

Index

• Numerics •

- 3GPP, 280
- 802.11a frequency, 186
- 802.11b frequency, 186
- 802.11g frequency, 186
- 802.11n frequency, 186
- 802.15.4a standard, 206
- 868.3 MHz frequency, 209
- 902-928 MHz frequency, 209
- 2405-2480 MHz frequency, 209

• A •

- absolute position, 13
- accelerometers, 182
- access point
 - defined, 185
 - Wi-Fi, 189
- accuracy
 - Bluetooth, 197
 - cellular network locating, 168
 - dead reckoning, 184
 - distributed model, 200
 - GPS, 160
 - locating technologies, 156
 - monitoring, 96
 - overview, 58
 - perceived, 230-232
 - precision compared with, 154
 - precision locating, 181
 - relationship with local area coverage, 180
 - tightly coupled model, 199
 - UWB, 206
 - Wi-Fi, 193
 - WiMAX, 173
- acoustic locating systems
 - accuracy, 181
 - overview, 211-212
 - process, 212
 - pros and cons, 212-213
- Active Badge System, 284
- Active BAT Location System, 284-285
- active low frequency (active LF), 125-127
- active RFID
 - accuracy, 181
 - air interface standards, 204
 - frequencies, 201
 - locating by associating, 222
 - overview, 200-202
 - process, 202-203
 - pros and cons, 203
- active tags, 29-30
- active UHF, 217
- adding value, 11-12, 104-105
- Address Resolution Protocol (ARP)
 - poisoning, 241
- aerospace sector, 23
- A-GPS (assisted GPS), 162-163
- AIDC 100, 281
- AIM Global, 279
- air interface standards, 204
- airwaves noise-level baselines, 244
- algorithms, 40
- aliasing, 194
- altimeters, barometric, 183
- amusement parks, 25-26
- analysis, traffic, 242-243
- analytic applications, 225
- Angle of Arrival (AOA)
 - computing tag locations, 44
 - overview, 39
 - UWB, 205
- applications
 - acoustic locating systems, 211-212
 - analytic, 225
 - cellular technology, 163
 - computer vision, 209-210
 - establishing objectives, 235
 - GPS, 157
 - locating by associating, 223-226
 - monitoring, 95-99
 - overview, 10, 52-53
 - presence-based, 217-218
 - safety, 224-225
 - security, 223-224
 - social-networking, 225-226
 - threat impacts, 246-248
 - TV signal-based positioning, 174
 - WiMAX, 171

- applying
 - infrared technology, 141–142
 - powerline positioning, 148–149
 - room-level locating, 138–139
 - ultrasound, 145–146
- architecture cost, 109
- area of coverage, 153
- area of service, 153
- ARP (Address Resolution Protocol)
 - poisoning, 241
- assessing
 - benefits, 295–302
 - deployment needs, 60–63
 - end-user experience, 261–262
- assets
 - connecting tags, 34–35
 - locating, 11, 235
 - tagging, 17–18
 - tracking, 17, 119
- assisted GPS (A-GPS), 162–163
- associating
 - locating by, 14
 - overview, 219–221
 - relationship with accuracy, 58
- asynchronous data routing, 107
- atmospheric effects, 177
- attaching tags, 91
- attenuates, 189
- audit, integration, 108
- authentication, 245
- automotive sector, 22–23
- availability
 - cellular network locating, 167
 - loss, 238–241
 - measuring, 234
 - overview, 67

• B •

- back-end network (GPS), 160
- backscatter, 29
- barometric altimeters, 183
- base stations, 164
- baselines, 99
- batteries. *See also* battery life
 - cell casing, 269–270
 - charging, 274
 - differences, 268–269
 - disposing of, 269
 - history, 268
 - low-battery indicator, 271–272
 - maintaining, 270–271
 - overview, 267

- replacement, 64
 - safety, 272
 - solar cells, 214
 - storing, 273–274
 - tag, 31–32
 - unauthorized use, 273
- battery assisted passive tags, 29–30
- battery life. *See also* batteries
 - active LF solutions, 128
 - building illumination, 214
 - cellular network locating, 168
 - GPS, 161
 - maximizing, 268
 - passive LF solutions, 127
 - semipassive UHF, 134
 - ZigBee, 208
- Beidou, 288
- benefits
 - assessing, 295–302
 - direct, 298–299
 - indirect, 299–300
 - quantifiable soft, 301–302
 - realization reports, 302–304
 - soft, 300–301
- bio sensors (tag), 34
- bio tamper detection, 244
- blocking
 - attacks, 240
 - GPS, 159
- Bluetooth
 - accuracy, 181
 - frequencies, 196
 - locating by associating, 222
 - overview, 195
 - process, 195–196
 - pros and cons, 197
 - SIG, 282
- book
 - conventions, 2
 - icons, 5
 - organization, 3–5
- broad portfolio, 88
- broadcast flooding, 240
- budget constraints, 78
- building illumination
 - accuracy, 181
 - overview, 213
 - presence-based positioning, 216
 - pros and cons, 214
- business constraints
 - budget and staffing, 78
 - business processes, 79–80
 - environmental, 79

- suppliers, clients and competitors, 80
- technical landscape, 78–79
- business markets, 16
- business metrics, 96
- business process, 79–80, 255
- button cells, 269
- buzzers feature, 12

• C •

- cabling, 61–62
- calibration (Wi-Fi), 191, 195
- call buttons feature, 11
- Canadian Standards Association (CSA), 32–33
- capability breadth, 262
- capacity, 271
- capital expenses, 297
- capturing risks to ROI, 303–304
- carbon monoxide sensor, 12
- carrier dependence (WiMAX), 173
- catching security attacks, 246
- cell casing, 269–270
- cell identity (cellular network locating), 166
- cell towers, 164
- cellular locating
 - frequencies, 165
 - improvising, 168–170
 - overview, 163
 - process, 164–167
 - pros and cons, 167–168
 - safety and security, 169
- CEN (Comité Européen de Normalisation), 281
- characterizing tags, 28–30
- charging batteries, 274
- chemicals (tag), 34
- Chirp Speed Spectrum, 206
- choke points
 - creating, 113–118
 - defined, 13, 113
 - determining direction, 119
 - limitations, 121
 - locating at, 13
 - locating with excitors, 115–116
 - locating with precision locating systems, 118
 - managing department interactions, 120
 - room-level locating method, 137–138
 - securing door locks, 118–119
 - technologies, 121–136
 - tracking asset location history, 121
 - using, 118–121
- client-based implementation (Wi-Fi), 187

- clients, 80
- clock errors (GPS), 161
- coherent receiver, 205
- coin cells, 269
- Comité Européen de Normalisation (CEN), 281
- compatibility, 252–253
- competitors, 80
- components, 9–10
- computer vision
 - accuracy, 181
 - overview, 208–209
 - process, 210
 - pros and cons, 210–211
- conducting pilot testing, 93
- confidentiality
 - defined, 242
 - loss, 242–243
 - overview, 68
- connecting tags to assets, 34–35
- connectors feature, 12
- consistency, 233
- construction fleet management
 - applications, 157
- consumer markets, 16
- contracts, 297
- conventions used in this book, 2
- cost
 - architecture, 109
 - capital, 297
 - cellular network locating, 168
 - computer vision, 211
 - dead reckoning, 184
 - determining integration, 253–254
 - GPS, 160
 - hardware, 65
 - infrared, 143
 - installation, 65–66
 - integration, 109
 - maintenance, 66, 235
 - operating, 109
 - passive HF, 130
 - passive UHF, 133
 - powerline positioning, 150
 - semipassive UHF, 134
 - software, 65
 - tightly coupled model, 198
 - TV-signal positioning, 177
 - ultrasound, 146
 - Wi-Fi, 192
 - ZigBee, 207
- countermeasures, security threat, 243–245
- crackers, 243

- creating
 - abstract business cases, 253
 - benefits realization reports, 302–304
 - choke points, 113–118
 - decision matrix, 56–57
 - implementation plan, 83
 - Cricket, 286–287
 - critical mass, 260
 - cross-reads, 200
 - CSA (Canadian Standards Association), 32–33
 - current (battery), 271
 - customer service, 19
 - cylindrical cells, 269
- D •
- data
 - personal, 292–293
 - routing, 107–108
 - transformation, 106–107
 - transport, 106
 - data transfer rate
 - infrared, 143
 - LF-based solutions, 125
 - passive HF, 130
 - deactivating tags, 239
 - dead reckoning (DR)
 - accuracy, 181
 - overview, 181–182
 - process, 182–183
 - pros and cons, 184
 - deadlines, 83
 - debugging tools, 110
 - decision matrix
 - building, 56–57
 - defined, 55
 - defense sector, 23
 - defining
 - integration implementation strategy, 109–110
 - metrics, 229–230
 - scope of implementation, 81–82
 - user interface, 75–76
 - denial of service (DOS) attacks, 169, 240–241
 - dependency
 - cellular network locating, 168
 - computer vision, 211
 - overview, 83
 - deployment
 - defined, 60
 - ease of, 61
 - overview, 56
 - pitfalls, 252–257
 - tools, 63
 - WiMAX, 173
 - detecting presence, 215–217
 - detention charges, 157
 - determining
 - compatibility, 252–253
 - direction, 119
 - tag locations, 43–51
 - developing
 - custom solutions, 263
 - proof of concept, 264
 - device management, 105
 - differential GPS (D-GPS), 162
 - diffused infrared, 141
 - direct benefits, 298–299
 - direct infrared, 141
 - discharge current, 271
 - discount rate, 296
 - distance
 - enlargement/reduction, 242
 - relationship with accuracy, 58
 - distributed model, 199–200
 - Doppler effect, 194
 - DOS (denial of service) attacks, 169, 240–241
 - DR. *See* dead reckoning (DR)
 - drift, 184
- E •
- eavesdropping, 169, 242
 - eco-friendliness, 57, 69
 - education sector, 26
 - 802.11a frequency, 186
 - 802.11b frequency, 186
 - 802.11g frequency, 186
 - 802.11n frequency, 186
 - 802.15.4a standard, 206
 - 868.3 MHz frequency, 209
 - electrical tamper detection, 244
 - eliminating redundant data cost, 103–104
 - embedding
 - passive UHF, 133
 - tightly coupled model, 198
 - emergency response, 19
 - enclosure ratings, 32–33
 - encryption, 245
 - end-user experience
 - checking, 261–262
 - consistency, 233
 - participation, 98–99
 - perceived accuracy, 230–232

perceived response time, 232–233
 process intrusion, 233–234
 tripping and training, 233

Enhanced Observed Time Difference (E-OTD), 167

enlisting support, 80–81

ensuring

- battery safety, 272
- eco-friendliness, 69

enterprise-wide coverage, 256

entry level, relationship with accuracy level, 58

environmental conditions

- building illumination, 214
- offsetting, 79
- UWB, 206
- ZigBee, 207

environmental tolerance

- distributed model, 200
- LF-based solutions, 124
- passive HF, 130
- passive UHF, 133
- SAW, 136
- tightly coupled model, 199

E-OTD (Enhanced Observed Time Difference), 167

EPCglobal, 132, 278–279

ephemeris, 160, 177

ergonomics, 31

establishing

- application objectives, 235
- baselines, 99
- social networks, 293

estimating

- integration costs, 109
- location sensor deployment, 254
- maintenance requirements, 64
- position with dead reckoning, 181–184

evacuations, 19

evaluating security, 67–68

evaluation criteria (pilot), 92

exciters

- defined, 115
- locating choke points, 115–116

exit level, relationship with accuracy level, 58

• F •

fault tolerant (ZigBee), 208

features (tags), 11–12

femtocells, 168

FHSS (Frequency Hopping Spread Spectrum), 196

fingerprint

- powerline positioning, 151
- Wi-Fi, 191, 195

firmware, 37

frequency

- active RFID, 201
- Bluetooth, 196
- cellular networks, 165
- diversity, 176
- television broadcasting, 174
- ultra wideband (UWB), 204
- Wi-Fi (wireless fidelity), 186
- ZigBee, 209

frequency band

- distributed model, 200
- passive UHF, 133
- tightly coupled model, 199

frequency coordination

- infrared, 143
- ultrasound, 147

Frequency Hopping Spread Spectrum (FHSS), 196

• G •

Galileo, 288

gases (tag), 34

Global Navigation Satellite System. *See* GNSS (Global Navigation Satellite System)

Global Positioning System. *See* GPS (Global Positioning System)

global regulations (ultrasound), 147

global standardization

- active RFID, 203
- distributed model, 200
- passive UHF, 133
- tightly coupled model, 199
- TV-signal positioning, 177

GLONASS, 287–288

GNSS (Global Navigation Satellite System)

- improvising GPS-based RTLS, 161–163
- overview, 156–157
- process, 158–160
- pros and cons, 160–161

GPS (Global Positioning System)

- applications, 157
- indoor, 162
- overview, 9
- safety and security, 159

granular logs, 98

ground-borne vibration, 33

gyros, 182

• H •

hack proof feature (tag), 36
 hardware
 costs, 65
 replacement, 64
 hardwired, 61
 healthcare sector
 improvements, 299
 increasing efficiency, 138–139
 indirect benefits, 300
 overview, 20–21
 quantifiable soft benefits, 301
 revenue benefits, 299
 savings, 298
 soft benefits, 300
 heartbeats, 244
 help staff, 77
 HiBall Tracking System, 285
 humidity (tag), 33, 34

• I •

icons used in this book, 5
 identifying
 debugging tools, 110
 pilot tasks and resources, 90–92
 testing tools, 110
 user facility, 76
 users, 74–75
 IEC (International Electrotechnical Commission), 32–33, 281
 IEEE, 278
 implementation
 client-based, 187
 costs, 297
 mobile-assisted, 166
 mobile-based, 165
 network-based, 165, 186–187
 sudden, 90
 implementation, planning
 anticipating future, 82
 business constraints, 77–80
 creating implementation plan, 83
 defining scope, 81–82
 enlisting support, 80–81
 technology, 82–83
 visualizing goals, 73–77
 improving
 asset utilization, 18
 customer service, 19
 overview, 299
 response times, 19
 structure of facilities, 19
 workflow, 19
 improvising
 cellular RTLS, 168–170
 GPS-based RTLS, 161–163
 Impulse Radio UWB, 206
 increasing
 healthcare efficiency, 138–139
 scalability, 105
 tag security, 36
 indirect benefits, 299–300
 indoor GPS, 162
 industry conferences, 25–26
 inertial guidance system, 182
 inertial navigation system, 182
 inertial reference platform, 182
 infrared (IR)
 applying, 141–142
 defined, 140
 diffused, 141
 direct, 141
 overview, 140–141
 pros and cons, 143–144
 standardization, 143
 uses for, 140
 infrastructure
 computer vision, 211
 cost (cellular network locating), 168
 dead reckoning, 184
 impact to existing, 60
 leverage of existing, 61
 powerline positioning, 150
 ZigBee, 208
 initial delay (GPS), 161
 inquiry procedure (Bluetooth), 196
 installation
 building illumination, 214
 cabling needs, 61–62
 conducting pilot, 90–93
 costs, 65–66
 effort, 61–63
 interviewing vendors, 87–88
 pre-pilot, 88–89
 selecting technologies, 86
 test model, 85–86
 integration
 adding new business value, 104–105
 audit, 108
 challenges, 110
 cost, 109, 253–254
 defined, 101
 increasing scalability, 105

- needs, 64–65
- overview, 56, 101–103
- performing, 108–110
- potential, 262–263
- redundant data, 103–104
- requirements, 106–108
- specifications, 108
- streamlining, 103
- unifying device management, 105
- integrity, 68
- integrity loss, 241–242
- intensity (building illumination), 214
- interference
 - acoustic locating system, 212
 - GPS, 161
 - infrared, 144
 - LF-based solutions, 125
 - passive HF, 130
 - powerline positioning, 151
 - SAW, 136
 - ultrasound, 148
 - UWB, 206
 - Wi-Fi, 195
 - ZigBee, 208
- Internal Rate of Return (IRR), 297
- International Electrotechnical Commission (IEC), 32–33, 281
- International Organization for Standardization (ISO), 124, 278
- interoperability, growth, 262–263
- interrogators
 - defined, 114
 - overview, 28–29
 - tracking tags, 114–115
- interviewing vendors, 87–88
- inventory
 - managing, 18
 - overview, 292
 - planning, 18
- IP-based network (WiMAX), 173
- IR. *See* infrared (IR)
- IRR (Internal Rate of Return), 297
- ISO (International Organization for Standardization), 124, 278

• J •

- jamming
 - attacks, 239–240
 - cellular networks, 169
 - GPS, 159
 - TV-signal positioning, 177

• K •

- KPI (Key Performance Indicators), 229

• L •

- LANDMARC, 286
- landmark tags (Wi-Fi), 191
- latency
 - passive LF solutions, 127
 - WiMAX, 173
- LCD screens feature, 12
- LEDs feature, 12
- life expectancy, 59
- lighting (building illumination), 214
- line of sight
 - acoustic locating systems, 212
 - defined, 86
 - GPS, 161
 - ultrasound, 147
 - UWB, 206
- local area coverage. *See* precision locating
- locating
 - accuracy of technologies, 156
 - assets on demand, 17
 - by associating, 14
 - choke points with exciters, 115–116
 - at choke points using precision locating systems, 118
 - models, 13–15
 - people and assets with tags, 11
 - people on demand, 18
 - precisely, 15
 - reading with receivers, 117
 - room level, 13
 - SAW, 136
 - sub-room level, 13
- location engine
 - computing tag locations, 43–50
 - defined, 38
 - overview, 10, 38
 - position estimation algorithm, 40–43
 - ranging techniques, 38–39
- location sensors
 - estimating deployment, 254
 - monitoring, 96
 - overview, 9, 37
 - spoofing, 241
 - theft, 238
- location-based operations, 243
- log destinations, 98
- logs, granular, 98
- low-battery indicator, 271–272

• M •

magnetic tamper detection, 244
 magnetometers, 182
 maintenance
 active RFID, 203
 costs, 66
 estimating requirements, 64
 measuring cost, 235
 ongoing, 297
 overview, 56
 underestimating efforts, 256
 management costs, 297
 managing
 department interactions, 120
 evacuations, 19
 inventory, 18
 man-in-the-middle attacks, 169, 240, 242
 manufacturing sector
 improvements, 299
 indirect benefits, 300
 overview, 21–22
 quantifiable soft benefits, 302
 revenue benefits, 299
 savings, 298
 soft benefits, 301
 markets, 16
 maximizing battery life, 268
 mean time between failures (MTBF), 234
 measuring
 availability, 234
 end-user experience, 230–235
 maintenance cost, 235
 mean time between failures (MTBF), 234
 operational excellency, 234–235
 reliability, 234
 Return on Investment (ROI), 65–66
 memory
 passive HF, 130
 SAW, 136
 message flooding, 240
 metrics, 229–230
 middleware
 monitoring, 96
 overview, 10, 51–52
 milestones, 83
 mining sector
 overview, 24
 quantifiable soft benefits, 302
 savings, 298
 soft benefits, 300
 mobile-assisted implementation, 166
 mobile-based implementation, 165

mobile locating (presence-based positioning), 217
 mobile stations, 165
 mobile TV, 177
 monitoring
 asset usage, 17
 overview, 95–96
 people's movements, 19
 proactive, 97–98
 procedures, 96–99
 reactive, 98
 motion sensor, 12
 motion (tag), 34
 MTBF (mean time between failures), 234
 multilateration, 40
 multipath
 fading, 193, 206
 TV-signal positioning, 177
 ultrasound, 148

• N •

National Electrical Manufacturers Association (NEMA), 32–33
 navigation applications, 157
 nearest neighbor technique
 computing tag locations, 48
 overview, 42–43
 NearMe, 287
 neighbor relationship, 42
 NEMA (National Electrical Manufacturers Association), 32–33
 Net Present Value (NPV), 296–297
 network
 active RFID, 203
 attacks, 239–241
 Bluetooth, 197
 computer vision, 211
 tightly coupled model, 199
 Wi-Fi, 192
 ZigBee, 208
 network-based implementation, 165, 186–187
 902-928 MHz frequency, 209
 noise detection (passive LF solutions), 127
 non-coherent receiver, 205
 NPV (Net Present Value), 296–297

• O •

objectives, 56–60
 offsetting environmental conditions, 79
 operating cost, 109
 operating pressure (battery), 268

operating temperature
 battery, 268
 tag, 33
 operational excellency, measuring, 234–235
 operations, 297
 optical tamper detection, 244
 options, 56–57
 organization of this book, 3–5
 orientation (passive HF), 130

• *p* •

packet size (active LF solutions), 129
 page, 196
 paging procedure (Bluetooth), 196
 parameter, physical, 37
 participation, end users, 98–99
 passive high frequency (passive HF),
 129–130, 217
 passive low frequency (passive LF), 122–125
 passive RFID
 accuracy, 181
 distributed model, 199–200
 locating by associating, 222
 overview, 197
 presence-based positioning, 217
 tightly coupled model, 198–199
 passive tags
 overview, 28–29
 specifications, 30
 passive ultra high frequency (passive UHF),
 131–133
 payback period, 296
 peer-to-peer networking (active LF
 solutions), 128
 penetration
 infrared, 143
 LF-based solutions, 124
 passive HF, 130
 ultrasound, 146
 UWB, 206
 people
 locating with tags, 11
 tagging, 18–19
 tracking, 19, 119
 perceived accuracy, 230–232
 perceived response time, 232–233
 performance, measuring
 application objectives, 235
 end-user experience, 230–234
 metrics, 229–230
 operational excellency, 234–235
 overview, 56, 68

performance metrics, 92
 performing
 integration, 108–110
 testing, 255
 perioperative, 139
 personal privacy, 289–294
 pesticide detection (tag), 34
 physical destruction, 238
 physical parameter, 37
 physical security threats, 238–239
 physical serviceability, 37
 pilot
 conducting pilot testing, 93
 conducting testing, 93
 identifying tasks and resources, 90–92
 overview, 90
 rollout, 93
 planning, inventory, 18
 police restricted areas, 19
 portfolio, broad, 88
 position estimation algorithm, 40–43
 position types, 13
 pouch cells, 270
 power consumption
 Bluetooth, 197
 dead reckoning, 184
 TV-signal positioning, 177
 WiMAX, 173
 powerline positioning
 applying, 148–149
 overview, 148
 presence-based positioning, 216
 pros and cons, 150–151
 standardization, 149–150
 types, 149
 precision
 accuracy level compared with, 154
 relationship with local area coverage, 180
 precision locating
 accuracy, 181
 defined, 153
 locating at choke points, 118
 methods, 138
 overview, 180
 technologies, 180–214
 prepilot phase, 88–89
 presence, detecting, 215–217
 presence-based applications, 217–218
 presence-based locating, 13
 pressure altimeter, 183
 pressure, operating, 268
 preventing
 sudden/premature battery death, 270–271
 unauthorized battery use, 273

- primary batteries, 267
 - prismatic cells, 270
 - privacy
 - dead reckoning, 184
 - GPS, 160
 - groups, 257
 - overview, 289
 - personal, allowing, 290
 - personal, protecting, 290–294
 - proactive monitoring, 97–98
 - probe requests, 186, 191
 - procedures, monitoring, 96–99
 - process intrusion, 233–234
 - product configuration, 241
 - product quality, 241, 261
 - programming, tags, 35–36
 - project tasks, 83
 - proof of concept, 88–89, 264
 - propagation
 - defined, 202
 - delay, 38
 - speed, 38
 - proprietary LF-based solutions, 125
 - protecting
 - assets, 17
 - people, 19
 - personal privacy, 289, 290–294
 - providing emergency response, 19
 - proximity, 38
 - pseudolites, 162
 - public safety sector, 26
 - public sector, 16
 - pull model, 107
 - push buttons feature, 11
 - push model, 107
- Q**
- quantifiable soft benefits, 301–302
- R**
- RADAR, 285–286
 - radiation (tag), 34
 - radio frequency identification (RFID) tags, 28–29
 - range
 - acoustic locating system, 212
 - Bluetooth, 197
 - computer vision, 211
 - infrared, 143
 - passive HF, 130
 - passive UHF, 133
 - ultrasound, 147
 - UWB, 206
 - WiMAX, 173
 - ZigBee, 208
 - ranging techniques
 - defined, 38
 - variables, 38–39
 - rate of irresponsible locating, 232
 - reactive monitoring, 98
 - read rate
 - LF-based solutions, 125
 - location with receivers, 117
 - passive LF solutions, 127
 - passive UHF, 133
 - semipassive UHF, 134
 - readers, 199. *See also* interrogators
 - Real Time Location System. *See* RTLS (Real Time Location System)
 - Received Signal Strength Indicator (RSSI)
 - cellular network locating, 166
 - computing tag locations, 48–49
 - overview, 39
 - Wi-Fi, 185
 - WiMAX, 172
 - receiver
 - coherent, 205
 - defined, 117
 - GPS quality, 161
 - non-coherent, 205
 - reading location, 117
 - redundancy (TV-signal positioning), 176
 - reference tags, 244
 - regulating data use, 293–294
 - regulations (infrared), 143
 - relative position, 13
 - reliability
 - measuring, 234
 - semipassive UHF, 134
 - remote
 - troubleshooting, 264–265
 - updates, 264–265
 - replaying, 242
 - requirements, integration, 106–110
 - research
 - Active Badge System, 284
 - Active BAT Location System, 284–285
 - Beidou, 288
 - Cricket, 286–287
 - Galileo, 288
 - GLONASS, 287–288
 - HiBall Tracking System, 285
 - LANDMARC, 286
 - NearMe, 287
 - overview, 283–284

- RADAR, 285–286
 - sector, 23
 - resources, 83. *See also* Web sites
 - response times
 - improving, 19
 - overview, 57–58
 - perceived, 232–233
 - retail sector, 24
 - Return on Investment (ROI)
 - capturing risks to, 303–304
 - classic, 295–296
 - measuring, 65–66
 - overview, 56
 - revenue benefits, 299
 - RF signal attenuation, 189
 - RFID Journal* (magazine), 282
 - RFID Monthly* (magazine), 283
 - RFID Product News, 283
 - RFID (radio frequency identification) tags, 28–29
 - RFID Tribe, 282
 - risks, capturing to ROI, 303–304
 - rollout, 92, 93
 - room-level locating
 - applying, 138–139
 - methods, 137–138
 - overview, 13
 - relationship with accuracy, 58
 - technologies, 138, 140–151
 - Round Trip Time (RTT)
 - computing tag locations, 49–50
 - overview, 39
 - WiMAX, 172
 - RSSI. *See* Received Signal Strength Indicator (RSSI)
 - RSSI-based Wi-Fi RTLS, 185–191
 - RTLS (Real Time Location System)
 - components, 9–10
 - defined, 9
 - expansion, 64
 - options, 56–57
 - RTT. *See* Round Trip Time (RTT)
 - RuBee
 - locating by associating, 222
 - overview, 127–129
 - pros and cons, 128–129
- S •**
- safety
 - applications, 224–225
 - battery, 272
 - cellular network, 169
 - dead reckoning, 184
 - GPS, 159
 - infrared, 143
 - school, 139
 - ultrasound, 147
 - satellite navigation systems
 - improvising GPS-based RTLS, 161–163
 - overview, 156–157
 - process, 158–160
 - pros and cons, 160–161
 - savings, 298–299
 - SAW (surface acoustic wave), 135–136
 - scalability
 - acoustic locating system, 212
 - GPS, 160
 - increasing, 105
 - overview, 60
 - Wi-Fi, 193
 - scatternet, 223
 - scene analysis technique
 - attack, 286
 - computing tag locations, 48
 - overview, 41
 - school safety, 139
 - scope of application, 57
 - scope of implementation, 81–82
 - scope (pilot), 91
 - secondary batteries, 267
 - sectors. *See also* healthcare sector; manufacturing sector; mining sector
 - aerospace, 23
 - amusement parks, 25–26
 - automotive, 22–23
 - defense, 23
 - education, 26
 - public, 16
 - public safety, 26
 - research, 23
 - securing door locks, 118
 - security
 - applications, 223–224
 - Bluetooth, 197
 - cellular network, 169
 - computer vision, 211
 - evaluating, 67–68
 - GPS, 159, 160
 - increasing tag, 36
 - infrared, 143
 - LF-based solutions, 124
 - overview, 56
 - ultrasound, 147
 - Wi-Fi, 195
 - ZigBee, 208

- security threats
 - applications, 246–248
 - availability loss, 238–241
 - catching attacks, 246
 - confidentiality loss, 242–243
 - countermeasures, 243–245
 - integrity loss, 241–242
 - overview, 237–238
 - selecting
 - technologies, 86
 - vendors, 259–265
 - semipassive tags, 29–30
 - semipassive ultra high frequency (semipassive UHF), 133–134
 - sensors. *See also* location sensors
 - calibration, 63
 - feature, 12
 - orientation, 62
 - power needs, 62–63
 - semipassive UHF, 134
 - server monitoring, 96
 - serviceability, 37
 - session hijacking, 169
 - shipping volumes, 264
 - shock (tag), 33
 - signal propagation error (GPS), 161
 - signal synthesis attacks, 242
 - signal-monitors, 177
 - site surveys, 263
 - size
 - distributed model, 200
 - overview, 59
 - semipassive UHF, 134
 - social-networking applications, 225–226, 293
 - soft benefits, 300–301
 - software
 - costs, 65
 - firmware, 37
 - serviceability, 37
 - solar cells, 214
 - spectrum analyzer, 244
 - speed
 - active LF solutions, 129
 - Bluetooth, 197
 - cellular network locating, 167
 - dead reckoning, 184
 - WiMAX, 173
 - ZigBee, 207
 - spoofing
 - cellular networks, 169
 - GPS, 159
 - staff emergency response, 235
 - staffing constraints, 78
 - standard, 277
 - standardization
 - active LF, 126
 - infrared, 143
 - passive HF, 130
 - powerline positioning, 149–150
 - RuBee, 128
 - SAW, 135
 - semipassive UHF, 134
 - UHF, 132–133
 - ultrasound, 146, 148
 - standards-based
 - Bluetooth, 197
 - solution, 69
 - Wi-Fi, 192
 - WiMAX technology, 173
 - ZigBee, 207
 - storage temperature (tag), 33
 - storing batteries, 273–274
 - strap sensor, 244
 - strategic vendor, 260–261
 - streamlining inefficient procedures, 103
 - structure of facilities, 19
 - sub-room level
 - locating at, 13
 - relationship with accuracy, 58
 - suppliers, 80
 - support
 - enlisting, 80–81
 - help staff, 77
 - ongoing, 297
 - pilot, 91
 - surface acoustic wave (SAW), 135–136
 - symbolic position, 13
 - synchronous data routing, 107
- T •
- tag ID set (SAW), 136
 - tag start-position initializer, 183
 - tagging
 - assets, 17–18
 - defined, 17
 - people, 18–19
 - tags
 - acoustic locating systems, 212
 - active, 29–30
 - active LF solutions, 128
 - battery, 31–32
 - birthing, 91
 - building illumination, 214
 - calibration (sample), 191
 - cellular network locating, 167
 - characterizing, 28–30

- cleaning, 64
- computer vision, 211
- computing locations, 43–51
- connecting to assets, 34–35
- deactivating, 239
- dead reckoning, 182–183
- defined, 27
- detachment, 238
- enclosure ratings, 32–33
- environmental capabilities, 33
- ergonomics, 31
- features, extra, 11–12
- indirect-positioning, 16
- landmark, 191
- LF-based solutions, 125
- locating people and assets, 11
- monitoring, 96
- overview, 9
- passive HF, 28–29, 130
- passive LF, 28–29, 123, 127
- pilot installation, 91
- programming, 35–36, 136
- reference, 244
- remote-positioning, 15
- security, increasing, 36
- self-positioning, 15
- semipassive, 29
- serviceability, 37
- specifications, 30
- spoofing, 241
- telemetry, 34
- theft, 238
- tracking with interrogators, 114–115
- tracking locations, 293
- unauthorized readings, 291–293
- value adds, 66–67
- tamper detection feature, 36, 243–244
- TCO (total cost of ownership), 297–298
- TDOA. *See* Time Difference of Arrival (TDOA)
- TDOA-based Wi-Fi RTLS, 191–192
- technical landscape, 78–79
- technological evolution, 181
- technologies
 - available, 50–51
 - choke points, 121–136
 - locating by associating, 221–223
 - overview, 15, 80, 82–83
 - selecting, 86
- technologies, choke point
 - active low frequency (active LF), 125–127
 - passive high frequency (passive HF), 129–130
 - passive low frequency (passive LF), 122–125
 - passive ultra high frequency (passive UHF), 131–133
 - RuBee, 127–129
 - semipassive ultra high frequency (semipassive UHF), 133–134
 - surface acoustic wave (SAW), 135–136
- technologies, precision locating
 - acoustic locating systems, 211–213
 - active RFID, 200–204
 - air interface standards, 204
 - Bluetooth, 195–197
 - building illumination, 213–214
 - computer vision, 208–211
 - dead reckoning (DR), 181–184
 - 802.15.4a standard, 206
 - overview, 180–181
 - passive RFID, 197–200
 - ultra-wideband, 204–206
 - Wi-Fi, 185–195
 - ZigBee, 207–208, 209
- technologies, room-level locating
 - infrared, 140–144
 - overview, 140
 - powerline positioning, 148–151
 - ultrasound, 144–148
- technologies, wide area coverage
 - locating with cellular, 163–170
 - overview, 155–156
 - satellite navigation systems, 156–163
 - TV-signal positioning, 174–177
 - WiMAX, 170–173
- telemetry, 34
- television. *See* TV
- temperature
 - measurement (SAW), 136
 - operating, 268
 - sensor, 12
 - tag, 34
- temporary setups, 25–26
- test model, 85–86
- test plan, 92
- testing
 - performing, 255
 - tools, 110
- theft
 - location sensors, 238
 - tags, 238
- TheRTLSblog, 283
- thin film batteries, 270
- 3GPP, 280
- throughput
 - passive HF, 130
 - passive UHF, 133
 - tightly coupled model, 199

- tightly coupled model, 198–199
 - time advance, 166
 - Time of Arrival (TOA)
 - computing tag locations, 45–46
 - overview, 38
 - time delay, 193
 - Time Difference of Arrival (TDOA)
 - overview, 39
 - UWB, 205
 - WiMAX, 172
 - Time Distance of Arrival, 46–47
 - Time of Flight (TOF)
 - computing tag locations, 47–48
 - overview, 39
 - TOA. *See* Time of Arrival (TOA)
 - TOF. *See* Time of Flight (TOF)
 - tolerance, 59
 - tools
 - debugging, 110
 - deployment, 63
 - testing, 110
 - total cost of ownership (TCO), 297–298
 - traceability, 292
 - tracing assets, 18
 - tracking
 - Alzheimer’s patients applications, 157
 - assets, 17, 119
 - Bluetooth, 197
 - people, 19, 119
 - performance, 68
 - stations, 160
 - tag locations, 293
 - tags with interrogators, 114–115
 - Wi-Fi, 193
 - traffic analysis, 242–243
 - training
 - costs, 297
 - pilot, 92
 - Wi-Fi, 192
 - transceivers. *See* interrogators
 - transponders. *See* tags
 - triangulation technique, 40, 42
 - trilateration technique
 - computing tag locations, 48–49
 - overview, 40–41
 - Wi-Fi, 189
 - troubleshooting
 - maintenance consideration, 64
 - remote, 264–265
 - Wi-Fi, 192
 - TV broadcasting frequencies, 174
 - TV tuner, 175
 - TV-signal positioning
 - frequencies, 174
 - mobile TV, 177
 - overview, 174
 - process, 175–176
 - pros and cons, 176–177
 - 2405-2480 MHz frequency, 209
- U •
- Ubiquitous ID Center, 279
 - UHF (ultra high frequency), 131, 217
 - UL-TDOA (Uplink Time Difference of Arrival), 166–167
 - ultra high frequency (UHF), 131
 - ultra wideband (UWB)
 - accuracy, 181
 - frequencies, 204
 - overview, 204
 - process, 205
 - pros and cons, 205–206
 - ultrasound
 - applying, 145–146
 - defined, 144
 - overview, 144–145
 - pros and cons, 146–148
 - standardization, 146
 - uses for, 145
 - unauthorized tag readings, 291–293
 - underestimating
 - integration cost, 253–254
 - maintenance efforts, 256
 - underground (LF-based solutions), 124
 - underwater (LF-based solutions), 124
 - Underwriters Laboratories Inc., 32–33
 - unifying device management, 105
 - updates, remote, 264–265
 - upgrades, 64
 - Uplink Time Difference Of Arrival (UL-TDOA), 166–167
 - urban areas
 - cellular network locating, 167
 - IV-signal positioning, 176
 - WiMAX, 173
 - urban canyons (GPS), 161
 - usability, 56
 - users
 - experience, 96
 - facility, 76
 - identifying, 74–75
 - interface, 75–76
 - pilot, 91
 - UWB. *See* ultra wideband (UWB)

• **V** •

value adds
 features, extra, 67
 overview, 11–12, 56
 tag, 66–67
 variables, 38–39
 vendors
 engagement level, 262
 interviewing, 87–88
 overview, 80
 selecting, 259–265
 strategic, 260–261
 technological focus, 262
 vertical silo, 103
 vibration (tag), 33
 vibrators feature, 12
 visitor information sector, 25
 visualizing implementation goals, 73–77
 voice to voice feature, 12
 voltage, 271

• **W** •

wall wart, 63
 Web sites
 AIDC, 100, 281
 AIM Global, 279
 Bluetooth SIG, 282
 cellular network frequencies, 165
 CEN (Comité Européen de Normalisation), 281
 commercial and non-profit organization resources, 282–283
 EPCglobal, 132, 278–279
 IEC (International Electrotechnical Commission), 32, 281
 IEEE, 278
 International Organization for Standardization (ISO), 124, 278
 NEMA, 32
RFID Journal, 282
RFID Monthly, 283
 RFID Product News, 283
 RFID Tribe, 282
 standardization and dedicated technology workforces, 277–282
 TheRTLsblog, 283
 3GPP, 280
 Ubiquitous ID Center, 279
 Wi-Fi Alliance, 279
 ZigBee Alliance, 280

wide area coverage
 cellular network frequencies, 165
 cellular network safety/security, 169
 comparing accuracy level and precision, 154
 GPS safety/security, 159
 mobile TV signal, 177
 overview, 154–155
 technologies, 155–177
 television broadcasting frequencies, 174
 WiMAX technology, 170
 Wi-Fi Alliance, 279–280
 Wi-Fi (wireless fidelity)
 accuracy, 181
 frequencies, 186
 locating by associating, 222
 overview, 185
 presence-based locating, 216
 presence-based positioning, 217
 process, 185–192
 pros and cons, 192–195
 WiMAX (Worldwide Interoperability for Microwave Access)
 overview, 170–171
 process, 171–172
 pros and cons, 173
 receivers (tags), 171
 technology, 170
 tower, 171
 wireless access point, 185
 wireless fidelity. *See* Wi-Fi (wireless fidelity)
 wireless router, 185
 workflow, 19
 Worldwide Interoperability for Microwave Access. *See* WiMAX (Worldwide Interoperability for Microwave Access)
 writeable memory feature, 12

• **Y** •

yard management applications, 157

• **Z** •

ZigBee
 accuracy, 181
 frequencies, 209
 how it works, 207
 locating by associating, 222
 overview, 207
 pros and cons, 207–208
 ZigBee Alliance, 280
 zone level, relationship with accuracy level, 58

