

# INDEX

*Note:* Page numbers followed by “*n*” indicate notes.

- A-weighted sound level, 129
- Abbreviated Injury Scale (AIS), 310
- Acceleration, 143
  - resistance to, 143–144
- Access, 253
- Accessibility, 6, 8, 20, 33, 48, 174, 261
- Accuracy, 256
- Acoustics, 114
  - frequency analysis, 116–117
  - practical measurement quantities, 118–120
  - sound levels and decibels, 114–116
  - sound travel, 117–118
- Active safety role, 154
- Active crossing, 301
- Activity-based modelling
  - technique, 14
- Aerodynamic noise, 125
- Agent-based modelling technique, 14
- Airborne transmission, 125–126
- ‘Alimentation par Sol’ system (APS system), 175
- Amsterdam train collision, 306
- Anthropomorphic test devices (ATDs), 307
- Anxiety, 30
- Appraisal, 16–17
- Approach behaviour, 27, 29–30
- Approach locking, 231
- Appropriateness of trackbed design
  - method, 84
- Apps, 246
- Articulated train sets, 165–168
- Artificial intelligence (AI), 241
- Asphalted track systems, 62
- Assessment methods, 312–313
- Assets, 326
- Association Européenne pour l’Interopérabilité Ferroviaire (AEIF), 156
- Association of Community Rail Partnerships (ACoRP) (*see* Community Rail Network)
- Association of Train Operating Companies (ATOC), 307
- Attention, 43
- Attractive, 33
- Automatic route setting (ARS), 237
- Automatic train operation (ATO), 245
- Automatic train protection (ATP), 225, 233, 246
  - classification of, 233–234
  - European Train Control System, 234
- Automation technologies, 237–238, 240
- Availability, 249
- Averch–Johnson effect, 273
- Avoidance behaviour, 27, 29–30
- Axle counter, 228
- Ballast, 99, 101, 106, 123, 196
- Ballasted track systems, 62–65
- Big data analytics, 240, 251
- Black, Asian and Minority Ethnic (BAME), 242
- Block systems, 227
  - fixed, 227–229
  - moving, 229
- Borrowings, 284, 289–291
- Braking system, 121
- British Rail modernisation
  - programme, 267
- British Transport Act, 287
- Broad-based community engagement, 45

- Building information modelling (BIM), 255
- Built largely as elevated (*see* ‘Skytrain’ system)
- Bus alternative, 178–179
- Business continuity, 260
- Cab signalling
  - block systems, 227–229
  - cab signalling with fixed block sections, 225–226
  - cab signalling with moving block, 226–227
  - train control by, 225
- Cab structure analysis model, 165
- Cairo Metro, 185
- Cant
  - deficiency, 67–68, 139
  - equilibrium, 67
- Capacity, 203–217
- Capital grants, 284
- Capital investment, 182
- Car body validation, 164
- Carbon emissions, 42
- Care, 130
- Careful planning, 10
- Cast-iron brake blocks, 121
- Central Station Leiden, 34
- Central Station Rotterdam, 34
- Centralised control, 236–237
- Centre for Research into Energy Demand Solutions (CREDS), 44
- Chiselling, 272
- Civil engineering, 266
- Clapham Junction rail accident, 307
- Classic household location models, 181
- Clear strategy, 287
- Climate crisis, 43
- ‘Climate emergency’, 43
- Cloud communications, 248
- Cloud computing, 240
- Cloud providers, 248
- Coil springs, 141
- Collative dimensions, 28
- Comfort, 22–23
  - experience, 28
- Commercial freedoms, 282
- Common safety indicators (CSIs), 296
- Communications, 248
  - communications-based train control, 245
  - research, 45
- Communications Based Train Control (CBTC), 171
- Community engagement, 43–46
- Community rail, 42–43
  - exploring community rail’s position and power to influence sustainability, 46–54
  - future development and lines of inquiry, 54–56
  - partnership, 328
  - postscript, 56–57
  - reviewing research, 43–46
- Community Rail Network, 42, 53
- Commuter vehicles, 153
- Competition and Markets Authority (CMA), 273
- Computable general equilibrium modelling (CGE modelling), 198
- Computer simulation, 312
- Computer-aided engineering tools, 255
- Computers development, 240
- Concrete sleepers, 64
- Conflicting routes, 231–232
- ‘Connected commuter’, 246
- Conrail, 278*n*1
- Contact patch, 135–137, 146
- Continuously welded rail (CWR), 64
- Contract plan, 287
- Corrugation, 121, 142–143
- Cost, 13, 193
  - controlling, 15–16
  - of urban rail construction, 12
- Cost–benefit analysis (CBA), 16, 300
- Covid-19 crisis, 260
- Crash management system (CMS), 309
- Crash process model (CPM), 154–155

- Crash safety, 311, 314
- Crash scenarios
  - category CI vehicles, 158
  - design cases, 164–165
  - like-to-like impact at 36 km/h with 40 mm vertical offset, 159
  - like to like impact, 158–159
  - train against 80t UIC Standard Wagon Impact, 159–160
  - train against level crossing object impact, 160
  - train against small object impact, 160–164
- Crash simulations, 306
- Crashworthiness, 153
  - CPM, 154–155
  - crash scenarios category CI vehicles, 158–165
  - design for structural crashworthiness, 156
  - European Standards and Regulations, 156–158
  - role of active and passive safety, 154
- ‘Creep control’, 138
- Creep forces, 139
- Critical timing, 256
- Critical velocity, 95–96
- Cronbach’s alpha, 32
- Curve squeal, 123–125
- Curving behaviour, 138–139
- Customer
  - buy-in, 249–250
  - customer-centric railway, 262
  - experience, 13
  - facing technologies, 249–250
  - needs, 21–23
- Cutting, 93
- Cyber-physical systems, 241
- Cybersecurity, 250
- Damping, 141
- ‘DART’ system, 172
- Data analytics, 241, 250–251
  - challenges, 251–253
  - SE, 258–260
  - simulation and modelling, 253–256
  - transformational leadership, 256–258
- Data management, 253
- Data transmission, 234
- ‘De-politicalisation’, 287
- Debt, 289–291
- Decarbonisation, 240
- Deceleration rate, 164
- Decibel (dB), 114–115, 118
- Deep-seated rotational failure, 99
- Deficit funding, 286
- Demand, 6
  - side factors, 12
- Den Haag Holland Spoor Station, 33
- Department for Transport (DfT), 46, 55, 270
  - Community Rail Development Strategy, 47
- Depreciation, 284–285
- Derailment, 142
- Design
  - methodology, 314
  - validation, 320
- Design, Build, Finance, Operate scheme (DBFO scheme), 277
- Determinants of injury severity, 309
- Diesel multiple unit (DMU), 145
- Digital inspection tools, 247–248
- Digital railway, 240
  - addressing challenges, 261–262
  - data analytics, 250–253
  - digital technologies, 243–250
  - digitalisation for sustainability, 241–243
  - elements of, 243
- Digital revolution, 240
- Digital signaling, 245
- Digital technologies, 243–244
  - challenges, 249
  - command and control, 245–246
  - communications, 248
  - cybersecurity, 250
  - identifying and incorporating technologies, 249

- interoperability, 250
- mobility, 246–247
- obsolescence management, 249
- reliability and availability, 249–250
- staff buy-in, 250
- supply chain, 247–248
- supply chain sustainability, 249
- technologies radar for horizon scanning, 245
- ‘Digital twin’, 253–254
- Digitalisation, 240
  - for sustainability, 241–243
- ‘Direct demand’ models, 14
- Displacements, 99
- Diversity, 258
- Drainage, 96
- Driverless operation, 177
- Dutch Safety Board (DSB), 306
  
- Earth embankments, 92
- Earthworks, 92, 106
  - embankment and cutting, 93
  - management, repair and stabilisation methods, 106–108
  - modern earthworks design and construction, 93–96
  - modern problems with old earthworks, 99–106
  - old earthwork construction, 96–98
- Economic benefits, 8, 15, 197, 286
- Economic sustainability, 12
  - controlling costs, 15–16
  - other sources of revenue and economic benefits, 15
  - predicting demand, 12–15
- Economic sustainability, 2
- Effects of railways on urban structure, 180–182
- Electrical engineering, 266
- Embankment, 93
- Emotions, 28
- Enabling actions, 287
- End-tipping gave embankments, 98
  
- Energy absorption, 154, 158, 163, 311
  - components, 165
  - concept for articulated vehicles, 167
  - device prior to crushing, 167
  - post crush, 168
- Energy consumption for urban railways, 149–150
- Engineering principles, 326
- Environmental impact of HSR, 195
- Environmental noise limits and noise mapping, 127–128
- Environmental quality, 27
- Environmental sustainability, 2, 9, 12
  - assessing risk and resilience, 12
  - choosing route, 9–11
  - whole-life impact assessment, 11
- Environmental variables, 22
- Equality, 258
- Equations of motion, 145
- Equilibrium cant, 67
- Equity, issues of, 183–184
- Equivalent continuous sound level ( $L_{eq}$ ), 119
- European Association for Railway Interoperability (*see* Association Européenne pour l’Interopérabilité Ferroviaire (AEIF))
- European Commission (EC), 308
- European Committee for Standardisation (CEN), 156, 308
- European Rail Agency (ERA), 312
- European Rail Community, 308
- European Rail Traffic Management System (ERT MS), 154–155, 234, 246
- European Shift2Rail programme, 243
- European Standards and Regulations, 156–158
- European Train Control System (ETCS), 234–235, 246
  - Level 1, 236
  - Level 2, 236
  - Level 3, 236

- European Union (EU), 187
- European Union Agency for Railways (EUAR), 296
- Excessive plastic deformation, 86
- Excitement, 30
- Experience, 22–23
  
- Factor analyses, 32
- Failure, 182
  - modes of, 99
- Fast and slow area, 24
- Fatalities at level crossings, 301–302
- Fatigue, wear and, 142–143
- Feelable vibration, 129
- Finance, 327
- Financial appraisal, 16
- Financial sustainability, 182–183, 281, 282–283
- Financially sustainable railway, 291
  - capital grants/borrowings/ investment requirements, 284
  - financial sustainability, 282–283
  - long-term financing, 289–291
  - operating costs and depreciation, 284–285
  - operating grant and subsidies, 284
  - operating revenue, 283
  - railway financial outgoings and sources of revenue, 282
  - short-term financing, 285–289
  - short/medium and long term, 285
- 5G radio technology, 234, 248
- Fixed block sections, cab signalling
  - with, 225–226
- Flank protection, 232–233
- Fostering innovation, 260
- Fouling material, 65
- Frequency analysis, 116–117
- Friction coefficient, 138
- Future Rail Mobile Communication System (FRMCS), 234
- Future Traffic Regulation Optimisation programme (FuTRO programme), 214
- G44 sleeper, 64
- General Data Protection Regulation (GDPR), 253
- Generic procedures, 11
- Geometrical constraints, 69
- Geotextiles, 107
- Global System for Mobile Communications–Railway (GSM-R), 234, 248
- Gradual subgrade failure, 86
- Great Britain, 271
- Greathead Shield method, 174
- Ground vibration, 114, 129
- Ground-borne noise and vibration, 128–130
  
- Halo effect, 28
- Hatfield train accident (2000), 270
- Head injury criteria (HIC), 319
- Hedonic tone, 28
- Hertz theory, 135
- High Speed 2 (HS2), 93, 208
- High-level output specification (HLOS), 270
- High-plasticity clays, 94
- High-speed networks, 241
- High-speed rail (HSR), 152, 187–188
  - benefit, 196–199
  - high-speed line system
    - development, 188–192
    - sustainability of, 193–199
    - technical characteristics, 192–193
    - temporal tipping points, 199–200
- High-speed railway, 93
- High-speed train route, 62
- High-speed vehicles, 152–153
- Historical development, 206
- HSR-COMET project, 25
- Human bio-modelling and testing, 309–310
- Human error, 299
- Hunting, 135, 139, 142
- Hyperbolic discounting, 17
  
- Impact noise, 123
- Impact object shape, 318

- Impact object stiffness, 319
- Impact velocity, 317–318
- In situ* geology, 94–95
- Inclusion, 258
- Income distribution, issues of, 183–184
- Industry 4. 0, 240–247
  - sustainability functions of, 241
- Inertial measurement units (IMUs), 79
- Infrastructure provision, 303
- Injury criteria, 309–310
- Injury severity, determinants of, 309
- Intelligent train control and monitoring systems, 155
- Intensity, 117–118
- Interchanges, layout of, 23–27
- Interior passive safety
  - assessment methods, 312–313
  - description of feasible standard and rationale behind requirements, 311–312
  - designing to requirement, 313
  - determinants of injury severity, 309
  - impact object shape, 318
  - impact object stiffness, 319
  - impact velocity, 317–318
  - injury criteria and use of human bio-modelling and testing, 309–310
  - minimising passenger injury, 317
  - need for passive safety requirement, 307–309
  - occupant containment, 313–316
  - passenger injury, 316
  - effect of seat and feature locations, 319
  - effect of seat pitch and height, 316
  - validation of design, 320
- Interlocking principles, 229
  - conflicting routes, 231–232
  - flank protection, 232–233
  - interlocking routes, 229–230
  - overlaps, 233
  - route locking, 230–231
- International Council on Systems Engineering (INCOSE), 259
- International Energy Agency (IEA), 149
- International Railway Journal (IRJ), 209–210
- International Railway Union (UIC), 188
- Internet of things (IoT), 240, 241
- Interoperability, 250
- Inverted U-curve, 28
  - and psychological reversal, 29
- Investment, 289–291
  - requirements, 284
- Japanese National Railways (JNR), 271
- Journey time
  - economic benefits of reduced, 197
  - end-to-end, 9
  - incremental, 199
  - rail, 13
  - reducing, 8
- Jubilee Line Extension (JLE), 180
- Key performance indicators, 150
- Kinematic oscillation, 134
- Klingel motion, 134
- L'Autorail Grande Capacité (AGC), 164
- Laminated rubber-metal springs, 141
- Land use transport interaction (LUTI), 197
- Land-use patterns, 12–13
- Layout of interchanges, 23–27
- Learning curve for quality improvement, 32
- Leiden Central Station, 34
- Level crossings, fatalities at, 301–302
- Li and Selig's method, 86
- Life cycle analysis, 11
- Lineside signals, train control by, 222–225
- London Underground, 97, 107, 171, 176, 180, 182, 205, 274–275
- Long-Term Evolution–Railway (LTE-R), 248
- Long-term financing, 289–291

- Machine learning (ML), 241
- Management dimensions, 30
- Management plan, 287
- Manchester Metrolink, 274
- Market-led proposals (MLPs), 277
- 'Market-led' approach, 216
- Mass Transit Railway (MTR), 205
- Matlab, 87*n*1
- Matrix management, 267–268
- Maximum contact pressure, 135
- Measuring quality, 79
- Mechanical engineering, 266
- Mechanised railway systems, 1
- MERLIN project, 150
- Metal coil springs, 141
- 'Metro' systems, 172
- Mitigation measure for curve squeal, 124
- Mobility as a Service offering, 328
- Modal integration, 209
- Modal shift, 48, 53, 183, 199, 209–211, 213, 216, 240, 241, 327
- Model sharing, 256
- Modern earthworks
  - critical velocity, 95–96
  - design and construction, 93
  - drainage and vegetation, 96
  - earthworks settlement and heave, 94–95
  - introduction, 93–94
  - slope stability, 94
- Modern locomotives, 92
- Modern problems with old earthworks, 99–106
- Modern sleepers, 64
- Modes of failure, 99
- Monitoring and evaluation, 17
- Monte Carlo simulation, 11
- Motion
  - equations of, 145
  - resistance to, 143–144
- Moving and staying, 24
- Moving block, 227
- Multidisciplinary-engineered system, 259
- Multidivisional structure, 269
- National-level ticketing, 328
- Network Rail (NR), 270, 291
  - in United Kingdom, 103
- New measurement train (NMT), 75
- Noise, 113
  - acoustics, 114–120
  - aerodynamic noise, 125
  - curve squeal, 123–125
  - ground-borne noise and vibration, 128–130
  - impact noise, 123
  - limits and mapping, 126–128
  - other sources of noise, 125
  - railway noise sources, 120
  - rolling noise, 120–123
  - sustained exposure, 113–114
  - vehicle interior noise, 125–126
- Noise barriers and window insulation, 128
- Noise Insulation Regulations, 127
- Noise limits on individual trains, 126–127
- 'Non-user benefits', 7
- Normal contact, 135–137
- Notified Body (NoBo), 151
- Obsolescence management, 249
- Occupant kinematics, 310
- Occupant Protection and Egress in Rail Systems (OPERAS), 312
- Office of Passenger Rail Franchising (OPRAF), 269
- Office of Rail and Road (ORR), 206, 250, 269
- Old earthwork
  - construction, 96–98
  - modern problems with, 99
  - overview, 99–100
  - transitions onto bridge structures, 106
  - ultimate failure, 101–104
  - vegetation and serviceability issues, 104–105
- One-size-fits-all solution, 328
- Openness, 261

- Operating costs, 284–285  
 Operational Philosophy (OP), 214  
 ‘Opposing locking’, 232  
 Optimal arousal theory, 28  
 Optimism bias, 290  
 Organisational reform, 285–289  
 Origin–destination matrix (OD matrix), 14  
 OSIRIS project, 150  
 Overall sustainability, 16–17  
 Overcrowding, 272  
 Overhead line electrification (OLE), 99  
 Overlaps, 233  
 Ownership, 253, 273–275  
  
 Pandemic, 13, 45, 211–212, 277–278  
 Paratelic state, 29  
 Paris Metro, 173, 177, 178, 185*n*2  
 Passenger injury, 316  
     minimising, 317  
 Passenger rolling stock, 150  
     articulated train sets, 165–168  
     crashworthiness, 153–165  
     high-speed vehicles, 152–153  
     materials, 168  
     rail vehicle taxonomy, 151–152  
     regional and commuter vehicles, 153  
 Passenger train service operations, 278  
 Passengers in excess of capacity (PIXC), 272  
 Passive safety  
     design, 306  
     requirement, 307–309  
     role, 154  
 ‘Passive’ crossing, 301  
 Pattern of railway  
     fatalities, 296–297  
     network, 207  
 Pay as you go (PAYG), 172  
 People, 31  
 Permanent Way Institution (PWI), 69  
 Persons with restricted mobility (PRM), 272, 307  
 Physical barriers, 10  
 Place, 31  
  
 Planning, 75–79  
     economic sustainability, 12–16  
     environmental sustainability, 9–12  
     overall sustainability, 16–17  
     social sustainability, 6–9  
     system and route planning for sustainable railway system, 5–6  
 Plastic Bodyform, 312–313  
 ‘Plug-and-play’ approach, 249  
 Politics, 285–289  
 Post-occupancy evaluation, 25–26  
 Power supply and energy, 174–176  
 Practical measurement quantities, 118–120  
 Preferred noise criterion (PNC), 129  
 Primary collision, 309  
 ‘Prime user’ model, 288  
 Privatisation, 268, 274  
     initial privatised structure, 270  
 Processes, 31  
 ‘Production-led’ approach, 216  
 Profitability, 2  
 Progressive shear failure, 86  
 Public control, 272  
 Public performance measure (PPM), 272  
 Public service obligations (PSOs), 282  
     contract payments, 286  
 Public–private partnerships (PPPs), 274  
 Pyramid of customer needs, 21–23  
  
 Quality  
     learning curve for quality improvement, 32  
     measurement, 79  
 Quality dimensions  
     in order of importance, 23  
     of service, 31  
 Quality of transport interchanges, 21–23  
 Quantitative regression analyses, 21  
  
 Radio Block Centre (RBC), 229, 246  
 Radio-based data transmission, 234  
 Rail corrugation, 142

- Rail dampers, 122
- Rail deflection, 70
- Rail Delivery Group (RDG), 44
- Rail inclination, 134
  - Rail roughness, 121
- Rail safety, 303–304
  - appraisal of railway safety measures, 300–301
  - fatalities at level crossings, 301–302
  - pattern of railway fatalities, 296–297
  - personal fatalities, 302
  - rail restructuring and rail safety, 303–304
  - train accidents, 297–300
  - trespassers and suicides, 302–303
- Rail Safety and Standards Board (RSSB), 245, 273, 307–308
- Rail Technical Strategy (RTS), 241
- Rail traffic management technologies, 236
  - automation technologies, 237–238
  - centralised control, 236–237
- Rail-specific regression modelling approach, 14
- Railway network
  - development, 2
  - in United Kingdom, 96–97
  - Railway profiles, 134–135
- Railway station and interchange
  - design
  - experience work, 27–31
  - focus on passenger, 20–21
  - layout of interchanges, 23–27
  - measuring all relevant quality aspects, 32–36
  - quality of transport interchanges, 21–23
- Railway track system
  - ballasted track systems, 63–65
  - locations of enhanced deterioration, 80
  - maintenance, 75
  - other, 81–82
  - planning, 75–79
  - principles of performance, 62–63
  - railway track performance, 69–75
  - S&C, 81
  - tamping, 79–80
  - track geometry, 65–69
  - trackbed design, 82–86
  - transitions, 81
- Railway(s), 266
  - accident, 296
  - changing emphasis, 208–210
  - evaluation, 17
  - financial sustainability, 281
  - historical development, 206–208
  - interior passive safety, 306
  - owners and promoters, 2
  - pattern of railway fatalities, 296–297
  - purpose of, 6–8
  - restructuring, 303–304
  - sustainable capacity provision, 211–215
  - sustainable timetabling, 215–217
  - system technology, 306
  - transformation, 57
  - vehicle taxonomy, 151–152
- Railways Act, 269, 270, 272
- Rapid drawdown effect, 101
- Rayleigh wave speed velocity, 95
- Regenerative braking, 172, 176, 214
- Regional vehicles, 153
- Regulation, 285–289
- Regulation of Railways Act 1889, 272–273
- Relaxation, 30
- Reliability, 22, 249–250
- Renewable energy, 327
- ‘Renewable’ power solutions, 2
- Repair, 106–108
- Resilience, 12
- Resilient, 262
- ‘Resource-led’ approach, 217
- Responsive, 261–262
- Retail Price Index (RPI), 272
- Rete Ferroviaria Italiana (RFI), 62
- Revenue, 12, 15, 210, 216–217, 282–285
- Reversal theory, 29–30

- Ride comfort, 139–142
- Risk assessment, 12
- Rolling contact fatigue (RCF), 121, 134
- Rolling noise, 120–123
- Rolling stock leasing companies (ROSCOs), 269
- Rolling stock technical categorisation system, 151
- Root mean square (rms), 114
- Rotterdam Central Station, modernisation of, 34–36
- Route choice, 9–11
- Route locking, 230–231
- Route planners, 10
- Route planning for sustainable railway system, 5–6
- RSSB Data Sandbox+ project, 251
- Safe train separation, 222
- SafeInteriors project, 308–309, 310, 321
- Safety integrity levels (SILs), 249
- Safety-critical information, 303
- Satellite communication, 248
- Seasonal shrink–swell movements, 104
- Seat systems, 320, 321
- Secondary collisions, 309
- Self-selective protective points, 232
- Service environment, 31
- Serviceability issues, vegetation and, 104–105
- Shallow translational failure, 99
- Sheet pile walls, 108
- Shift2Rail, 243, 248
- Short-term financing, 285–289
- Signalling
  - ATP, 233–236
  - interlocking principles, 229–233
  - rail traffic management technologies, 236–238
  - steel rail system, 221–222
  - train control principles, 222–229
- Signalling and telecommunications (S&T), 266
- Simulation and modelling, 253–256
  - challenges, 256
  - critical timing, 256
  - model sharing, 256
  - validation and accuracy, 256
- Skills gap, 258
- ‘Skytrain’ system, 174
- Slab tracks, 62
- Sleeper, 65
  - selection, 64
  - used in United Kingdom, 64
- Slope stability, 94
- Smart energy management, 150
- Smartrail 4. 0, 242
- Social distancing, 277
- Social inclusion, 8–9, 46, 48, 52, 207
- Social psychology, 45
- Social safety, 22
- Social sustainability, 2, 6
  - integration with broader policy and planning, 8–9
  - purpose of railway, 6–8
- Social sustainability of railways, 2
- Social value, 46, 53–54, 56
- Soft rail pads, 122
- Sound exposure level (SEL), 120
- Sound level meter, 118
- Sound pressure level (SPL), 114–115
- Spatial wayfinding, 24
- Specific Targeted Research Projects (STReP), 308
- Speed, 22
- Speed dependence of noise level, 125
- Spring, 141
- Stabilisation methods, 106–108
- Staff, 31
- Staff buy-in, 250
- Stand-alone DAS, 246
- Standard deviation (SD), 77–78
- Station adoption/friends, 53
- Station choice models, 12
- Station Experience Monitor (SEM), 32
- Steel rail system, 221
- Stimulus–Organism–Response Model, 28
- Straight curved plain line, 65–69
- Strategic Rail Authority (SRA), 270
- Structural crashworthiness, design for, 156

- Structures for urban railways, 180–182
- Sub-national transport bodies (SNTBs), 277
- Suicides, 302–303
- Supply chain, 247–248
  - sustainability, 249
- Supply side factors, 13
- Suspension
  - levels of, 140
  - primary, 129, 140–141
  - secondary, 140–141
  - vehicle, 140–141, 146
  - wheel and bogie, 191
- Sustainability, 1–2, 6, 42, 150, 182, 325
  - achieving sustainable development, 53–54
  - aiding access to sustainable, healthy travel, 48–51
  - creating more inclusive railway, 51–53
  - DfT's Community Rail
    - Development Strategy, 47
  - digitalisation for, 241–243
  - effect on urban structure and, 180–182
  - exploring community rail's position and power to influence, 46
  - financial, 182–183
  - functions of Industry 4. 0, 241
  - growing grassroots movement, 46
  - of HSR, 193–199
  - railways and, 204–206
  - social, 6–9
  - supply chain, 249
  - voicing local needs and opportunities, 47–48
- Sustainable capacity provision, 211–215
- Sustainable development, 1
  - achieving, 53–54
- Sustainable railway
  - organisation, 266–271
  - ownership, 273–275
  - regulation, 271–273
  - route planning for, 5–6
  - system, 2–3
- Sustainable timetabling, 215–217
- Sustainable transport, 42–43
- Sustainable travel, 7, 48, 50, 51
- Sustainable urban railways
  - broader role of urban rail systems, 179–182
  - bus alternative, 178–179
  - CBTC, 171
  - financial and economic issues, 182
  - financial sustainability, 182–183
  - issues of equity and income
    - distribution, 183–184
  - power supply and energy, 174–176
  - signalling and control, 176–177
  - structures, 173–174
  - system capacity, 177–178
  - track, 172–173
- 'Sweat the assets' approach, 212
- Switches and crossings (S&C), 63, 81
- System planning, 17
  - for sustainable railway system, 5–6
- Systemic risks, 12
- Systems engineering (SE), 243, 258
  - challenges, 260
  - fostering innovation, 260
  - INCOSE, 259
- 'Taktfahrplan', 216–217
- Tamping, 79–870
- Tangential contact, 137–138
- Taxonomy, 152, 276
- Technical recommendation (TecRec), 308
- Technical requirements document (TRD), 152
- Technical specifications for
  - interoperability (TSI), 126, 151–152, 187, 250, 272, 307
  - environmental noise limits and noise mapping, 127–128
  - noise barriers and window insulation, 128
  - noise limits on individual trains, 126–127
- Technological development, 174
- Telic state, 29

- 10-point scale, 30, 32–33
- TGV Haute-Picardie, 285
- Theory of rolling contact, 137
- Three management dimensions, 30–31
- Three-dimensional environments (3D environments), 255
- Threshold injury, 310
- Timetabling, 206, 215
  - sustainable, 215–217
- Top-down governance, 328
- Track circuit, 228
- Track decay rate, 122, 127
- Track design, 173
- Track geometry, 65
  - quality, 79
  - straight or uniformly curved plain line, 65–68
  - transition curves, 68
  - vertical curves, 68–69
- Track maintenance, 75–80
- Track performance, 69–75
- Track recording vehicle, 75
- Trackbed design, 82
  - design principles, 85
  - evaluating appropriateness of, 84
  - general, 82–83
- Trackbed load, 70–71
- Tractive effort, 92, 143
- Traditional transport modelling, 199
- Traffic management system (TMS), 242
- Train accidents, 296
- Train against 80t UIC Standard Wagon Impact, 159–160
- Train against level crossing object impact, 160
- Train against small object impact, 160–164
- Train control and monitoring systems (TCMS), 155
- Train control, 222
  - by cab signaling, 225–227
  - by lineside signals, 222–225
- Train journey, 30
- Train operating companies (TOCs), 270
- Train performance calculations, 143
  - equations of motion, 145
  - resistance to motion and other accelerations, 143–144
  - tractive force, 143
  - worked example, 145
- ‘Train protection’, 300
- Train resistance, 143–144
- Train simulators, 255
- Trans-European Network (TEN), 152
- Transformational leadership, 256–258
  - challenges, 258
  - equality, diversity and inclusion, 258
- Transit-oriented development, 7
- Transition curves, 68
- Transitions, 81
- Transport Decarbonisation Plan, 56
- Transport interchanges, quality of, 21–23
- Trespassers, 302–303
- Trip end model, 13–14
- Trip rate model, 13–14
- Tunnel boring machines (TBMs), 174
- TWINS model, 121
- UK Digital Railway, 242
- UK Rail Research and Innovation Network (UKRRIN), 252
- UK Transport Industry Skills Strategy, 258
- Ultimate failure, 101–104
- Ultra-high-frequency radio
  - identification tags, 247
- Under sleeper pad (USP), 65
- Under-track crossing (UTX), 81–82
- Underfunding, 288–289
- Uniformly curved plain line, 65–69
- Union des Industries Ferroviaires Européennes (UNIFE), 156
- Union of European Railway Industries (*see* Union des Industries Ferroviaires Européennes (UNIFE))
- Union of Railways (UIC), 240
- United Nations Sustainable Development Goals, 328

- Urban rail systems, 179–182
- Urban railways, 172–173
  - broader role of urban rail systems, 179–182
  - bus alternative, 178–179
  - CBTC, 171
  - financial and economic issues, 182
  - financial sustainability, 182–183
  - issues of equity and income
    - distribution, 183–184
  - power supply and energy, 174–176
  - signalling and control, 176–177
  - structures, 173–174
  - system capacity, 177–178
  - track, 172–173
- Validation, 256
  - of design, 320
- ‘Value-added’ services, 13
- Valuing people, 262
- Vegetation, 96
  - and serviceability issues, 104–105
- Vehicle dynamics, 133–134
  - consequences of vehicle–track interaction, 142–143
  - curving behaviour, 138–139
  - normal contact, 135–137
  - ride comfort, 139
  - tangential contact, 137–138
  - train performance calculations, 143–145
    - wheel and rail profiles, 134–135
- Vehicle interior noise, 125–126
- Vehicle safety, 151
- Vehicle–track interaction, 133–134, 142–143
- Vertical curves, 68–69
- Viareggio accident, 298
- Vibration
  - environment, 139–140
  - ground-borne noise and, 128–130
  - velocity, 115
- Vignole, 63
- Virtual integration, 270
- Visual intrusion, 175
- Voicing local needs and opportunities, 47–48
- Volume, variety, velocity, veracity and value (5Vs), 252
- Volunteering, 46, 52–53, 56
- Warming climate, 43
- Wayfinding process, 24
- Wear and fatigue, 142–143
- WebTAG, 16, 197
- Well-functioning intermodal station, 24
- Wheel, 134–135
- Wheel damping treatments, 124
- Wheel–Rail Interface, 66
- Whole-life impact assessment, 11
- Wi-Fi, 248
- Wider Economic Impacts (WEIs), 180
- Williams–Shapps Plan, 278
- Window insulation, noise barriers and, 128
- Workplace, noise in, 113
- World Wide Web, 240
- Yiwu–London route, 241
- Zero carbon transport system, 2