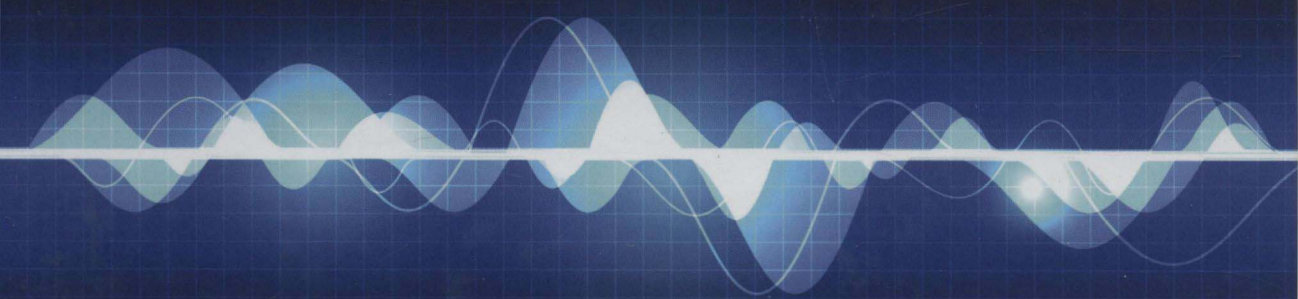
INTERFERENCE ANALYSIS

MODELLING RADIO SYSTEMS FOR SPECTRUM MANAGEMENT



JOHN PAHL

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MODELLING RADIO SYSTEMS FOR SPECTRUM MANAGEMENT

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To my family

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Every attempt has been made to avoid typographic errors: if any should be spotted, the author would greatly appreciate notice via email at johnpahl@transfinite.com.

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Overlay from NASA: *Visible Earth* full credit: NASA Goddard Space Flight Center Image by Reto Stöckli (land surface, shallow water, clouds). Enhancements by Robert Simmon (ocean color, compositing, 3D globes, animation). Data and technical support: MODIS Land Group; MODIS Science Data Support Team; MODIS Atmosphere Group; MODIS Ocean Group Additional data: USGS EROS Data Center (topography); USGS Terrestrial Remote Sensing Flagstaff Field Center (Antarctica); Defense Meteorological Satellite Program (city lights).

Contents

Foreword

Radiocommunications is the generic term to describe the various uses of the radio-frequency spectrum that have gradually become an integral part of our daily life in the last 30 years.

Television and sound broadcasting, satellite communications, radionavigation systems (such as GPS), mobile telephones or smartphones, Wi-Fi or Bluetooth systems or garage door openers, radars, emergency or defence communications, aircraft or maritime communications, radio relays, meteorological radiosondes or satellites, scientific or Earth exploration satellites, radio astronomy and deep space missions are only a few examples of the ever-increasing number of systems and applications that rely on spectrum to exist.

The associated investments represent trillions of dollars and are increasing every day as gathering and exchange of data also increase. The task of ensuring a viable ecosystem for the coexistence of these investments in the short, medium and long terms is entrusted to the International Telecommunication Union (ITU), which celebrated its 150th anniversary on 17 May 2015.

The objective of the ITU in this regard is to ensure the rational, efficient, equitable and economical use of the natural resources of the radio-frequency spectrum and satellite orbits. This is done by the application and regular updating of the ITU Radio Regulations, the international treaty that regulates the use of these resources by all countries in the world. The overriding objective of these regulations is to ensure operation of the radiocommunication systems of all countries free of harmful interference, thereby protecting these systems and the associated investments and providing the assurance that existing and future investments will be protected in the future.

To this end, any change foreseen in spectrum use is duly scrutinized by a population of experts coming from all parts of the world to attend frequent and multiple meetings of the Study Groups and Working Parties of the ITU Radiocommunication Sector. These experts literally dedicate their lives to building the future of radiocommunication systems and applications. Mr John Pahl is one of them. Over the last 20 years, he has played a key role in pushing the state of the art in analysis of interference between complex systems and developing appropriate regulations and best practices for their use of spectrum.

His book benefits from his long experience in world-level discussions within the technical, operational and regulatory decision-making process of the ITU Radiocommunication Sector. It covers the various aspects that need to receive careful consideration in assessing the interference that may occur among radiocommunication systems, at the design or coordination stage of these systems.

With the increased use of spectrum required to satisfy the growing demand for orbit and spectrum resources, more efficient use of these resources will come with increased complexity in system design, regulations, frequency assignment and coordination. Mr John Pahl's book will certainly be a gold mine for the current and future generations of spectrum managers, communication system designers and regulators in their day-to-day work to continue to deliver viable radiocommunication services and meet the growing expectations of the world's population in this regard.

François Rancy
Director, ITU Radio Sector

Preface

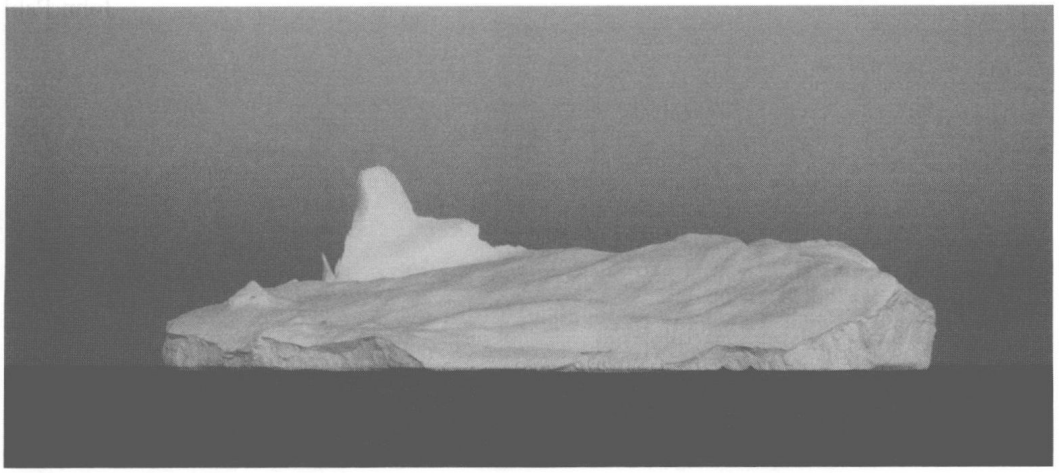

Photo credit: the author

We were on the lookout for ice.

I was in a 32 foot sailing yacht with writer and explorer Tristan Gooley, undertaking a double-handed sail from Scotland through the Faroes up to 66° 33′ 45.7″ N and the midnight sun. Now sailing out of the Arctic Circle we were approaching Iceland from the north, heading for the Denmark Straits, where ice flowed south. The Admiralty Pilot warned of bergs but the ice charts we had sailed with were over a week old. We needed an update.

So I reached for the Iridium satellite phone and rang a number in Greenland. A polite voice reassured us that as long as we kept within 50 nm of Iceland we should be okay.

Though I'd never had need of a satellite phone before that call, it was a technology I'd been involved in for nearly 20 years. It was by working on one of the other non-GSO mobile-satellite systems that I learnt the techniques and engineering principles of interference analysis. It turned

out that there was a lot to cover: dynamics, antennas, link budgets, service objectives, thresholds, methodologies, modulations, coverage and much, much more.

On that voyage we didn't get to see any icebergs but the following year would make up for it when I sailed from Iceland over to Greenland and then down its east coast to Tasiilaq, passing close to the one in the photo on the previous page.

A berg like this drifted into the Atlantic in 1912 to sink the *RMS Titanic*, which radioed in distress for a rescue that was to come too late. Just a few months after this disaster, the International Radiotelegraph Conference in London was spurred to agree on common frequencies, and this led to what we now call the Radio Regulations.

I would have to learn about those too, first studying the ITU-R Regulations, Recommendations and Reports, then writing some of my own, getting them approved within the ITU-R, understanding the processes and, where necessary, chairing meetings.

Interference analysis involves engineering and regulation, and this book will by its nature cover both.

My hope is that it will assist those who want to learn about these topics and help others to avoid some of the potential icebergs.

John Pahl