Preface

Geolocation of RF Signals: *Principles and Simulations* offers an overview of the best practices and innovative techniques in the art and science of geolocation over the last 20 years. It covers all research and development aspects including theoretical analysis, RF signals, geolocation techniques, key block diagrams, and practical principle simulation examples in the frequency band from 100 MHz to 18 GHz or even 60 GHz. Dr. Progri reveals the research and development process by demonstrating how to understand and explain geolocation of RF signals from basic diagrams to the final principle simulation examples and makes recommendations for the future final products of geolocation of RF signals. Starting with RF signals, the book progressively examines various signal bands – such as VLF, LF, MF, HF, VHF, UHF, L, S, C, X, Ku, and, K and the corresponding geolocation requirements per band and per application – to achieve required performance objectives of up to 0° precision. Next follows a step-by-step approach of RF geolocation techniques and concludes with notes on state-of-the-art geolocation designs as well as advanced features found in signal generator instruments. The book also includes the best mathematical techniques employed for geolocation of RF signals at 100 MHz to 18 GHz or even 60 GHz.

The book is designed into two parts taking into consideration the vastness, depth, and resourcefulness of the material. Part I contains Chaps. 1–3 and part II includes Chaps. 4–6.

Part I of the book is intended to engage and immerse the reader with unique, powerful ideas, detailed descriptions and discussions, powerful analysis, important principles and visualization tools, and most of all provide the means to deepen the reader's imagination for future research and development work, applications, and product, and development of future prototypes. Figures make the reader aware of the vastness of opportunities to refine future models and modeling, principle recopies, and analysis tools.

Part II of the book is intended to engage, train, and prepare the reader with powerful principle "recipe secrets" for analyzing, modeling, and simulating GRFS systems. Since this is the first edition of the book, the emphasis here is given in the

main principles, algorithm descriptions, best blind signal array processing techniques, recursive algorithms, and adaptive array algorithms.

Chapter 1 is an introduction to the *Geolocation of RF Signals*: *Principles and Simulations*, hereto are referred to as GRFS, which includes a discussion on GRFS system concept, proper technical definition, and performs the classification of the GRFS systems into outdoor, indoor, air, and underwater GRFS systems, perhaps the most detailed and organized discussion on requirements of GRFS systems, GRFS system main description, a brief discussion on best state-of-the-art GRFS techniques, and finally is concluded with applications of GRFS systems.

Chapter 2 provides a review of the research, investigation, and proposal of the navigation, communications, and geolocation requirements, and capabilities of indoor, urban, suburban, global, and satellite GRFS systems. It has the most unique organization, the most extensive discussion, and the most detailed graphical illustration. It also illustrates what areas and applications are matured, what areas have scare information and what areas need special attention. In this chapter, the reader will become aware of the vastness, depth, complexity, and resourcefulness of this area of research, development, and commercialization of GRFS systems both to the military and civil users.

Chapter 3 builds upon the work already discussed in Chaps. 1 and 2. From this chapter, the reader expects to understand the finer details of RF signals that will connect the information prepared in Chaps. 1 and 2 and also later in the part II in Chaps. 4–6. This chapter includes a great discussion on *RF Signals Main Parameters*, *Best Described RF Signals*, and then discusses several candidates of RF signals for indoor, urban, suburban, global, and satellite GRFS systems.

Chapter 4 starts the part II of the book with the adaptive array algorithms for GRFS systems. A great deal of discussion on this chapter is dedicated to adaptive antenna array employing a blind adaptive algorithm which can be exploited to extract signals with unknown characteristics coming from unknown locations based only on very limited knowledge of the received signal properties. These signals may be RF sources of interference to a desired GPS signal, Mobile phone, wireless network, two-way radio, satellite TV, FM station, etc. and whose locations might be determined once these signals are extracted and illustrate the performance of the blind algorithm by comparing the extracted signals with the original signals for very simple signal designs in 2001 and 2002 and more contemporary signal designs in 2010 and the estimated signal locations with the corresponding actual signal locations up to 0° precision.

Chapter 5 incorporates the discussion of the best recursive linear algorithms for adaptive array processing which enables these algorithms and systems to be implemented in real time or near-real time. There are three main principles discussed in Chap. 5: gain in computation time, i.e., perform a computation faster; reduction of computation memory, i.e., utilize as little software and hardware resources as possible; and improvement in robustness, i.e., maintain stability.

Chapter 6 discusses adaptive array beamforming for interference mitigation for GRFS systems. Dr. Progri reveals the research and development process by

demonstrating how to understand, explain, model, and simulate four most recognized adaptive array beamforming processing techniques for interference mitigation for GRFS systems which are: (1) adaptive temporal selective attenuator (ATSA); (2) adaptive spatial selective attenuator (ASSA); (3) adaptive spatial temporal selective attenuator (ASTSA); and (4) an improved adaptive spatial temporal selective attenuator (IASTSA) (or an ASTSA with restored phase); from basic diagrams to be utilized to the principle simulation examples and makes recommendations for the future final products of geolocation of RF signals.

With six chapters and a variety of topics, young or experienced professionals have many tools to analyze, model, simulate very complex RF signal models, build complex and sophisticated real-time digital signal array processing capabilities into existing systems, or propose future passive systems. *Geolocation of RF Signals*: *Principles and Simulations* should be a very useful tool for the Department of Defense government agencies which are looking for further research and development in the area of GRFS systems. The book is very useful for large corporations which dictate and produce future requirements for GRFS transmitters such as satellites, mobile array transmitters. The book should be an indispensable guide for small research and development companies which rely on government contracts and also on collaboration from large corporations because further discussion on this book is based upon strong and close collaboration between small and large businesses. This book should offer a unique opportunity to Ph.D. students to engage in very complex and sophisticated analysis, modeling, and cutting edge research. The material of this book can be also taught in part or as a whole in small or large conferences such as IEEE RadarCom, IEEE Globecom, ION/IEEE PLANS, and ION GNSS, etc.

This book would have been impossible without the numerous opportunities I had while working with a number of outstanding people whose name and contributions I would like to acknowledge publically.

I would like to thank my high-school math teacher Gergji Papanikolla and Fredi Fundo who prepared me to win in three mathematical, national high-school competitions at “Themistokli Gërmenji” High School in Korça, Albania from 1986 to 1989. During my undergraduate university studies I would like to express immense gratitude to my professors Jorgo Malita, Raimonda Bualoti, and especially to Niko Thomo at the Polytechnic University of Tirana, Tirana, Albania. Professor Jorgo helped me especially with my theoretical mathematical background while I was completing the proofs of the theorems of his books on Calculus I, II, III, and IV. Raimonda was the first person to introduce me to some of the recursive algorithms for solving complex linear system of equations. Professor Niko Thomo was the first to introduce me to famous book on *Mathematical Methods for Physicist* (which is referred in this manuscript) which became a great foundation for my graduate mathematical preparation from 1990 to 1994.

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Six and a half years of my Ph.D. studies became without doubt the most solid building block for my knowledge of signals, systems, communications, linear and numerical algebra, and geolocation background. During this time, I became without doubt the Ph.D. student in the ECE department at WPI with most publications. I am indebted to Professor William R. Michalson who supervised my Ph.D. dissertation and introduced me to systems such as GPS, GNSS, Indoor Geolocation Systems, and hardware and real-time embedded software requirements on interference mitigation techniques from 1998 to 2003. Dr. Matthew C. Bromberg became a great resource and we worked together in a few projects which are: in blind adaptive equalization, statistical adaptive array signal processing, and recursive algorithms.

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