

AVT-323 Hybrid/Electric Aero-Propulsion Systems for Military Applications

Technical Evaluation Report

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ABSTRACT

The objective of Research Symposium 323 was to convene an international grouping of scientists, engineers, end users and other important stakeholders with a specific focus on military use of hybrid/electric propulsion. The intent was to cover design and operation of future aircraft utilizing hybrid/electric and coupled aero-propulsion technologies in military applications. Although a greater number of the technical papers presented could have articulated associations with military applications, future symposia and workshops plan on a targeted technical coverage of military applications addressing specific military related challenges for focused solutions. The intent for this Research Symposium was achieved and led by two keynotes that set the stage for the 27 technical papers presented.

Key words

Research Symposium 323, hybrid/electric, military applications, Brigadier General Christian Leitges, Dr. John Cavolowsky

INTRODUCTION

The Symposium took place in the Scandic Lerkendal Hotel, Trondheim, Norway, 7 – 11 October 2019. It offered two keynote speakers: Brigadier General Christian Leitges, Head of the Air Force Principles/Future Development Division, German Air Force Headquarters, Germany, who shared perspectives about future operational requirements; and Dr. John Cavolowsky, Director of Transformative Aeronautics Concepts Program, NASA Aeronautics Research Mission Directorate (ARMD), United States, who provided an overview of technological strategies currently undertaken by NASA.

BACKGROUND

The NATO Science and Technology Organization (STO) delivers innovation, advice and scientific solutions to meet the Alliance's ever-changing needs. It ensures that NATO maintains its military and technological edge to face current and future security challenges. The STO is the world's largest collaborative research forum in the field of defense and security. Its mission is to conduct and promote co-operative research and information exchange [1].

STO consists of a three level organization: the Science and Technology Board, the Panels and the Technical Teams. The Applied Vehicle Technology (AVT) panel, comprising more than 1000 scientists and engineers, strives to improve the performance, reliability, affordability, and safety of vehicles through advancement of appropriate technologies. The Panel addresses platform technologies for vehicles operating in all domains (land, sea, air, and space), for both new and ageing systems.

PAPER SOLICITATION THEMES

The Research Symposium 323 Program Committee selected 6 themes to provide a comprehensive focus on the most challenging technical areas in aviation that face us today—namely:

- Hybrid/Electric Propulsion Systems Architectures
- Electrical Energy Storage, Power Management and Distribution
- Electrical Machines and Power Electronics
- Integrated Thermal Regulation and Control Systems
- Synergistic Aero-Propulsion Technologies
- Integrated Vehicle Design

Authors responded to these themes by submitting 27 technical papers covering the following 5 general topics which formulated the topic outline for the Symposium:

- Hybrid/Electric Research: Global Perspective (4 papers)
- Systems and Architecture (4 papers)
- Aircraft Conceptual Design (6 papers)
- Integrated Power-train (7 papers)
- Integrated Vehicle Design (6 papers)

PURPOSE AND SCOPE

Technical Evaluation Reports (TERs) serve the purpose of keeping all STO bodies alert to the results and implications of STO Technical Meetings. At the same time the intent is to keep the NATO Military Authorities and National Authorities informed on STO activities in order to stimulate action within NATO and its individual member Nations. The scope of this TER covers an assessment of technical papers presented, audience participation and discussions created by the technical presentations, and recommendations for future technology emphasis.

EVALUATION

The inter-relations of the technical research work presented during the Symposium includes the observation that the exchanges of ideas and sharing of research studies from 86 authors representing 16 nations was well received and pertinent to addressing today's hybrid/electric challenges for aviation. This observation resulted in an assessment that the Hybrid/Electric Propulsion Systems Architectures topic generated the most discussion. In contrast, the Integrated Thermal Regulation and Control Systems topic generated the least dialog. The remaining topic areas generally had equal audience and presenter discussion exposure.

An assessment of the “paper and presenter combination” that most significantly addressed the following attributes in each topic area was accomplished by evaluating: (a), presenter's ability to clearly articulate the paper's technical aspects, (b), technical innovation, (c), NATO/Military applicability, and (d), ability of the presenter to eloquently answer questions from the audience. The paper that was strongest in each of the 5 topic areas are singled out here:

- Paper 04: Challenges Associated to High-power Hybrid Electric Propulsion in Aerospace

- Paper 08: Enabling Sub-megawatt Hybrid-electric Propulsion through High Efficiency Recuperated Inside-out Ceramic Turbo Generator
- Paper 09: Multi-mission Performance Optimization of Hybrid/Electric Unmanned Aerial Vehicles
- Paper 19: Evaluation and Experimentation of Hybrid/Electric Propulsion Technologies for Unmanned Aerial Vehicles
- Paper 26: Blended Wing-body UAV Powered by Distributed Electric Propulsion

A general overall “technical gap” can be gained from observing all presented papers particularly when coupled with the dialog generated by questions and answers. This “technical gap” suggests the need for the next gathering/workshop/symposium of the scientific community to focus on a targeted military problem/challenge/issue in order to guide solution options. These solution options should then be discussed, prioritized, evaluated for development funding requirements to enable sufficient testing that will lead to eventual certification of the technical solution.

The essential lessons taken from the Symposium include the need for collaboration between various research being conducted, to build on foundational results from testing technology options, and to address the requirement to protect Intellectual Property.

Feedback from the audience was very positive with comments that indicated the Symposium provided ideas and technologies of high quality. It created many opportunities to extend the network of interactions between industry, academia and government. This network working opportunity was highly appreciated and witnessed through lively discussion amongst participants during Symposium breaks. A general comment to help improve presenting technical papers in the future was, “It would be useful if each presenter would have a clear statement in his/her presentation and which problem he/she is addressing with the presentation”. A few other observations from the audience included having clearer requirements to help focus future work—an extended workshop to jointly work on a predefined set of requirements might inspire the work needed for a solution breakthrough.

More presentations from industry would have been appreciated. And, we still have the “chicken-egg” problem; academia doesn’t know what military users need, military users need to understand what’s possible. The technical areas still need to be further focused and defined where hybrid/electric propulsion systems can bring real benefit.

CONCLUSIONS

The Research Symposium 323 was timely and pertinent regarding the technology challenges facing aviation today. The information shared was value-added and the technical discussions between the audience and the presenters was rewarding. The Symposium highlighted the need to collaborate on a targeted military requirement—possibly selected by the Program Committee working with NATO military leaders. If such a requirement or set of requirements could be articulated, it would go a long way to engage the combined wisdom of the technical community to help create a viable, applicable, and certifiable solution.

RECOMMENDATIONS

The next gathering/workshop/symposium of the scientific community should focus on a targeted military problem/challenge/issue to guide solution options. Request the Research Task Group 310 organize the next symposium or workshop to bring together technologists, academia and industry to address a military targeted outcome/opportunity in a global way. The outcome/opportunity should be discussed, prioritized, evaluated for development funding and testing that is likely to result in eventual certification. The commercial aviation community would greatly benefit from the hybrid/electric technologies used in military applications.

The Symposium identified the need to consider more collaboration between various researches being conducted, to build on foundational results from testing technology options to implementing agreements to protect Intellectual Property. The Symposium's opening address, including remarks made by both keynote presenters, defined the technical-scientific situation which challenges us today. From an aviation perspective, a major task for hybrid/electric technologists is in answering the development question, "What cluster of technology are we involved in—is it possible to merge different technologies to address a wider mission requirement?" Such a development question challenges us to focus on sustained peak performance, operational flexibility, low observability, dispatch reliability, survivability, turnaround time, autonomous operations and operating economics. Since Hybrid/electric is a new topic when applied to aviation vehicles, a few thoughts for future activity for consideration include:

- Identifying capabilities that open up because of what hybrid/electric offers in both performance and successful missions. For example, noise and emission reductions
- Challenging scientists to have a Medium Altitude Long Endurance aircraft flying for 36 hours be able to generate, at a moment's notice, 5 MW for 10 seconds
- Defining a reference problem to focus experimental work that accomplishes a radically different solution than we have today

REFERENCES

- [1] NATO https://www.nato.int/cps/en/natohq/topics_88745.htm as of 13 November 2019