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Nanophotonics and Macrophotonics for Space Environments V

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Editors

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2 Space Experiments and Components II
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3 Signal Processing and Architectures
Edward W. Taylor, International Photonics Consultants, Inc. (United States)

Introduction

The convening of the Nanophotonics and Macrophotonics for Space Environments V (NMSE V) Conference was well-attended and highlighted by the presentation of two invited Keynote Presentations. Professor Peter J. Delfyett, Jr. of the College of Optics and Photonics, University of Central Florida provided an excellent Keynote presentation describing a valuable new area of investigation titled: *Ultra Coherent Optical Signal Processing Technologies and Applications Using Stabilized Optical Frequency Combs* within the Signal Processing Session which described a very efficient approach for improving the large scale selective detection and processing of multiple signals. Stephen Forbes of the Air Force Research Laboratory, Kirtland AFB, New Mexico, presented a Keynote Presentation opening the Hardened Gyro Session which was titled: *Strategic Photonic Sensors: Technology Needs and Challenges*. The presentation was very well received by the conference participants that posed many important application and technical questions followed by the speaker's answers that were well received by the audience.

Approximately one-third of the presentations addressed radiation-induced effects in photonics technologies aimed at space applications including presentations from NASA Langley and NASA Goddard Research Centers regarding the testing of optical and photonic components in low-Earth orbit and also for NASA's planned Jupiter Europa Orbiter Mission. Other NASA presentations included the reporting of recent test data on the performance of fiber optic connectors and cables in harsh environments as well as the utility of a new web-based tool (OLTARIS) for analyzing materials exposed to space radiation environments. Papers from industry were also presented concerning the effects of ionizing radiation on interferometric fiber optic gyros and MEMS inertial sensors, as well as an excellent theoretical paper describing a model for *Self-Trapped Holes in Glassy Silica: Basic Science with Relevance to Photonics in Space* that was presented by Dr. David L. Griscom. The theoretical model based on decades-long data bases prompted much interest from the audience.

A review paper from the Katholieke University, Leuven, Belgium, discussed the historical investigation of molecular photonic components responses in space and simulated space environments which set the tone for other papers in the Advances in Organic and Polymer Materials Session. This session provided new and interesting approaches for using Hyper-Rayleigh Scattering measurement techniques for advancing the design and selection of organic and polymer materials for space applications. The Conference attendees were also provided a wide variety of other excellent presentations reporting the advancement of components and materials for space applications in topic areas such as: laser pulse shaping; THz and millimeter-wave detection; InAs/GaSb strained layer

superlattice detectors; optical switching fabrics; new polycrystalline laser materials; and, the advancement of 2 micron lasers and materials.

We expect next year's SPIE NMSE agenda to focus on the same topic areas with special emphasis on additional polymer based nanophotonic sessions. The Chairs and Cochairs wish to thank the Program Committee, speakers, session chairs, and especially the SPIE staff for their many contributions to making the NMSE V Conference a success.

Edward W. Taylor
David A. Cardimona

Integrity ★ Service ★ Excellence

Strategic Photonic Sensors

Technology and Challenges

23 August 2011

Stephen Forbes
RVSV
Air Force Research Laboratory

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Outline

- Overview
- Technology Needs
- Requirements
- Technology Development Efforts
- The Future

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Overview of Strategic Systems and Launch Technologies

- Part of the AFRL Space Vehicle Directorate at Kirtland AFB, NM
- Two technical thrusts
  - Strategic Systems
    - Focused on developing solutions to address technology gaps in the Air Force's strategic mission
  - Launch Technologies
    - Focused on developing technology to reduce launch costs and schedules

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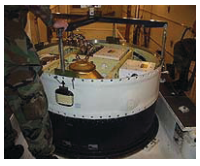
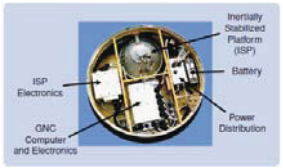
Technology Needs

- Widespread reliance on GPS in both DoD and civil sectors
- GPS vulnerabilities necessitate alternative navigation/mitigation methods
- SSLT focuses on inertial navigation technology





Photos of Current Minuteman III Guidance Set from the web

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Requirements

- Radiation
  - Prompt ionizing radiation
  - Neutron radiation
  - Natural space environment
  - MDA also has prompt radiation requirements*
- Long operating life/high MTBF
- Vibration and Shock
- Thermal
- Vacuum

* See MDA SBIR solicitations

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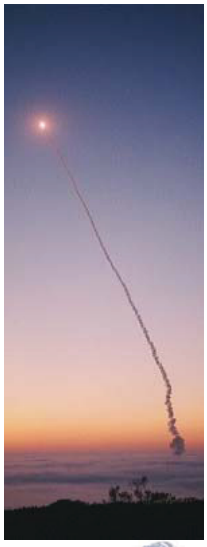
Technology Development Efforts

- Adaptive Launch Guidance
- Novel data fusion for situational awareness
- GPS Denied Navigation
- Inertial Instruments
  - Inertial Measurement Units
  - Accelerometers
  - Fiber Optic Gyroscopes

Instruments currently under development



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Fiber Optic Gyroscope

- SSLT is developing a single mode strategic grade fiber optic gyroscope
- Emphasis on high MTBF and radiation hardness
- Prompt ionizing radiation drives optical component selection
- Significant effort has been spent on testing parts

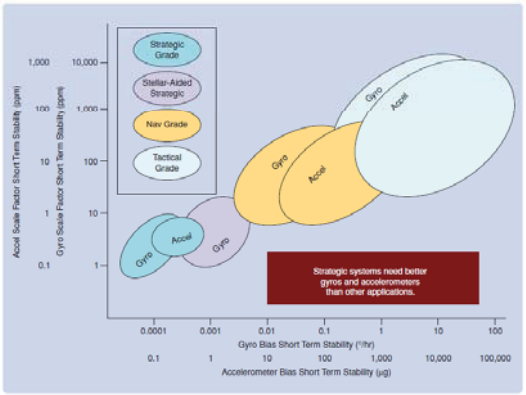
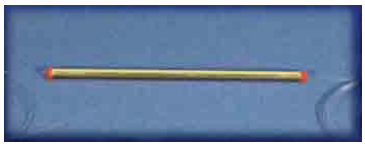
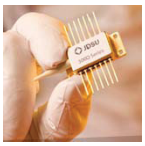


Table from Wang and Williams, "Strategic Inertial Navigation Systems", IEEE Control Systems Magazine, Feb 2008

FOG Development Challenges

- Optical parts
- To a lesser extent electronic components
- 3 main issues
  - Vendor stability/parts availability
  - Lack of vendor test data
  - Parts' parametric stability over time
- Most parts lack prompt ionizing radiation testing





The Future

- Current instrument technologies are reaching the performance limit
- Looking for the future gyroscope and accelerometer technology
  - Atom interferometry
  - Fast light ring laser gyroscope and accelerometer
  - Other?

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