Contents

Preface xv
Acknowledgements xvii
About the Author xix

1 Predicting the Future is a Necessary Part of Business 1

2 Previous Predictions have been Accurate 3
   2.1 Introduction 3
   2.2 There have been Huge Changes in the Telecoms Climate 3
   2.3 What we Predicted for the Period 2000–2005 6
   2.4 How Well did we do? 7
   2.5 Our Predictions for 2005–2010 8
   2.6 How Good do these Predictions Look Now? 9
   2.7 Implications for Forecasting the Future 9

3 How to put Together a Forecast 11

4 The Current Position 13
   4.1 The Value of a Good Understanding of the Starting Position 13
   4.2 Mobile Communications 14
      4.2.1 Cellular 14
         Introduction to Cellular [1–3] 14
         2G Cellular 15
         3G Cellular 17
         WiMax for Mobile Applications 18
         ‘4G’ Cellular 19
         Convergent Technologies 21
         Summary for Cellular 22
      4.2.2 Private Mobile Radio 22
         Introduction 22
         Analogue Communications 23
         Digital Communications 23
4.2.3 Mobile Mesh Systems
4.2.4 Cognitive Radio
4.3 Fixed wireless
  4.3.1 Introduction
  4.3.2 Key Drivers for Fixed Wireless
  4.3.3 Key Competitors to Fixed Wireless
  4.3.4 Likely Success of Fixed Wireless
  4.3.5 Enlarging the Market with a Nomadic Offering
  4.3.6 The Prognosis for Fixed Wireless
4.4 Short-range Devices
  4.4.1 Introduction
  4.4.2 Overview of the Standards for Short-range Devices
  4.4.3 Ultra Wideband (UWB)
  4.4.4 Wireless LANs [5]
  4.4.5 BlueTooth [6]
  4.4.6 DECT
  4.4.7 Zigbee
  4.4.8 RFIDs
  4.4.9 The Prognosis for Short-range Devices
4.5 Core Networks
4.6 Broadcasting
  4.6.1 Conventional Broadcasting
  4.6.2 Mobile Broadcasting
4.7 Industry Structure
4.8 Summary
4.9 Appendix: The Role for OFDM
  OFDM is Increasingly in Favour
  A Quick Introduction to OFDM
  Multipath: the Key Difference between OFDM and SCM
  Equalisers may become too Complex to be Realisable
  Problems Specific to OFDM
  Specific Applications
  So is OFDM the New ‘Technology of Choice’?
References

5 End User Demand
5.1 Why What the User Wants is Critical
5.2 How People React to New Concepts
5.3 Changing Patterns of Spending
5.4 What they have Today
5.5 What they want Now
5.6 Security, Privacy and Health Concerns
5.7 The Handset Subsidy Problem
5.8 In Summary

6 Technology Progress
6.1 Technology is a Critical Input to any Forecast
6.2 Key Technical Fundamentals: The ‘True’ Laws
6.3 Key Technical Observations: The ‘Empirical’ Laws 62
  6.3.1 Moore’s Law 62
  6.3.2 Metcalfe’s Law 63
  6.3.3 Gilder’s Law 64
  6.3.4 Cooper’s Law 65
  6.3.5 Edholm’s Law 67
  6.3.6 Growth in Disk Size 68
  6.3.7 Goodhart’s Law 70
  6.3.8 Laws or Trends? 70

6.4 Technologies on the ‘Radar Screen’ 70
  6.4.1 Technologies Enhancing the Efficiency of Transmission 71
    Software-defined Radio 71
    Smart Antennas 71
    Wireless Mesh Networking 72
    Interference Cancellation 73
    Cognitive Radio 74
  6.4.2 Technologies Lowering Cost: Backhaul 74
  6.4.3 Technologies Enhancing Interaction with Terminals 76
  6.4.4 Technologies Leading to ‘Artificial Intelligence’ 84
  6.4.5 Compression Technologies 85

6.5 Technology Prognosis: No Key Breakthroughs 85
6.6 Implications for the Future 85
References 86

7 Major World Events 87
  7.1 Introduction 87
  7.2 World Events 87
  7.3 Events in Related Industries 89
  7.4 Summary 90
  7.5 The Next Chapters 90

8 Future Military Wireless Solutions 91
  Paul S. Cannon and Clive R. Harding
  8.1 Introduction 91
  8.2 Operational Context 92
  8.3 Technical Features Important to Secure and Robust Global Military
      Communications 93
  8.4 New Platforms and Missions: Their Impact on Military Communication Systems 94
    8.4.1 Impact of Unmanned Vehicles 94
    8.4.2 Impact of High-Altitude Platforms (HAPs) 95
    8.4.3 Impact of Future Infantry Soldier Technology 96
    8.4.4 Impact of Wireless Sensor Networks 96
  8.5 Developments in Military Communications Systems 97
    8.5.1 Introduction 97
    8.5.2 Very Low-Frequency (VLF) Communications 97
    8.5.3 High-Frequency (HF) Communications 98
    8.5.4 Terrestrial VHF, UHF and SHF Tactical Communications 99
    8.5.5 Satellite Communications 100
  8.6 Emerging Communications Techniques 103
    8.6.1 Introduction 103
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.3.4 Private and Public Transportation</td>
<td>138</td>
</tr>
<tr>
<td>10.3.5 Metro-area Broadband Networks</td>
<td>139</td>
</tr>
<tr>
<td>10.3.6 Mining and Manufacturing</td>
<td>139</td>
</tr>
<tr>
<td>10.3.7 Corporate Networks</td>
<td>139</td>
</tr>
<tr>
<td>10.3.8 Sensor Networks and Things-to-Things Communication</td>
<td>140</td>
</tr>
<tr>
<td>10.4 Enabling the Next Generation of Ad-hoc Connectivity</td>
<td>140</td>
</tr>
<tr>
<td>10.5 Types of Ad-hoc Network</td>
<td>142</td>
</tr>
<tr>
<td>10.5.1 Autonomous Peer-to-Peer Networks</td>
<td>142</td>
</tr>
<tr>
<td>10.5.2 Hybrid Mesh Networks</td>
<td>143</td>
</tr>
<tr>
<td>10.6 Integrated Ad-hoc and Wide Area Networks</td>
<td>144</td>
</tr>
<tr>
<td>10.6.1 Linking of Ad-hoc Workgroups</td>
<td>144</td>
</tr>
<tr>
<td>10.6.2 Extension of carrier broadband networks</td>
<td>144</td>
</tr>
<tr>
<td>10.6.3 Enhanced Network Performance</td>
<td>144</td>
</tr>
<tr>
<td>10.7 Enabling Technologies</td>
<td>145</td>
</tr>
<tr>
<td>10.7.1 Self-configuration and Self-organisation</td>
<td>145</td>
</tr>
<tr>
<td>10.7.2 Multi-hopping and Dynamic Routing of Data Packets</td>
<td>145</td>
</tr>
<tr>
<td>10.7.3 Smart Sensors and Devices</td>
<td>146</td>
</tr>
<tr>
<td>10.7.4 Location-awareness</td>
<td>146</td>
</tr>
<tr>
<td>10.7.5 Low-power and Energy-scavenging Technologies</td>
<td>146</td>
</tr>
<tr>
<td>10.7.6 End User Control over Preferences and Privacy</td>
<td>147</td>
</tr>
<tr>
<td>10.8 New Business and Usage Models</td>
<td>147</td>
</tr>
<tr>
<td>10.9 Benefits of Ad-hoc Technology Wireless Carriers and Internet Providers</td>
<td>150</td>
</tr>
<tr>
<td>10.9.1 Incumbent Wireless Carriers</td>
<td>150</td>
</tr>
<tr>
<td>10.9.2 Cable Broadband Operators</td>
<td>150</td>
</tr>
<tr>
<td>10.9.3 ‘Mom and Pop’ Wisps</td>
<td>151</td>
</tr>
<tr>
<td>10.9.4 Greenfield Operators</td>
<td>151</td>
</tr>
<tr>
<td>10.9.5 Marketers</td>
<td>151</td>
</tr>
<tr>
<td>10.10 A Decentralised Future and Boundless Opportunities</td>
<td>152</td>
</tr>
<tr>
<td>Reference</td>
<td>152</td>
</tr>
<tr>
<td>Biographies</td>
<td>153</td>
</tr>
</tbody>
</table>

11 Interference and Our Wireless Future

*Dennis A. Roberson*

11.1 Introduction 155
11.2 History 156
11.3 Spectrum Scarcity 157
11.4 Regulatory Directions Toward Scarcity Amelioration 157
11.5 Scarcity Amelioration Approaches 162
11.6 Emerging Wireless Communications Devices and Systems 162
References 165
Biography 166

12 Three Ages of Future Wireless Communications

*Simon Saunders*

12.1 Introduction 167
12.2 The Age of Wireless Proliferation: 2007 to 2011 169
12.2.1 Introduction 169
12.2.2 Services and Applications 170
12.2.3 Devices 172
12.2.4 Infrastructure 173
14 Assimilating the Key Factors 213
14.1 Introduction 213
14.2 Summary of the Current Position 213
14.3 Summary of End User Demand 214
14.4 Summary from Technology Advances Section 214
14.5 Summary from the Contributors 215
Paul Cannon 215
Peter Cochrane 216
Gary Grube and Hamid Ahmadi 216
Dennis Roberson 216
Simon Saunders 217
Stephen Temple 217
14.6 Key Factors brought out by the Contributors 218
14.6.1 Areas not Included in Previous Discussion 218
Connectivity 218
Backhaul 219
Applications 219
Technology 219
Regulation 219
14.6.2 Areas of Disagreement 219
14.7 Reaching a Verdict on the Areas of Disagreement 220
14.8 Drawing these Key Factors Together 221

15 The Future Roadmap 223
15.1 Introduction 223
15.2 Predictions for 2011 223
15.3 Predictions for 2016 227
15.4 Predictions for 2021 232
15.5 Predictions for 2026 233
15.6 Key New Applications 235
15.7 Key New Technologies 236
15.8 Key Changes in Networks 237
15.9 Major Growth Areas 238
15.10 Areas we Predict Will not be Successful 238
15.11 Implications for Stakeholders 239
Manufacturers 239
Operators 239
Service Providers 240
Regulators 240
Academics and Researchers 240
15.12 Differences from the Prediction Made in 2000 241
15.13 The Future in a Page 243
15.14 . . . And the Elevator Pitch 244

List of Acronyms 245

Index 249