

INDOOR RADIO PLANNING

**A Practical Guide for GSM,
DCS, UMTS, HSPA and LTE**

Morten Tolstrup

Second Edition



 **WILEY**

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Morten Tolstrup

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A Practical Guide for GSM, DCS,
GPRS, HSPA and LTE

Second Edition

Per Oluf Tolstrup

Technical Director, Denmark



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Foreword by Professor Simon Saunders

The compelling need for in-building wireless systems derives directly from the needs of the people who use wireless – and that means, increasingly, all of us. We spend most of our time inside buildings, whether in the office or at home, at work or at play. Typically at least two-thirds of voice traffic on cellular networks originates or terminates inside buildings, and for data services the proportion is still higher – probably in excess of 90%.

Yet for too long, most indoor service has been provided from outdoor systems requiring high transmit powers, major civil engineering works and using a relatively large amount of spectrum to serve a given traffic level. This makes great sense for providing economical initial coverage to a large number of buildings and for ‘joining the dots’ to enable wide area mobility. However, ‘outside-in’ thinking is ‘inside-out’, from a technical and practical viewpoint, when attempting to serve users with very high quality and coverage expectations, and for delivering high data rate services within limited spectrum. Buildings offer their own remedy to these challenges, by providing signal isolation from nearby systems and enabling the fundamental principle of cellular systems – that unlimited capacity is available from limited spectrum if the engineering is done right.

Despite these compelling benefits, in-building wireless systems have hitherto been a poor relation of the ‘mainstream’ macrocellular network operations. With relatively few enthusiasts and a wide range of different favoured techniques for system design and installation, the field has at times resembled a hobby rather than a professional activity. The industry desperately needs best-practice techniques to be shared amongst a wider base of individuals to serve the growing demand – there are not enough engineers for the buildings requiring service – and for these techniques to become standardised in order to drive down costs, improve reliability and drive volumes.

Given this background, I welcome the publication of this book. Morten Tolstrup is a leading practitioner in the field and an engaging and entertaining public speaker. He has written a truly practical and helpful guide to indoor radio planning, which will enable a much wider audience to convert their skills from the old world of two-dimensional networks, comprising macro cells alone, to the new world of three-dimensional hierarchical networks comprising macro, micro, pico and femto cells delivering services to unlimited numbers of users. Following the simple guidelines provided, built on years of real-world experience, will help to avoid some very expensive mistakes.

Most of all, I hope that this book will help to professionalize the industry and encourage sharing of best-practice to the ultimate benefit of end-customers for compelling wireless broadband services.

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Preface to the Second Edition

This is Still Not a Book for Scientists!

This book is intended for RF planners, to serve as a practical tool in their daily work designing indoor radio distribution systems.

Based on feedback from readers of the first edition it was clear to me that I needed to add more material and in depth description of the basics of indoor systems based on using repeaters; this has grown into a new Section 4.7.

There was also a strong demand to add more detail and dedicate a full chapter to radio planning in tunnels, for both rail and road tunnels; and redundancy principles in the design focus for solving the challenge of handover zones. An entire Chapter 11 is now dedicated to tunnel radio planning.

Also, although one could argue that this actually belongs in a book about indoor radio planning, I have added the relatively new and exciting option of designing and implementing outdoor DAS. The fact is that this outdoor DAS is implemented primarily to provide indoor coverage – so yes I do think that it is important to include it in this edition, in Chapter 12.

Obviously LTE was the hot topic as I was writing the manuscript; I have added the basics on LTE, MIMO and how to implement LTE inside buildings. Naturally I cannot include all of the deep insight into LTE – for that please refer to [7] and [8]. At this point only a few deployments of LTE indoors have been carried out and these by vendors – understandably I do not want to disclose all of their secrets and results. However, I have tried to my best to share what I know at this point – I am sure that these are merely the early days of a long and exiting journey with LTE.

So with additional material amounting to more than 25% in the second edition, I do hope that you find this new edition even better than the first.

The Practical Approach

Once again, my focus in this second edition is the practical approach to how to plan and implement indoor wireless solutions, and to share some of the hard learned lessons, lessons learned by me or my good friends in the industry.

As I stated in the first edition ‘I am not an expert’. I am both surprised and honored by the feedback for the first edition – thanks for that. But I need to make it clear: I am still not an expert.

I do however, have the great pleasure of working with, and meeting a lot of very experienced and knowledgeable people in the industry – you are the experts. What I learn

and have published is based on projects and knowledge sharing with you good people. Thanks for that; this makes me a student, I am learning every day and I enjoy it. So please keep sharing... that's how we all get better.

Keep the Originals!

Please also remember to keep the originals, so purchase your copy of a good book rather than a pirate download of a PDF copy, that's the only way to assure new books for all of us! I hope you find this book to be a useful tool in your daily work. That was my intention.

Morten Tolstrup
January, 2011

Preface to the First Edition

This is Not a Book for Scientists

This book is intended for the RF planners, to serve as a practical tool in their daily work designing indoor radio distribution systems. It is not a complete book about all the deep aspects and corners of GSM, DCS, UMTS and HSPA networks, or all the core network systems. It is dedicated to the last 10–70 m of the network, the indoor air interface between the mobile user and the indoor mobile network.

I have spent the past 20 years working on various parts of the exciting business of cellular communication. During this time I have mostly focused on the planning of the radio interface between the network and the mobile user, with a dedicated focus on indoor radio planning. I have always tried to approach that small part of the systems that involved me, the radio interface, from a practical angle. I have struggled with most of the books available on these subjects mainly due to a theoretical level far beyond my needs. My hope with this book is to present a level of theory that is usable and accessible for a radio planner with basic radio experience.

I also need to emphasize that no matter the radio platform or standard, GSM, UMTS, HSPA or 4G, as long as the interface between the mobile and the network uses radio communication, it will always be a matter of a link calculation with a given signal-to-noise ratio for a given service requirement. After all, it is ‘just’ radio planning.

The Practical Approach

I am not an expert in cellular, GSM, UMTS or HSPA systems, far from it – but I have gained a lot of experience with RF design, especially with regards to indoor radio planning. An old mountaineering saying is that ‘good judgment comes from experience, but experience is often a result of bad judgment’. I have made my share of mistakes along the way, and I will help you avoid making the same mistakes when designing and implementing indoor solutions.

It has been my goal to include what I believe are the most important considerations and design guidelines to enable the RF planner to design and implement a high-performing indoor distributed antenna system.

It was not my intention to provide a deep hardcore mathematical background on RF planning, but to present the most basic calculations of the various parameters that we need to consider when designing a distributed antenna system.

I hope you can use the result – this book. It has been hard but also great fun to write it and to revisit all the background stuff, projects and measurement results that are the basis for this book. I hope you find it to be a useful tool in your daily work. That was my intention.

Morten Tolstrup

Acknowledgments

Second Edition

Once again I have called in favors from the best people in the business to help me verify and check the additional chapters in this second edition.

In particular I want to thank my friends and colleagues for many years for their input and help on the repeater and tunnel planning section; Mr Henrik Fredskild – Denmark, and Mr Stephen Page – Australia. Your input and guidance has added enormous value to the new chapters in this second edition.

I also want to thank: Mr Lance Uyehara – USA, Mr Jaime Espinoza – Chile, Mrs Marianne Riise Holst – Denmark/Norway, Lars Petersen – Spain/Denmark for their input and corrections.

Also, thanks to so many of you who have given me so much positive feedback, via mail, via groups on the WEB and at conferences and meetings, etc.

When I was writing the first edition I was not sure that there was a need for a book covering the practical approach – now I know.

Thanks once again to the team from Wiley: Mark Hammond, Susan Barclay and their team, for their support in the production of this book.

Last, but not least, thank you Karin, my dear wife, once again for your patience – even though I did promise you not to take on yet another book. Thanks for your support on this project, and for once again letting me spend so many late nights, early mornings and weekends on this book.

Without your support and patience Karin, this book would not have been possible.

If you want to contact me, or should you find any errors or have suggestions for more topics for any future editions, let me know.

You can contact me via: www.ib-planning.com.

Remember that the best form of optimization you can provide for your network is to plan it correctly from day one. This also applies to indoor radio solutions.

First Edition

This book would not have been possible if it was not for my many colleagues and friends who I have spend the better part of the last 20 years with. These friends and colleagues I know mainly from my many indoor projects around the world and from other mobile operators when working on mutual indoor projects. Many hours have I spent with you guys during the design phase, site visits, project implementations and measurements, from the fanciest indoor projects to deep below ground on a tunnel project conducting verification measurements.

I want to thank Simon Saunders for contributing the foreword. Simon is one of the people in this industry I respect the most, for his dedicated work and contribution to so many fields in the industry of telecommunication.

I also thank my friends who have helped me by reviewing the book: Bernd Margotte, Lars Petersen, Kevin Moxsom, Stein Erik Paulsen and Mario Bouchard. In particular, I want to thank Robin Young for his help and inspiration on the section about noise and link budgets. Peter Walther is also acknowledged for his input on the HSPA section, and the link budget example for HSDPA.

Thanks also to the team from Wiley, Mark Hammond, Sarah Hinton and their team, for the support and production of this book.

Last, but not least, thank you Karin my dear wife, for your support on this project and for letting me spend so many late nights, early mornings and weekends on this book. Without you this project would not have been possible. Thanks also for your design concept of the front cover, and the photo for the cover.

Even though I have spent many hours on this project, checking and double-checking everything, there might be an error or two. Let me know, and I will make sure to correct it in any future editions.

You can contact me via: www.ib-planning.com

Morten Tolstrup
Dronninglund, Denmark

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