TITLE: Practical Adaptive Processing for OTHR and Emerging Applications.

PRESENTER:
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Giuseppe A. Fabrizio received his B.E. and Ph.D. degrees from the Department of Electrical Engineering at Adelaide University, Australia, in 1992 and 2000. Since 1993, Dr Fabrizio has been with the Defence Science and Technology Organization (DSTO), Australia, where he leads the EW and adaptive signal processing section of the high frequency radar branch. Dr Fabrizio is responsible for the development and practical implementation of innovative and robust adaptive signal processing techniques to enhance the operational performance of the Jindalee Operational Radar Network (JORN) – a multi-billion-dollar over-the-horizon (OTH) radar network. Dr Fabrizio is a senior member of the IEEE and is the principal author of over 50 peer-reviewed journal and conference publications. He is a co-recipient of the prestigious M. Barry Carlton Award for the best paper published in the IEEE Transactions on Aerospace and Electronic Systems (AES) on two occasions (2003 and 2004). In 2007, he received the coveted DSTO Science Excellence award for his contributions to adaptive signal processing for JORN. In the same year, he was granted a DSTO Defence Science Fellowship to pursue collaborative research at La Sapienza University in Rome, Italy. Dr Fabrizio has delivered OTH radar tutorials in the national and international IEEE Radar Conference series and is an Australian representative on the IEEE International Radar Systems Panel. He is currently serving as Vice President for Education on the AESS Board of Governors. Dr. Fabrizio was selected as the recipient of the distinguished IEEE Fred Nathanson Memorial Radar Award in 2011 for his contributions to OTH radar and radar signal processing. His is the sole author of the text “High Frequency Over-the-Horizon Radar”, published by McGraw-Hill in June 2013.

TOPIC:

The main theme of the tutorial is to motivate, describe and illustrate the practical application of contemporary adaptive signal processing techniques to real-world OTH radar systems. In addition, the tutorial delves into a number of emerging applications including passive OTH radar, blind signal separation using antenna arrays, and multipath-driven emitter geolocation. The scope of the tutorial is to introduce a variety of signal detection and estimation problems encountered by real-world systems in challenging interference and clutter environments and to provide a framework for developing and implementing robust adaptive processing methods that can address these problems effectively in operational systems. This includes adaptive processing in space, time and space-time for active and passive HF radars in surveillance applications, as well as novel techniques that exploit multipath propagation for high-fidelity waveform estimation and target geolocation. The depth of treatment ranges from explaining the fundamental principles of OTH radar systems to a mathematical description of validated signal models and the adaptive processing techniques based upon them. The tutorial contains many examples of experimental results at all stages of the presentation to demonstrate the benefits achieved through the use of advanced processing relative to conventional methods.
BACKGROUND:

Skywave OTH radars operate in the high frequency (HF) band (3-30 MHz) and exploit signal reflection from the ionosphere to detect and track targets at ranges of 1000 to 3000 km. The long-standing interest in OTH radar technology stems from its ability to provide persistent and cost-effective early-warning surveillance over vast geographical areas (millions of square kilometres) as an integrated element of a multi-layered sensor suite. The nature of the OTH radar mission, combined with the low data rates and large computing infrastructure relative to many other types of radars, has meant that OTH radars are the typically the first operational systems able to implement computationally-intensive state-of-the-art adaptive techniques in real-time. In this sense, OTH radar is often at the forefront of demonstrating the operational effectiveness of advanced radar processing techniques before it is possible to implement these techniques in radar systems operating at higher frequencies on military platforms.

DESCRIPTION:

The tutorial is organized into three parts. The first introduces the fundamental principles of OTH radar design and operation in the challenging HF environment. This serves to motivate and explain the architecture and nominal capabilities of modern OTH radar systems. The second describes experimentally-validated mathematical models of the skywave propagation channel and adaptive processing techniques for clutter and interference mitigation. The third delves into emerging applications, including OTH passive radar, blind signal separation, and multipath-driven geolocation for target echoes and HF emitters of interest. A highlight of the tutorial is the prolific inclusion of experimental results illustrating the practical application of robust signal processing techniques to real-world systems in all three parts.

**Part I: Fundamental OTH Radar Principles**
- Concept of operation and practical applications
- System characteristics and nominal capabilities
- Intelligent resource management and waveform design
- Conventional processing for target detection and tracking

**Part II: Advanced Adaptive Processing Techniques**
- Space-time model of HF propagation channel
- Time-varying adaptive beamforming for nonstationary interference mitigation
- Space-time adaptive processing (STAP) for interference and clutter mitigation
- Adaptive CFAR detection based on generalized likelihood ratio test (GLRT)

**Part III: Emerging Research and Applications**
- HF passive radar (incl. experimental results)
- Blind signal separation (incl. experimental results)
- Multipath-driven geolocation (incl. experimental results)
- MIMO radar concept (in brief if time permits)

AUDIENCE:

The tutorial is intended for students, researchers, and radar practitioners with little or no prior knowledge of HF radar and with an interest in the application of robust adaptive processing techniques to practical systems. It is expected that participants will gain an understanding of canonical signal detection and estimation problems commonly encountered in operational systems (not limited to OTH radar), and state-of-the-art adaptive processing techniques that may be brought to bear to address these problems effectively in practice.
PREREQUISITE:

The audience is not expected to possess any prior knowledge of HF radar, but is expected to have a basic working knowledge of radar and its associated signal processing. A rudimentary prior knowledge of adaptive processing is not essential but desirable.

RELEVANCE:

Although the general topic of adaptive processing has been well represented for many years at IEEE radar conferences, it is also true that each presenter brings his or her own unique insights and contributions to the field. The different perspectives are often acquired through personal experience, particularly to achieve robust performance in an operational context. One important reason for this tutorial is that exposure to new perspectives provides value (i.e., knowledge growth) when they are shared with the international community. In addition, the tutorial is not limited to active radar, but also covers a number of emerging applications, such as OTH passive radar, blind signal separation and multipath-driven geolocation. These areas are gaining interest in our community but have received relatively less attention in IEEE radar conference tutorials. The OTH radar theme is aligned with one of the special sessions being organized at the conference and this subject also features prominently among the topics listed in the call for papers. Further to the contributions provided by Parts II and III of the tutorial, the introductory material in Part I may also be useful to participants as a primer for the OTH radar special session and related papers to be presented at the conference. For all of the aforementioned reasons, the tutorial is regarded as important, timely and relevant to the 2015 IEEE International Radar Conference.

PREVIOUS EDITIONS:

This new tutorial has not been offered previously. The content and emphasis is significantly changed from the introductory OTH radar tutorial that has been presented at previous IEEE radar conferences held in Rome 2008 (about 25 participants), Washington DC 2010 (about 20 participants), Ottawa 2013 (about 13 participants), Adelaide 2013 (about 28 participants), and Cincinnati 2014 (about 8 participants). The tutorial proposed for the 2015 IEEE International Radar Conference will draw on the contents of the previous edition for Part I to introduce the vagaries of OTHR to the audience, but the core aspects in Parts II and III are completely new.

EQUIPMENT: Standard equipment, as specified on the website.

OTHER:

In addition to receiving colour slides for the tutorial, there may also be the opportunity for participants to receive a free copy of the OTHR text book below to complement the slides. At the 2013 IEEE International Radar Conference in Adelaide, McGraw-Hill sponsored the introductory OTH radar tutorial to permit this initiative in exchange for low-level advertising. Feedback from surveys confirmed that this initiative helped to increase attendance (about 28 tutorial participants for a conference attendance of around 250), and this option may be considered again. The presenter is also willing to make adjustments to the tutorial content and structure as required by the committee to best suit the needs of the conference.
Selection of Personal Publications Relevant to Tutorial

**HIGH FREQUENCY OVER-THE-HORIZON RADAR:**
*Fundamental Principles, Signal Processing, and Practical Applications*

Giuseppe (Joe) Fabrizio, Ph.D.
ISBN13: 9780071621274
ISBN10: 007162127X
Division: McGraw-Hill Professional Publishing
Pub Date: JUN-13
Pages: 944
Format: Hardcover (also available as Kindle e-book)
Audience: College/higher education General/trade, Professional and scholarly

1. A Multipath-Driven Approach to HF Geolocation
   Fabrizio, G.A.; Heitmann, A.
   Signal Processing, Volume 93, Issue 12, December 2013, Pages 3487–3503
   Special Issue on Advances in Sensor Array Processing in Memory of Alex B. Gersman

2. Robust adaptive beamforming for HF surface wave over-the-horizon radar
   Fabrizio, G.A.; Gershman, A.B.; Turley, M.D.;
   Awarded the Barry Carlton Best Paper Prize for 2004

3. Spatial adaptive subspace detection in OTH radar
   Fabrizio, G.A.; Farina, A.; Turley, M.D.;
   Awarded the Barry Carlton Best Paper Prize for 2003

4. Using sources of opportunity to compensate for receiver mismatch in HF arrays
   Fabrizio, G.A.; Gray, D.A.; Turley, M.D.;

5. Experimental evaluation of adaptive beamforming methods and interference models for high frequency over-the-horizon radar
   Fabrizio, G.A.;Gray, D.A.; Turley, M.D.;

6. Adaptive cancellation of nonstationary interference in HF antenna arrays
   Pages:19 - 24

   G. Fabrizio, F. Colone, P. Lombardo, A. Farina

8. The GEMS Spatial Filter for Blind Waveform Estimation in Diffuse Multipath Channels
   Fabrizio, G.A.; Farina, A.

9. Parametric localisation of space-time distributed sources
   Fabrizio, G.A.; Gray, D.A.; Turley, M.D.;

10. Stochastic constraints in nonstationary hot clutter cancellation
    Anderson, S.J.; Abramovich, Y.I.; Fabrizio, G.A.;

11. Blind Signal Separation with the Generalized Estimation of Multipath Signals (GEMS) Algorithm
    Fabrizio, G.A.; Farina, A.
    Accepted for publication, IET Proceedings on Radar, Sonar and Navigation, August, 2014.