

PROCEEDINGS OF SPIE

# ***Technologies for Optical Countermeasures XIV***

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**Robert J. Grasso**  
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*Editors*

**12–13 September 2017**  
**Warsaw, Poland**

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SPIE

**Volume 10435**

Proceedings of SPIE 0277-786X, V. 10435

SPIE is an international society advancing an interdisciplinary approach to the science and application of light.

Technologies for Optical Countermeasures XIV, edited by David H. Titterton, Robert J. Grasso,  
Mark A. Richardson, Proc. of SPIE Vol. 10435, 1043501 · © 2017 SPIE ·  
CCC code: 0277-786X/17/\$18 · doi: 10.1117/12.2303730

Proc. of SPIE Vol. 10435 1043501-1

The papers in this volume were part of the technical conference cited on the cover and title page. Papers were selected and subject to review by the editors and conference program committee. Some conference presentations may not be available for publication. Additional papers and presentation recordings may be available online in the SPIE Digital Library at [SPIDigitalLibrary.org](http://SPIDigitalLibrary.org).

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Please use the following format to cite material from these proceedings:

Author(s), "Title of Paper," in *Technologies for Optical Countermeasures XIV*, edited by David H. Titterton, Robert J. Grasso, Mark A. Richardson, Proceedings of SPIE Vol. 10435 (SPIE, Bellingham, WA, 2017) Seven-digit Article CID Number.

ISSN: 0277-786X  
ISSN: 1996-756X (electronic)

ISBN: 9781510613348  
ISBN: 9781510613355 (electronic)

Published by

**SPIE**

P.O. Box 10, Bellingham, Washington 98227-0010 USA  
Telephone +1 360 676 3290 (Pacific Time) · Fax +1 360 647 1445  
[SPIE.org](http://SPIE.org)

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Printed in the United States of America.

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**Ove Steinvall**, FOI-Swedish Defence Research Agency (Sweden)



# Introduction

This year's conference, held in Warsaw Poland, was well attended with many excellent papers in all fields of technology related to Optical Countermeasures. The welcome, introductions, and administrative notes for the conference were given by Conference Chairmen David Titterton and Robert Grasso.

The keynote session started the conference with two excellent papers, the first one by Philip Perconti, US Army Research Laboratory (presented by Ed Habbour in Phil's absence), and Simon Drinkall and Matt Foster (in place of Paul Winstanley) of the UK Defence Solutions Centre (DSC). Ed spoke about how advances in technology shaped the outcome of the Second World War and beyond, whilst The DSC Team spoke about objectives of achieving better alignment between UK-Government and International requirements and improving collaboration in the value chain. Both of these key-note addresses had an underlying theme of avoiding the so-called 'valley of death', whereby valuable innovation activities fail to mature at an appropriate time for a whole range of reasons.

Session 2 on Threats, Threat Detection, and Discrimination was hit badly by withdrawal of the first two papers, one of them an invited paper. Jaroslaw Pawluczyk presented a paper on high temperature operation of quadrant detectors in the 2 to 11  $\mu\text{m}$  range, which created a lot of interest and valuable discussion.

Session 3, Quantum Cascade Lasers (QCLs) saw four papers presented. The presenter of the first paper was not able to make the conference owing to Hurricane Irma; however, Co-Chairman Robert Grasso presented a paper on Coherent and Incoherent Combining of Quantum Cascade Lasers. This was followed by three more excellent papers, the first by Philip Barletta on Advanced Thermal Management of High-Power Quantum Cascade Lasers, the second by Richard Maulini on Performance Optimized QCL's for IRCM applications, and the last one by Hans Dieter Tholl on Actively and Passively Cooled Mid-IR QCL's. These papers described technological developments that are being made to advance the state-of-the-art of QCL's to generate higher output powers and greater overall performance for advanced IRCM applications.

Session 4, Lasers and Sources, consisted of two very good papers, the first by Edgaras Dvinelis on a compact 2.1  $\mu\text{m}$  laser module for IRCM applications (Band I). This was followed by an excellent paper on radiation-hardened optical amplifiers based upon multicore fibres for telecommunication satellites.

Session 5, Atmospheric Effects, dealt with how the Earth's atmosphere can affect the beam as it travels through the atmosphere, and in some instances, the entire scene. The first paper, by Alexander M.J. van Eijk presented an account of atmospheric laser-beam propagation and described the impact of the phenomena of absorption, scattering, and atmospheric turbulence and how these 'effects' serve to degrade the otherwise perfect beam profile we try to propagate through this medium. This was followed by Christopher Westgate of Dstl, who discussed experimental validation of turbulence effects predicted by phase-screen models. This is of particular interest, as turbulence must be represented accurately in sufficient detail for any atmospheric propagation model to be valid, and therefore have any utility. Next was an excellent paper by Marie-Therese Velluet, ONERA, on power-in-the-bucket and angle-of-arrival

in the presence of platform-induced turbulence. This is an important area where the chairmen would like to see additional papers, as it represents how the laser beam is affected when it leaves the platform and what photons actually arrive at the intended target location.

Session 6, Mid-IR Transmission Fibres saw two excellent invited papers presented; unfortunately a third paper had to be withdrawn just prior to the start of the conference. The first was given by Dan Hewak, University of Southampton, on enhancing the performance of chalcogenide fibres for mid-IR applications. The second paper provided an overview on chalcogenide negative-curvature fibres by Curtis Menyuk, University of Maryland. Mid-IR transmitting fibres are becoming increasingly important as a transport medium for many emerging IRCM applications. Here, several emerging IRCM architectures would rely on these fibres to transport the photons from the laser source to the intended exit port/beam director. These advanced architectures will be dependent upon high throughput, low loss and high power handling optical fibres, operating in the MWIR region, which both Dan and Curtis are presently working to fulfil this requirement.

Session 7, Laser Effects, saw six excellent papers that dealt with those effects caused at the intended target. Two papers were given by Frances Bodrucki, University of North Carolina, the first one on the development of anti-aliasing algorithms and the second on analysis of polarization effects from retro-reflection from commercial of the shelf (COTS) sensors. Itor James, Cranfield University, presented a paper on a physics-based performance model of missile seekers operating in the UV spectral region. Markus Henricksson, FOI, presented an excellent account of platform-induced effects and how these affect both threat warning sensors and laser-beam propagation through platform-wake induced turbulence. The two final papers in this excellent session were from Anna Pytel, Warsaw University of Technology, which assessed Brillouin Scattering in multicore optical fibres and Jan Szczepanek on the development of Artificial Saturable Absorbers.

We hope to establish a separate session during next year's conference that deals primarily with platform-induced effects, their impact on beam propagation and sensor performance and the consequences for installed performance.

There was a 'Panel Discussion' at the close of proceedings on Tuesday afternoon, debating directed energy and its potential value to IRCM applications. This was a most valuable discussion highlighting many critical points for consideration and the potential utility of the higher-power directed-energy approach causing damage instead of confusion in a missile's target tracking algorithm. This event was particularly well attended.

Overall the Chairmen were very pleased with the quality of the papers, attendance, detailed treatment of the subjects and the quality of the questions when the papers were opened for discussion. At the conclusion the Chairmen thanked the Programme Committee for the effort over the year to secure good papers, thanked the presenters for their excellent work and encouraged them to join us at next year's conference, and wished everyone safe travels with the hopes of seeing everyone next year at the conference in Berlin.

**David H. Titterton**  
**Robert J. Grasso**  
**Mark A. Richardson**

## Panel Discussion Summary

### Directed Energy meets IRCM

As in previous years, this year's Conference had a panel discussion, which gave the Conference participants a forum to discuss a topic relevant to the theme of this Conference. This year's topic was "Directed Energy Meets IRCM" and was moderated by Conference Chairmen Robert Grasso and David Titterton.

As seeker technology matures and becomes more resistant to the "classical" pulse-code modulation waveform countermeasures, it is highly likely that new methods will be required to defeat these advanced threats. Directed Energy becomes an attractive alternative to classical IRCM-jammer techniques owing to its "threat agnostic" approach to defeating a whole range of threats. Some of the areas of discussion covered included:

- 1) is this approach practical?
- 2) how would size, weight, and power (SWAP) affect platform installation?
- 3) what are the potential cost implications?
- 4) what additional requirements may be placed on the system and platform for successful implementation?
- 5) could such a system ever be cost effective?

One participant brought up the point to stay ahead of advancing threat technology there may be a need to examine a combined EO/IR/RF approach to threat defeat, thus becoming truly threat agnostic. Another mentioned how a closed-loop approach might ease some of the requirements of a DE-kill type system as the elegance of closed-loop might offset the brute force required for classical DE-kill mechanisms. Another participant mentioned that emitted or projected power itself is not the answer, as there are several means that can be thought of when discussing DE-kill mechanisms. One might be to damage the detector in the seeker, another might be to damage the seeker itself; both of these approaches would render the guidance loop unable to maintain a track on the target, and a third is to damage the missile body itself, potentially the most difficult and costly approach.

Another area that was discussed was the advancing threat and how these might be resistant to "classical" countermeasures, leaving DE-type approaches the only viable option. One participant mentioned that an "in-band" type of system might be better than an "out-of-band" approach. This might be based upon the assumption that an in-band source might be less costly and require less overall energy than an out-of-band type of system. One participant mentioned that, if possible, it might be advantageous to ignore the seeker and penetrate the threat 'hard body' itself.

The moderators posed the question about aim-point selection and pointing. Is pointing to the anticipated accuracy (micro-radians) required to achieve and maintain sufficient energy-on-dome or on the body structure (typically the missile's forebody) even feasible, moreover, is it possible within the confines of a system architecture, to have the capability to generate both power and pointing accuracy at a reasonable cost to allow proliferation over a large number of platforms? One participant suggested that all of these considerations may be scenario dependent, to which the moderators responded that it would have to work for all possible scenario's to be deemed acceptable by the user community. The moderators then went on to pose the

question that if by trading power, pointing precision, threat agnosticism and 'levelling' these to an acceptable trade off, can such a system be realised?

A participant went on to mention threat resilience, and if sufficient data exist to be able to fully comprehend what it would take to defeat threats without any *a-priori* knowledge. This is a very interesting point and serves to make sufficient advocacy for DE-type approaches. The discussion further examined threat resilience; what happens when the threat spectrum to a platform includes guided and ballistic weapons? Further discussion mentioned costs of such a system and if this could ever become feasible given potential cost implications.

Finally the moderator suggested that everyone consider the case if we take account of emerging technology, cost, and risk, and, level these factors to where each is acceptable and achievable, can a practical and effective DE-architecture be developed in the near term? The moderators asked everyone to ponder this question, thanked everyone for their participation and concluded the forum. Interestingly, there was little or no discussion of technical risk!

Moderators  
**Robert J. Grasso**  
**David H. Titterton**