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Introduction

The Fiber Optic Sensors and Applications XIII conference included a special 40th Anniversary Fiber Optic Gyro Program dedicated to the memory of Professor Shaoul Ezekial, one of the early pioneers of fiber optic gyro research, who helped organized the 5th (with Herve Arditty) and 15th (with Eric Udd) Anniversary Fiber Gyro conference. His early efforts, compelling presentations, and promotions of the field will be sorely missed. Glen Sanders of Honeywell Technology (United States) offered an overview of his life and technical efforts.

The fiber optic gyro has unique features that have allowed it to be successfully developed for and introduced to a wide range of applications that include: cutting soccer fields, navigation of land vehicles, as well as several major commercial aircrafts and spacecrafts. It has successfully supported Japanese missions to the moon, steered space-based satellites, and is used on the Spirit, Opportunity, and Curiosity rovers on Mars.

The fiber sensor community lost a second pioneer this past year. Professor Annamaria Verga Scheggi pioneered work in biochemical and biomedical research on fiber optic sensor research in Italy and influenced much of the work in that country. Anna Grazia Mignani and Francesco Baldini, two of her prominent students who are now world renowned researchers themselves, offered a heartfelt tribute.

The papers in this conference include a mix of invited and tutorial papers that provided a level of depth and clarity that allowed many of the contributed papers to be more fully appreciated. The chairs would like to extend their thanks to the many experts who took the time to support these extended and very useful talks.

In additions to strong sections on fiber optic gyros and the many applications of fiber grating sensors, important papers were presented in the area of fiber optic chemical and gas sensing. This was followed by a series of papers outlining important approaches to extending fiber optic sensor technology into new applications areas.

Finally, the conference was supported by an assessment of the fiber optic sensing market by David Krohn of Lightwave Venture Consulting (United States) that projects the market for fiber sensors at $1.5 billion in 2018 and growing. The projection did not include the fiber gyro market or the emerging medical marketplace instead it focused on oil and gas, civil structures, military, power lines and wind energy that are better known.

We would like to thank all the contributors to this conference and the staff at SPIE for their excellent support.

Eric Udd
Gary Pickrell
Henry H. Du

Distributed Fiber Optic Sensors: Technology and Commercialization

This presentation was divided into three segments:

- Technology Overview
- Market Overview
- Standards Activity

Technology Overview

Fiber optic sensing technology has evolved over 60 years of development and commercialization. While many applications are for point sensors, the rapid expansion has been for distributed fiber optic sensing systems which was the focus of the presentation. Distributed fiber optic sensing systems fall into two categories: quasi distributed (multipoint) systems and continuous systems. The technologies associated with these systems were covered in some detail including: Bragg gratings, interferometric, and Raman (DTS), Brilloiun (DTSS), and Rayleigh scattering (DAS). These sensing concepts can be used to measure strain, temperature, vibration, pressure, acoustic emission, electric and magnetic fields, chemical detection and other parameters.

Distributed fiber optic sensors are an enabling technology that creates smart systems in a variety of applications. The initial development and commercialization efforts focused on military applications. However, the need to function in harsh environments, and the development of optical fiber technology that can survive in these applications has significantly impacted the oil and gas industry.

These smart sensing systems provide benefits throughout the life of a well; from exploration to drilling and completion, production, and reservoir management. There is no other technology that can provide critical process control information spatially throughout the well in real-time over long periods. Without smart well technology, fracking monitoring and analysis and applications like steam-assisted gravity drainage (SAGD) would be very difficult to effectively implement. A very important point that is understated is that fiber optic sensing systems have enabled smart oil and gas wells that are allowing North America to gain energy independence.

The availability of this sensor capability has been used in a broad range of applications. In addition to oil and gas exploration and extraction, other applications include expanded energy applications such as geothermal, monitoring wind turbines and pipelines, industrial monitoring, homeland security, military surveillance, and smart structures.

Market Overview

Market forecasting has been a challenge due to the oil price dynamics and uncertainties in government spending. However, the presentation provided projections for the overall market by applications, and for specific technologies through 2020.

The distributed fiber optic sensor market stood at $651 million in 2014 with 49% associated the oil and gas market segment. The overall market was forecasted to contract in 2015 due to the fall in oil prices. By mid-year 2015, recovery of oil prices was underway as projected, but a second more severe decline coupled with investment cutbacks in this sector are having a profound effect that will linger well into 2017. The continued pressure on oil prices will negatively impact the overall market forecast. However, the long term picture is still cautiously optimistic. While the price of oil is negative for the oil wells market segment, it will have a positive effect on refineries and potentially pipelines which should increase sensor use for these applications. In addition, increased government funding for military and homeland security applications is anticipated.

Standards Activity

The Institute of Electrical and Electronics Engineers (IEEE) Standards Association is an organization within IEEE that develops global standards in a broad range of industries. IEEE, in conjunction with the Photonic Sensor Consortium, initiated a standards activity related to fiber optic sensors. There are several organizations working on fiber optic sensor standards. However, each activity is of limited scope which results in fragmented landscape. There is no central organization tracking all the standards activities. As fiber optic sensing systems emerge, there is a significant level of customization which has a high impact on cost. High cost has been a negative driver for expanded growth. Understanding and defining where standards can decrease cost and facilitate applications can greatly expand market opportunities. The goal is to move forward with standards that can impact cost and promote growth. A brief overview of this activity was presented.