain Avoidance
TF	Terrain Following
TG	Task Group
TI	Thermal Imagery
TNO	Netherlands Organization for Applied Scientific Research
TRL	Technology Readiness Level
TTCP	The Technical Cooperation Program
UAV	Unmanned Aerial Vehicle
UH	Utility Helicopter
UK	United Kingdom
US	United States
USAARL	Unites States Army Aeromedical Research Laboratory
USL	Under Slung Load
VMC	Visual Meteorological Conditions

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1st meeting: Moffett Field, CA, USA, US Army AFDD, October 2007 – Host: Mr. Zoltan Szoboszlay

2nd meeting: Paris FRA, IRBA, April 2008 – Hostess: Dr. Anne-Emmanuelle Priot

3rd meeting: Munich DEU, ESG Corp., September 2008 – Host: Capt. Detlef Kolletzki (retired)

4th meeting: Ft. Rucker, AL, USA, USAARL, March 2009 – Host: Dr. Art Estrada

5th meeting: Toronto CAN, DRDC, September 2009 – Host: Dr. Bob Cheung

6th meeting: London GBR, USAF EOARD, June 2010 – Hostess: LtCol. Tammy Savoie

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Brownout landing	Helicopter flight training	Tactile display
Brownout mitigation	Rotary-wing aircraft	White-out
Brownout symbology		

14. Abstract

The RTO HFM-162 Rotary-Wing Brownout Mitigation Task Group was formed to examine the effects of Rotary-Wing Brownout (RWB) and whiteout on pilots during operations. Brownout is the condition developed by recirculating rotor downwash as a helicopter lands or takes off in an arid or a snowy (whiteout) environment. The dust, dirt, or snow that is developed by the downwash renders out-the-cockpit visibility severely degraded or non-existent. The resultant mishaps due to the Degraded Visual Environment (DVE) are a serious problem and partner nations report losses of aircraft and personnel. This study was undertaken to investigate the incidence and severity of the problem in partner nations, to examine and document current and planned technology developments, and to evaluate and document the brownout training procedures within NATO. To provide a true, multi-purpose helicopter sensor, the TG members envision laser radar technology integrated with a navigation forward looking infrared radar. Intuitive hovering and landing cockpit display symbology, such as that described in this report, must also be an integral part of an effective system for DVE landings.

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