

# **2022 IEEE International Conference on Space Optical Systems and Applications (ICSOS 2022)**

**Kyoto City, Japan  
28 – 31 March 2022**



**IEEE Catalog Number: CFP22CSO-POD  
ISBN: 978-1-6654-3440-9**

**Copyright © 2022 by the Institute of Electrical and Electronics Engineers, Inc.  
All Rights Reserved**

*Copyright and Reprint Permissions:* Abstracting is permitted with credit to the source. Libraries are permitted to photocopy beyond the limit of U.S. copyright law for private use of patrons those articles in this volume that carry a code at the bottom of the first page, provided the per-copy fee indicated in the code is paid through Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923.

For other copying, reprint or republication permission, write to IEEE Copyrights Manager, IEEE Service Center, 445 Hoes Lane, Piscataway, NJ 08854. All rights reserved.

***\*\*\* This is a print representation of what appears in the IEEE Digital Library. Some format issues inherent in the e-media version may also appear in this print version.***

IEEE Catalog Number:	CFP22CSO-POD
ISBN (Print-On-Demand):	978-1-6654-3440-9
ISBN (Online):	978-1-6654-3439-3

**Additional Copies of This Publication Are Available From:**

Curran Associates, Inc  
57 Morehouse Lane  
Red Hook, NY 12571 USA  
Phone: (845) 758-0400  
Fax: (845) 758-2633  
E-mail: [curran@proceedings.com](mailto:curran@proceedings.com)  
Web: [www.proceedings.com](http://www.proceedings.com)

CURRAN ASSOCIATES INC.  
**proceedings**  
.com

# TABLE OF CONTENTS

Latest Status of the CCSDS Optical Communications Working Group.....	1
<i>Bernard L. Edwards</i>	
Optical High-Speed Data Network in Space - An Update on HyDRON's System Concept .....	7
<i>Christopher A. Vasko, Pantelis-Daniel Arapoglou, Guray Acar, Monica Politano, Wael El-Dali, Josep Perdigues Armengol, Harald Hauschildt, Carlo Elia</i>	
LUCAS: The second-generation GEO satellite-based space data-relay system using optical link .....	14
<i>Shiro Yamakawa, Yohei Satoh, Takamasa Itahashi, Yutaka Takano, Shintaroh Hoshi, Yuko Miyamoto, Masahiko Sugiho, Takeshi Yoshizawa, Yusuke Koizumi, Masakazu Yukizane, Sota Suzuki, Hiroki Kohata</i>	
DSTG Laser Satellite Communications -Current Activities and Future Outlook.....	17
<i>Kerry Mudge, Bradley Clare, Elisa Jager, Vladimir Devrelis, Francis Bennet, Michael Copeland, Nicholas Herral, Ian Price, Gottfried Lechner, Jeewani Kodithuwakkuge, Joseph Magarelli, Dharmapriya Bandara, Christopher Peck, Monique Hollick, Paul Alvino, Peter Camp-Smith, Barbara Szumylo, Agam Raj, Kenneth Grant</i>	
Challenges, Lessons Learned, and Methodologies from the LCRD Optical Communication System AI&T .....	22
<i>Bernie Edwards, Trisha Randazzo, Nidhin Babu, Kendall Murphy, Shane Albright, Nick Cummings, Javier Ocasio-Perez, William Potter, Russell Roder, Sharon A. Zehner, Ricardo Salah, Jonathan Woodward</i>	
Recent R&D activities of the Lunar – the Earth Optical Communication Systems in Japan .....	32
<i>Tomohiro Araki, Hideaki Kotake, Yoshihiko Saito, Hiroyuki Tsuji, Morio Toyoshima, Katsumi Makino, Masaru Koga, Naoki Sato</i>	
Status Update on Laser Communication Activities in NICT.....	36
<i>Dimitar Kolev, Koichi Shiratama, Alberto Carrasco-Casado, Yoshihiko Saito, Yasushi Munemasa, Junichi Nakazono, Phuc V. Trinh, Hideaki Kotake, Hiroo Kunimori, Toshihiro Kubooka, Tetsuharu Fuse, Morio Toyoshima</i>	
The communication experiment result of Small Optical Link for ISS (SOLISS) to the first commercial optical ground station in Greece .....	40
<i>Hiroaki Yamazoe, Hennes Henniger, Kyohei Iwamoto</i>	
Satellite-based QKD for Global Quantum Cryptographic Network Construction .....	47
<i>Atsushi Mamiya, Kentaro Tanaka, Saori Yokote, Masahide Sasaki, Mikio Fujiwara, Masaki Tanaka, Hideaki Sato, Yusuke Katagiri</i>	
A CubeSat platform for space based quantum key distribution.....	51
<i>Srihari Sivasankaran, Clarence Liu, Moritz Mihm, Alexander Ling</i>	
CARAMUEL: The future of Space Quantum Key Distribution in GEO .....	57
<i>Angel Alvaro, Luis Pascual, Antonio Abad, Pedro Pinto, Alberto Alvarez-Herrero, Tomas Belenguer, Carlos Miravet, Pablo Campo, Luis F. Rodriguez, Marcos Reyes, Jorge Socas, Javier Bermejo</i>	
Bit Error Rate Performance of a Laser Ground-to-Satellite Uplink Communications Systems in the Presence of Atmospheric Turbulence and Loss.....	66
<i>Larry B. Stotts, Larry C. Andrews</i>	

Optical Transmitter Diversity With Phase-Division in Bit-Time .....	74
<i>Christian Fuchs, Dirk Giggenbach, Ramon Mata Calvo, Werner Rosenkranz</i>	
Experimental Setup for Single-Pixel Imaging of Turbulent Wavefronts and Speckle-Based Phase Retrieval .....	78
<i>Michael Taylor, Mohamadreza Pashazanoosi, Steve Hranilovic, Costel Flueraru, Antony Orth, Oliver Pitts</i>	
Turbulence Mitigation via Multi-Plane Light Conversion and Coherent Optical Combination on a 200 m and a 10 km Link .....	85
<i>Antonin Billaud, Andrew Reeves, Adeline Orieux, Helawae Friew, Fausto Gomez, Stephane Bernard, Thibault Michel, David Allieux, Juraj Poliak, Ramon Mata Calvo, Olivier Pinel</i>	
RF and Optical Hybrid LEO Communication System for Non-Terrestrial Network .....	93
<i>Takashi Eishima, Soichiro Inoue, Akihiro Yonemoto, Jumpei Sudo, Takayuki Hosonuma, Shinichi Nakasuka, Atsushi Shirane, Takashi Tomura, Kenichi Okada, Kosuke Kiyohara</i>	
Multi-layer Constellation based Is-OWC employing NOMA .....	100
<i>Wataru Tachikawa, Ajsaonkar Swarali Ashish, Kazutoshi Yoshii, Jiang Liu, Shigeru Shimamoto</i>	
Analysis of Tracking Gimbal Angles for Inter-Satellite Optical Communication System Between Two Orbits.....	107
<i>Ryuichi Hirayama, Shinichi Nakasuka</i>	
Pulse positioned differential phase shift keying for high data rate satellite optical communications.....	113
<i>Won-Ho Shin, Young-Jin Hyun, Sang-Kook Han</i>	
4-Level Optical Modulation Formats for LISLs in a Satellite Broadband Constellation Network .....	117
<i>Amrita Gill, Gnanam Gnanagurunathan, Nafizah Khan, Amin Malekmohammadi</i>	
A study of cloud cover over multiple sites within Australia for satellite/ground atmospheric optical communication links .....	124
<i>Helen Chedzey, Mervyn Lynch, Brett Nener, Vladimir Devrelis, Kerry Mudge, Ken Grant</i>	
Greek Chelmos Observatory readies for Optical and Quantum Communication.....	128
<i>Zoran Sodnik, Donatas Miklusis, Hans Smit, Harald Hauschildt, Emmanuel M. Xilouris, Panayotis Hantzios, John Alikakos, Alexis Gourzelas, Athanasios Maroussis, Spyros Basilakos, Manolis Plionis</i>	
The Mount Stromlo Optical Communication Ground Station.....	134
<i>Marcus Birch, Noelia Martinez, Francis Bennet, Michael Copeland, Doris Grosse</i>	
Beacon system for ESA IZN-1 Optical Ground Station.....	138
<i>Shaif-Ul Alam, Andrea Di Mira, Mike Yarrow, Clemens Heese, Jason Singleton, Andre Kloth, Jens Steinborn, John Clowes</i>	
BER Performance Improvement using Spatial Diversity Combining in an Atmospheric Turbulent Channel with Satellite Vibration-Induced Fading .....	142
<i>Charleston Dale Ambatali, Vinicius Ferreira Nery, Shinichi Nakasuka</i>	
Low-power-consumption coherent receiver architecture for satellite optical links.....	149
<i>A. W. Bernini, M. J. Fice, K. Balakier</i>	

PhLEXSAT - A Very High Throughput Photo-Digital Communication Satellite Payload.....	154
<i>Madhubrata Chatterjee, Chiara Palla, Edem Fiamanya, Marta Beltran, Miguel Angel Piqueras, Antoni Castells Cervello, Laurent Roux, Patrick Runge, Jakub Zverina, Nigel Cameron</i>	
Compact radiation resistant, high-gain optical fiber preamplifier for small 1.55 um laser-com terminals .....	158
<i>Leontios Stampoulidis, Ahmed Osman, James Edmunds, Clive Palmer, Keith Simpson, Anaelle Maho, Michel Sotom</i>	
Robust atmospheric FSO communication receiver based on the coherent combination of spatial modes: an experimental evaluation .....	164
<i>Anaelle Maho, Vincent Billault, Jerome Bourderionnet, Luc Leviandier, Patrick Feneyrou, Arnaud Brignon, Michel Sotom</i>	
Capacity Analysis of a MIMO Laser Link From Lunar Surface to Earth .....	168
<i>Hung Le Son, Robert T. Schwarz, Marcus T. Knopp, Dirk Giggenbach, Andreas Knopp</i>	
DLR's Optical Communication Terminals for CubeSats.....	175
<i>Christopher Schmidt, Benjamin Rodiger, Jorge Rosano, Christos Papadopoulos, Marie-Theres Hahn, Florian Moll, Christian Fuchs</i>	
TBIRD 200-Gbps CubeSat Downlink: System Architecture and Mission Plan.....	181
<i>Curt M. Schieler, Kathleen M. Riesing, Bryan C. Bilyeu, Bryan S. Robinson, Jade P. Wang, W. Tom Roberts, Sabino Piazzolla</i>	
SelenIRIS: a Moon-Earth Optical Communication Terminal for CubeSats.....	186
<i>Jorge Rosano Nonay, Christian Fuchs, Davide Orsucci, Christopher Schmidt, Dirk Giggenbach</i>	
On-Orbit Risk Mitigation for a ½-U Orbital Laser Guidestar Link.....	196
<i>Albert Thieu, Lulu Liu</i>	
Architecture for Reconfigurable Next-Generation Lasercom Terminals.....	203
<i>Robert T. Carlson</i>	
NICT's versatile miniaturized lasercom terminals for moving platforms.....	213
<i>Alberto Carrasco-Casado, Koichi Shiratama, Phuc V. Trinh, Dimitar Kolev, Femi Ishola, Tetsuharu Fuse, Hiroyuki Tsuji, Morio Toyoshima</i>	
Agile Beaconless Laser Beam Alignment with Adaptive Mm-Wave Beamforming for Inter CubeSat Communication.....	218
<i>Chengtao Xu, Thomas Yang, Eduardo Rojas</i>	
Development and Testing of the Laser Transmitter and Pointing, Acquisition, and Tracking System for the CubeSat Laser Infrared CrosslinK (CLICK) B/C Mission.....	224
<i>Hannah Tomio, Peter Grenfell, William Kammerer, Paul Serra, Ondrej Cierny, Charles Lindsay, Maddie Garcia, Kerri Cahoy, Myles Clark, Danielle Coogan, John Conklin, David Mayer, Jan Stupl, John Hanson</i>	
Telesat Lightspeed™ - Enabling Mesh Network Solutions for Managed Data Service Flexibility Across the Globe .....	232
<i>Gerry Jansson</i>	
Multi-aperture Transmission and DSP Techniques for Beyond-10 Tb/s FSO Networks .....	236
<i>Keisuke Matsuda, Hayato Sano, Yukari Takada, Masashi Binkai, Shota Koshikawa, Yuta Yokomura, Tsuyoshi Yoshida, Yoshiaki Konishi, Naoki Suzuki</i>	

Link Budget Design of Adaptive Optical Satellite Network for Integrated Non-Terrestrial Network .....	240
<i>Hideaki Kotake, Yuma Abe, Mariko Sekiguchi, Tetsuharu Fuse, Hioryuki Tsuji, Morio Toyoshima</i>	
An investigation into the technical and system operational impacts of applying FSO point-to-multipoint communications technology .....	248
<i>Barry A. Matsumori, Paul Searcy</i>	
FEELINGS : the ONERA's optical ground station for Geo Feeder links demonstration .....	255
<i>Petit Cyril, Bonnefois Aurelie, Conan Jean-Marc, Durecu Anne, Gustave Francois, Lim Caroline, Montri Joseph, Paillier Laurie, Perrault Philippe, Velluet Marie-Therese, Volatier Jean-Baptiste, Vedrenne Nicolas</i>	
New Results From the 2021 FEEDELIO Experiment - a Focus on Reciprocity .....	261
<i>Perrine Lognone, Aurelie Montmerle Bonnefois, Jean-Marc Conan, Laurie Paillier, Cyril Petit, Caroline B. Lim, Serge Meimon, Joseph Montri, Jean-Francois Sauvage, Nicolas Vedrenne</i>	
End-to-End Performance Analysis of Analog Coherent Optical Satellite Feeder Links .....	267
<i>C. Willem Korevaar, Jeroen J. Boschma, Remco Den Breeje, Johannes Ebert</i>	
Link technology for all-optical satellite-based quantum key distribution system in C-/L-band.....	275
<i>Florian Moll, Jan Krause, Nino Walenta, Ronald Freund, Eltimir Peev, Andrew Reeves, Rene Ruddenklau, Agnes Ferenczi, Luca Macri, Stefanie Hausler, Jorge Pacheco Labrador, Marie-Theres Hahn, Jurai Poliak, Davide Orsucci, Friederike Fohlmeister</i>	
Design considerations for a Transportable Optical Ground Station with Adaptive Optics .....	281
<i>Luis Fernando Rodriguez Ramos, Joan Torras Estruch, Noelia Martinez Rey, Jorge Socas Negrin, Iciar Montilla, Marcos Reyes Garcia-Talavera, Alex Oscoz, Angel Alonso Sanchez, Pablo Gonzalez De Chaves Fernandez</i>	
Large - Scale LEO Satellite Constellation to Ground QKD links: Feasibility Analysis.....	288
<i>Argiris Ntanos, Nikolaos K. Lyras, Saif Anwar, Obada Alia, Dimitris Zavitsanos, Giannis Giannoulis, Athanasios D. Panagopoulos, George Kanellos, Hercules Avramopoulos</i>	

**Author Index**