SCIENCE AND TECHNOLOGY ORGANIZATION

APPLIED VEHICLE TECHNOLOGY PANEL

Science & Technology Organization
Collaboration Support Office
Applied Vehicle Technology Panel

AVT-SET-396(+SCI) Research Symposium on

Technological and Operational Challenges Due To Hypersonic Flight and The Related Weapons Threat

Koblenz, Germany

14-17 October 2024

This Symposium is open to NATO Nations plus Australia and Japan

Theme-Meeting Objective:

Hypersonic flight is defined as flight in the higher atmosphere at a speed of more than Mach five (five times the speed of sound) and with the capability to do deceptive and evasive manoeuvres during flight. Hypersonics was identified as an Emerging Disruptive Technology (EDT) by NATO. It is a game-changer technology with potential benefits including increased survivability, high effectiveness against time-critical targets and strategic deterrence.

The main objectives of the Research Symposium is to distribute information, understand issues of hypersonic flight vehicles, provide a realistic appraisal of hypersonic weapons feasibility and capabilities and also help to demystify the potential threat.

Topics to be covered:

- Aerothermodynamics and effects
- Design, Structures and Materials for hypersonic vehicles (incl. material characterization at high temperatures)
- Propulsion technologies (RamJets, SCRamJets, Detonation Engines and rockets)
- Platform Technologies (HGV, HCM, HR, Interceptors)
- System Architecture Challenges (HGV, HCM, HR, Interceptors) – military requirements vs. technical needs and feasibility
- Launch Platforms - Options and Constraints
- Guidance and Control, Communication (strike and defensive)
- Onboard sensors and issues (strike and defensive)
- Detecting and tracking hypersonic weapons (RADAR, IR, related Issues)
- Defence Architecture Considerations (Defence design, Area Defence, Point Defence, synthetic environment …)

- C3I (Command, Control, Communication and Intelligence) for hypersonic weapons defence
- Conceptual Design Examples for offence (HGV,HCM, HR)
- Conceptual Design Examples for defence (Interceptors)
- Non-Kinetic Defence against hypersonic Weapons (Laser, Directed Energy, Blinding, Jamming …)

Background

The hypersonic weapons threat has emerged in recent years and operational capabilities were claimed and tested by RED Nations. The Air-Launched hypersonic missile Kinzhal is being used by Russia in the Ukraine war with limited success and in some cases, there may have been an intercept by Ukrainian air defence.

Research and development work is urgent and ongoing in NATO and affiliate Nations to build up operational capabilities for hypersonic strike and for defence against hypersonic weapons threat. For this it is paramount to understand challenges posed by hypersonic flight and design and architecture of hypersonic flight vehicles. It is equally important to understand capabilities and limitations of hypersonic weapons to design effective defence systems reaching from general architecture to the individual components for detecting, tracking and intercept.

Together with reports originated from the NATO STO activities cited before this Research Symposium will summarize state of the art technology and important fields of research to fill remaining gaps.

Development work run by NATO Nations towards operational hypersonic for strike or defence or classified intelligence will not be considered due to the ‘NU’- format of the Specialists’ Meeting. However, a broad technological overview will pinpoint key feasibility issues for hypersonic flight and related vehicles and assessment of generic weapon systems will provide important information about inherent capabilities and limitations.

Registration

Online registration for the AVT-SET-396 RSY is mandatory for all symposium delegates, programme committee members, authors, presenters and external guests. Participation is free of charge. Due to security restrictions only duly registered and re-confirmed AVT-SET-396 participants will have access to the General Information Package (GIP) with detailed information on conference location and logistics.

For online registration please go to this website:

https://events.sto.nato.int/index.php/upcoming-events/event-list/event/17-sy/591-avt-set-396-sci-rsy-on-technological-challenges-due-to-hypersonic-flight-and-the-related-weapons-threat

Registration will close 4 weeks before the event. Thank you for your cooperation.

AVT Executive Office, Collaboration Support Office (CSO), Paris – Points of Contact:

Dr. Kerstin HUBER
AVT Executive Officer
Tel: +33 (0)1 55 61 22 93
Kerstin.Huber@cso.nato.int

Ms. Isavela KONTOLAIMAKI
AVT Panel Executive Assistant
Tel: +33 (0)1 55 61 22 88
Isavela.Kontolaimaki@cso.nato.int

Ms Isabel BIANCA
AVT Panel Assistant
Tel: +33 (0)1 55 61 22 18
isabel.bianca@cso.nato.int

Programme Committee

for AVT Panel

Dipl. Ing. Hans-Ludwig BESSER
MBDA Missile Systems Germany
Hagenauer Forst 27
86529 Schrobenhausen, Germany
Tel.: +49 151 17434304
Email: hans-ludwig.besser@mbda-systems.de

for SET Panel

Prof. Dr. Daniel O'HAGAN
Fraunhofer Gesellschaft
Fraunhoferstrasse 20
5333 Wachtberg, Germany
Tel: +49 228 9435389
Email: daniel.ohagan@fhr.fraunhofer.de

for SCI Panel

Dr. Rogerio PIMENTEL
Defence Research and Development Canada
Valcartier Research Centre
2459 de la Bravoure Road,
Quebec, Canada, G3J1X5
Tel : +1 418 844 4000 4170
Email: Rogerio.GomesPimentel@forces.gc.ca

Canada

Dr. Prakash PATNAIK
Aerospace Research Centre
National Research Council Canada
1200 Montreal Road, Building M-17

Netherlands

Ms. Linda VAN DER HAM
TNO - Defence Safety and Security…
Oude Waalsdorperweg 63,
2597 AK Den Haag / The Hague, Netherlands
Tel: +31 88 866 22 23

Ottawa, Ontario, Canada, K1A 0R6
Tel: +1 613-355-5099
Email: Prakash.Patnaik@nrc-cnrc.gc.ca

Dr. Allison NOLTING
Defence Research and Development Canada
Atlantic Research Centre
PO Box 99000 Station Forces,
Dartmouth, Nova Scotia, Canada, B3K 5X5
Tel: +1 902 407 0387
Email: Allison.Nolting@forces.gc.ca

Germany
Dr. Patrick GRUHN
DLR Inst. of Aerodynamics and Flow Technology, Supersonic and Hypersonic Technologies Dept.
Linder Hoehe
51147 Cologne
Germany
Tel: +49 17193069827
Email: Patrick.Gruhn@dlr.de

Technical Evaluator
Prof. Dr.-Ing. habil. Cord C. ROSSOW
ret. Director, Institute of Aerodynamics and Flow Technology
German Aerospace Center (DLR)
Email : cord.rossow@dlr.de

Panel Mentor
for AVT-Panel
Christoph MÜLLER
MBDA Missile Systems Germany
Hagenauer Forst 27
86529 Schrobenhausen, Germany
Tel: +49 175 875 149
Email: Christoph.Mueller@mbda-systems.de

Email: Linda.Vanderham@tno.nl

USA
Prof. Dr. Russell CUMMINGS
USAF Academy
2354 Fairchild Dr., Suite 6H-101, HQ USAFA/DFAN, USAF Academy, CO 80840
USA
Tel: +17193069827
Email: Russell.Cummings@afacademy.af.edu

Denmark
Mr. Waseim ALFRED
Danish Ministry of Defence/ Acquisition and Logistics Organization
Lautrupbjerg 1-5,
2750 Ballerup
Denmark
Tel: (0045)25237978
Email: fmi-uk-vv71@mil.dk

for SET-Panel
Dr. Stefan Brueggenwirth
Fraunhofer Gesellschaft
Fraunhoferstrasse 20
5333 Wachtberg, Germany
Tel: +49 228 9435173
Email:stefan.brueggenwirth@fhr.fraunhofer.de

Programme

DAY 1

Monday, 14 October 2024, 14:00 - 17:30

Session 0 Opening & Setting the Scene

14:00		AVT-SET-396 Opening Remarks H.-L. BESSER, AVT-SET-396 Co-Chair and Special Advisor MBDA Germany, Germany
14:30	KN 1	Keynote Speaker General C. BADIA, Deputy Supreme Allied Commander Transformation, NATO Allied Command Transformation (ACT)
15:15		Fireside Chat General C. BADIA, Deputy Supreme Allied Commander Transformation, NATO Allied Command Transformation (ACT) Dr. D. ZIMPER, German Member of NATO Science & Technology Board (STB) and Member of the Board MBDA Germany, Germany
16:00	KN 2	Food for Thought on Hypersonic Operational Threats from the Operator Colonel (USAF) M. HANSON, Chief of Staff, JAPCC
16:45		Beer Call
17:30		End of Day 1

Day 2

Tuesday, 15 October 2024, 09:00 - 17:30

Session 1 Defence against Hypersonic Operational Threats – 1

09:00	1	Territorial Defence against Hypersonic Missiles Dr. G. BAHMEIER, AMDC GmbH, Germany
09:30	2	Hypersonic Encounters Dr. K. WEINAND, MBDA Germany, Germany

10:00	3	Sensor related requirements of an integrated Hypersonic Missile Defence system N. DE BRUJIN, Thales Group, The Netherlands
10:30		COFFEE BREAK

Session 2 Defence against Hypersonic Operational Threats – 2

11:00	4	The role of Radar in Hypersonic Missile Defence (HMD) Prof. Dr. D. O'HAGEN, Fraunhofer FHR, Germany
11:30	5	Battle Management and Interoperability Challenges due to the Hypersonic Weapons Threat Dr. L. VAN DER HAM, TNO, The Netherlands
12:00	6	Simulations of atmospheric hypersonic weapon intercept LtCol J. ÖSTROM, Air Force Command Finland, Finland
12:30		LUNCH

Session 3 High Speed Vehicles – 1

14:00	7	Use of Hypersonic Rockets in Ukraine - Potential versus Observed Performance W. HALSWEIJK, TNO, The Netherlands
14:30	8	Performance assessment of the DPRK's January 2022 hypersonic missiles Dr. R. SAVELSBERG, Netherlands Defence Academy, The Netherlands
15:00	9	Design and analysis of generic hypersonic glide vehicles Dr. P. GRUHN, German Aerospace Center (DLR), Germany
15:30		COFFEE BREAK

Session 4 High Speed Vehicle – 2

16:00	10	Aerodynamic wind tunnel testing on the generic hypersonic glide vehicle 1 (GHGV-1) Dr. T. GAWEHN, German Aerospace Center (DLR), Germany
16:30	11	Design of a generic hypersonic cruise missile as a basis for threat analysis Dr. J. RIEHMER, German Aerospace Center (DLR), Germany
17:00	12	Aerodynamic Controllability Testing of a Canard-Controlled Hypersonic Model in a Short Duration Facility M. VAN HOFFEN, University of Southern Queensland, Australia
17:30		End of Day 2

DAY 3 Parallel Session 1

Wednesday, 16 October 2024, 09:00 - 17:30

Session 5 High Speed Vehicles – 3

09:00 13 Analysis of the Performance and Maneuverability of a Scramjet Vehicle
Dr. Craig Johansen, THINK SOLUTIONS ENGINEERING, Canada

09:30 14 Design constraints on Hypersonic Missiles following use of a seeker
N. DE BRUIJN, Thales Group, The Netherlands

10:00 15 Including uncertainty in the impact area estimation of hypersonic glide vehicles
L. MIDDELDORP, TNO, The Netherlands

10:30 COFFEE BREAK

Session 6 Interceptor

11:00 16 Protection of High-Value Assets against Hypersonic Threats as an Interceptor Guidance Principle
H. MEIER, Diehl Defence, Germany

11:30 17 Concept Design of a Counter-Hypersonic Area Defence Interceptor
W. HALSWEIJK, TNO, The Netherlands

12:00 18 Guidance derived from optimized trajectory datasets (OTD Guidance)
J. ANDRES, MBDA Germany, Germany

12:30 LUNCH

Session 7 Propulsion – 1

14:00 19 Combined-Cycle Propulsion Technology for High-Speed Aerial Vehicles
M. CORBIELL, University of Calgary, Australia

14:30 20 Research on SCRamjet Combustion Processes at DLR Lampoldshausen
Dr. C. KIRCHBERGER, German Aerospace Center (DLR), Germany

15:00 21 APEX-TD a technology demonstrator for Ramjet and Scramjet propulsion technologies
Dr. J. Riehmer, Germany Aerospace Center (DLR), Germany

15:30 COFFEE BREAK

Session 8 Propulsion – 2

16:00 22 Ramjet Propulsion System Design against Hypersonic Threats
Dr. C. BAUER, Bayern-Chemie GmbH, Germany

16:30 23 Tactical High-speed Offensive Ramjet for Extended Range (THOR-ER) – Demonstrator Summary
E. ORBEKK, Nammo Raufoss AS, Norway

17:00 24 Scramjet Combustor Design via Assisted Multi-Objective Optimization
Prof. Dr. A. INGENITO, Sapienza University of Rome, Italy

DAY 3 **Parallel Session 2**

Wednesday, 16 October 2024, 09:00 - 17:30

Session 9 Structures and Materials – 1

09:00 25 Protective Coatings Adressing Thermal Management formulated by Physics - informed Artificial Intelligence
Dr. P. PATNAIK, Aerospace Research Centre, National Research Council Canada, Canada

09:30 26 Environmental Protection of Ceramic Matrix Composites for Hypersonic Applications
V. V. PANKOV, Aerospace Research Centre, National Research Council of Canada, Canada

10:00 27 Towards integrated thermal management prediction of aerothermal heating at hypersonic conditions
Dr. J.-P. HICKEY, University of Waterloo, Canada

10:30 COFFEE BREAK

Session 10 Structures and Materials – 2

11:00 28 Development of a Structural Toolbox for Hypersonic Flight via Ground and Flight Tests
Mr. H. WEIHS, German Aerospace Center (DLR), Germany

11:30 29 Reactive Melt Infiltration of Pitch-Based Fibre Preforms: CMC Manufacture, Characterization and Applications for Hypersonic Flight
Dr. M. FRIESS, Germany Aerospace Center (DLR), Germany

12:00 30 Nammo's Experience in Refinement of the Liquid Silicon Infiltration Method to Manufacture High Temperature Resistant Ceramic Matrix Composites of Various Geometries
F. OLUFSEN, Nammo Raufoss AS, Norway

12:30 LUNCH

Session 11 Detect and Track – 1

14:30 31 Improved Radar Detection Against Hypersonic Weapons
Dr. P. COX, TNO, The Netherlands

15:00 32 Potential Contributions of OTH-Radar Systems against Hypersonic Threats
Dr. M. GLENDE, TMS, Germany

15:30 COFFEE BREAK

Session 12 Detect and Track – 2

16:00	33	Hypersonic Radar Signatures: About the Change of Radar Microwave Scatter by Plasma, Ablation and Shock Waves Mr. R. PETERVARI, Fraunhofer FHR, Germany
16:30	34	Detection of Hypersonic Boost Glide Vehicles from Space Mr. A. GARHAMMER, AMDC GmbH, Germany
17:30		End of Day 3

DAY 4

Thursday, 17 October 2024, 08:30 - 17:30

Session 13 Structures and Materials – 3

08:30	35	Modelling and simulation of chemical reactions at the surface of an ablative wall interacting with a hypersonic flow Mr. G. CORIA, ONERA, France
09:00	36	Experimental Verification of an Ablation Model for PTFE Radome Materials in Hypersonic Applications Dr. M. FÖRSTER, MBDA Germany, Germany
09:30	37	Wind tunnel testing for the aerothermal qualification of infrared windows in high-speed missile domes Dr. O. HOHN, German Aerospace Center (DLR), Germany
10:00	38	Long duration, aerothermoelastic response of aerospace structures at Mach 4 Mr. Z. RILEY, USAF, University of Illinois, United States
10:30		COFFEE BREAK

Session 14 Aerodynamics & Aerothermal – 1

11:00	39	Aerothermodynamic Challenges of Hypersonic Flight Prof. Dr. R. CUMMINGS, US Air Force Academy, United States
11:30	40	Advances in Modeling and Simulation for Hypersonics Mr. G. CANDLER, University of Minnesota, United States
12:00	41	Test facilities in Support of Hypersonic Aeropropulsion Research Dr. R. STOWE, Defence Research and Development Canada, Valcartier Research Centre, Canada
12:30		LUNCH

Session 15 Aerodynamics & Aerothermal – 2

14:00	42	An efficient computational method for the determination of thermal loads on a hypersonic glide vehicle along its flight path Dr. C. SCHNEPF, German Aerospace Center (DLR), Germany

14:30 43 A Study of Hypersonic Aerothermal Shape Distortion Over a Reference Flight Trajectory
Mr. L. POLLOCK, University of New South Wales, Australia

15:00 44 Experiments on Supersonic Fluid-Structure Interaction for an Incident Shock Configuration in the Wind Tunnel TMK
Dr. D. DAUB, German Aerospace Center (DLR), Germany

15:30 COFFEE BREAK

Session 16 Summary and Adjourns

16:00 TE Technical Evaluator Comments and Discussion
Prof. C. ROSSOW, Germany

17:00 Closing Remarks and Future Plans
Mr. H.-L. BESSER, German Aerospace Center (DLR), Germany
Prof. D. O'HAGEN, Fraunhofer Gesellschaft, Germany

17:30 SYMPOSIUM ADJOURNS

Science and Technology Organization in NATO

In NATO, Science & Technology (S&T) 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:

- The 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.
- The 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 Science and Technology Organization - STO

The mission of the NATO 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;
- 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;
- Supporting decision-making in the NATO Nations and NATO.

Acknowledgement

AVT-SET-396 Research Symposium on Technological and Operational Challenges Due To Hypersonic Flight and The Related Weapons Threat

The Applied Vehicle Technology Panel expresses its thanks to Germany
for the invitation to hold this meeting in Koblenz and for the facilities and personnel,
which make this meeting possible.