TITLE: **Over-the-Horizon Radar – Fundamental Principles, Adaptive Processing and Emerging Applications.**

PRESENTER:
Dr Giuseppe A. Fabrizio,
Group Leader – Radar Systems
Defence Science and Technology Group (DSTG)
PO Box 1500, Edinburgh, South Australia 5111,
Tel +61 (08) 73896775, Fax +61 (08) 73896673.
Email: joe.fabrizio@dst.defence.gov.au

Giuseppe A. Fabrizio received his B.E and Ph.D. degrees from the Department of Electrical Engineering at Adelaide University, South Australia, in 1992 and 2000. Dr Fabrizio commenced at the Australian Defence Science and Technology Group (DSTG) in 1993 and has over 20 years of experience in leading research and development of High Frequency (HF) radar systems. From 2005-2015, he led the Electronic Warfare (EW) and adaptive signal processing section of the HF Radar branch, where he was responsible for the development and practical implementation of innovative and robust adaptive array signal processing techniques to enhance the operational performance of the Jindalee Operational Radar Network (JORN). Dr Fabrizio is a Fellow of the IEEE and is the principal author of over 60 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) in 2003 and 2004. In 2007, he received the DSTG Science and Engineering Excellence award for contributions to adaptive signal processing for JORN. In the same year, he was granted a DSTG Science Fellowship to pursue collaborative research at La Sapienza University in Rome, Italy. Dr Fabrizio has delivered eight Over-the-Horizon Radar (OTHR) tutorials in the IEEE Radar Conference series. He is a member of the IEEE International Radar Systems Panel and serves an IEEE AES Society Distinguished Lecturer. He served as Vice President of Education and Executive Vice President on the AESS Board of Governors and is currently the President of the IEEE AES Society. Dr Fabrizio has collaborated with international defence agencies including NRL, AFRL, IARPA, DRDC and ONERA under MoU agreements and has represented Australia in NATO SET-179,182 and 227 task group activities. He has engaged extensively with private industry and collaborated with numerous academic institutions in Australia and abroad. Dr. Fabrizio received the IEEE Fred Nathanson Memorial Radar Award in 2011 for his contributions to OTHR and radar signal processing. His is the author of the text "*High Frequency Over-the-Horizon Radar – Fundamental Principles, Signal Processing and Practical Applications*"**,** McGraw-Hill, NY, 2013.

TOPIC:
The tutorial introduces the fundamental principles of over-the-horizon radar (OTHR) design and operation in the challenging high frequency (HF) environment to motivate and explain the architecture and capabilities of modern OTHR systems. It describes conventional and adaptive processing techniques for clutter and interference mitigation as well as emerging applications, including HF passive radar, blind signal separation and multipath-driven geolocation. A highlight of the tutorial is the prolific inclusion of experimental results to illustrate the practical application of advanced signal processing to real-world OTHR 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 emitter geolocation.

AUDIENCE:
The tutorial is relevant for students, engineers, researchers, practitioners and end-users with an interest in OTHR and the application of robust signal processing techniques to practical systems for long-range surveillance and other functions. Introductory material is provided for participants with little or no prior background in HF radar. A basic working knowledge of radar and its associated signal processing is assumed. A qualitative understanding of rudimentary adaptive processing principles is desirable but not essential. There is no requirement for attendees to bring any equipment to the tutorial.

OUTCOMES:
It is expected that participants will gain an understanding of the fundamental principles of OTHR design and operation in the challenging HF environment as well the architectures and capabilities of modern OTHR systems. Participants will also gain an understanding of state-of-the-art adaptive processing techniques to address operational problems effectively in practice. The nature of OTHR missions combined with the low data rates and large computing infrastructure relative to the majority of microwave radar systems has meant that OTHR systems are typically the first to implement computationally-intensive advanced adaptive processing techniques operationally. OTHR is often at the forefront of demonstrating the operational effectiveness of such techniques before it is possible to implement them in radar systems operating at higher frequencies.

DESCRIPTION:

Skywave OTHR operates 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). This unique attribute of OTHR systems plays an important role in effectively cueing more precise line-of-sight sensors, which often have a more limited or circumscribed coverage, as an integrated element of a multi-layered sensor suite.

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 OTHR 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 passive radar, blind signal separation, and multipath-driven geolocation.

Part I: Fundamental OTH Radar Principles (60 min + 15 min for Q&A)
- 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 (60 min + 15 min for Q&A)
- 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 (60 min + 15 min for Q&A)
- 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)

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 their own unique insights and contributions. In addition, the tutorial is not limited to active radar, but also covers a number of emerging applications, such as passive radar, blind signal separation and multipath-driven geolocation. These areas are gaining interest in the radar community but some of them have received relatively less attention in IEEE radar conferences. The theme and contents of the tutorial are well aligned with several topics listed in the call for tutorials. For these reasons, the tutorial is regarded as relevant to the 2020 IEEE Radar Conference.

PREVIOUS EDITIONS:

The content and emphasis of this tutorial is changed from the introductory OTHR tutorial that has been presented at previous IEEE radar conferences 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 2020 IEEE Radar Conference will draw on the contents of the previous edition for Part I to introduce the fundamental principles of OTHR to the audience, but the core aspects in Parts II and III are relatively new.

MATERIAL:

In addition to receiving the course notes for the tutorial (approximately 150 colour slides), there is also an opportunity for participants to receive a copy of the OTHR text book described below to complement the viewgraphs. At the 2013 IEEE International Radar Conference in Adelaide, McGraw-Hill Professional sponsored the OTHR tutorial to permit this initiative in exchange for low-level advertising in the conference bag. Feedback from surveys confirmed that this offer helped to increase attendance. This or an alternative option could be considered. 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.

https://www.amazon.com/High-Frequency-Over-Horizon-Radar/dp/007162127X