INDEX

A(H1N1) influenza, 725
abstraction hierarchy complexity, 298
acceptable risk, 17, 435
criterion of, 441
level of, 457
acceptance criterion, 296
accident investigation, 117, 123–125, 129–130, 133
accidents
Challenger, Space Shuttle, 176, 647, 651, 655, 751, 757, 761, 765, 772
Chernobyl, xxviii, 20, 120, 394, 647, 649, 652–653, 656, 715, 717, 751, 757, 761
Clapham Junction, 763
Columbia, Space Shuttle, 647
explosion, in the port of Tianjin, 239
Exxon Valdez oil spill, 757
Fukushima, 572, 583, 647–649, 653, 758
Three Mile Island, 717, 756
Windscale, 361–362
Ackoff, Russell, 349
active failures, 69
actively caring for people, 680
age-based maintenance, 541
AHC, 298
Ahteensuu, Marko, 279, 594, 618
aircraft safety assessment, 736
air traffic management, 204, 364
ALAP, 595–596
ALARA, 2, 19–20, 451, 475, 491, 593–601, 615–618
alarm system, 58, 313, 321–322, 713, 715
algorithm
evolutionary, 515, 521, 526, 530, 532, 536
genetic, 521–522, 531
allowed best technology, 606
Alm, Håkan, xxvii, 15, 305
Alphen aan den Rijn, 430–431
anthrax, 722
arguments
deductive, 368
inductive, 368
layered model, 741
risk, 371
Ashby, Ross, 22, 754
Ashby’s Law of Requisite Variety, 123
as low as practicable, 595–596
as low as reasonably achievable, 2, 19–20, 451, 475, 491, 593–601, 615–618
assembly breakdown, 208
assessment of activity, 176
attention, divided, 317
auditory displays, 308, 317–320
automation, 328
automobile safety, 57
autonomy, 705

© 2018 John Wiley & Sons, Inc. Published 2018 by John Wiley & Sons, Inc.
<table>
<thead>
<tr>
<th>Bannon, Liam</th>
<th>Beninson, Dan J.</th>
</tr>
</thead>
<tbody>
<tr>
<td>168</td>
<td>600</td>
</tr>
<tr>
<td>barrier, 63–71, 81</td>
<td>BEP, 603, 605</td>
</tr>
<tr>
<td>active and passive, 73</td>
<td>Bergman, Bo, xxvii, 16, 333</td>
</tr>
<tr>
<td>classical view of, 82</td>
<td>Beronius, Anna, 279</td>
</tr>
<tr>
<td>classification of, 71</td>
<td>best available control technology, 603</td>
</tr>
<tr>
<td>design and installation of, 79</td>
<td>best available technology, 593–594,</td>
</tr>
<tr>
<td>function, 66–69, 71, 74</td>
<td>601–606, 615–618</td>
</tr>
<tr>
<td>functional, 150</td>
<td>concept of, 605</td>
</tr>
<tr>
<td>human, 73</td>
<td>not entailing excessive costs, 603</td>
</tr>
<tr>
<td>incorporeal, 150</td>
<td>methodology of, 605</td>
</tr>
<tr>
<td>maintenance of, 80</td>
<td>reference documents, 602</td>
</tr>
<tr>
<td>management, 69, 71, 79–82</td>
<td>regulations of, 606</td>
</tr>
<tr>
<td>non-physical, 73</td>
<td>strategies of, 606</td>
</tr>
<tr>
<td>physical, 72</td>
<td>best environmental practice, 603, 605</td>
</tr>
<tr>
<td>primary, 74</td>
<td>best practicable</td>
</tr>
<tr>
<td>purpose of, 75</td>
<td>control technology, 603–604</td>
</tr>
<tr>
<td>quality and efficiency of, 79</td>
<td>environmental option, 603</td>
</tr>
<tr>
<td>radical interpretation of, 82</td>
<td>means, 603</td>
</tr>
<tr>
<td>strategy, 69</td>
<td>Bhopal, 757, 761</td>
</tr>
<tr>
<td>system, 45–47, 57, 59, 68, 74, 78, 80, 82</td>
<td>Birnbaum metric, 447–448</td>
</tr>
<tr>
<td>Bayesian belief network, 448, 582</td>
<td>Bisphenol A, 259</td>
</tr>
<tr>
<td>Bayesian paradigm, 432</td>
<td>Blackwell’s theorem, 554</td>
</tr>
<tr>
<td>Bayes’ theorem, 310</td>
<td>blowout preventer, 750</td>
</tr>
<tr>
<td>BBN, 448, 582</td>
<td>Bokrantz, Jon, xxvii, 17, 397</td>
</tr>
<tr>
<td>BBS, 21, 158–159, 300, 677–679, 686, 689,</td>
<td>bow-tie</td>
</tr>
<tr>
<td>691, 693, 695, 699, 701–706, 748</td>
<td>diagram, 449</td>
</tr>
<tr>
<td>behavior</td>
<td>method, 48, 449</td>
</tr>
<tr>
<td>direct, 690</td>
<td>brain cramp, 688</td>
</tr>
<tr>
<td>improvement, 691</td>
<td>brainstorming, 467, 482, 485</td>
</tr>
<tr>
<td>modification programs, 704</td>
<td>branch probabilities, 446</td>
</tr>
<tr>
<td>spurious, 206</td>
<td>breakdown</td>
</tr>
<tr>
<td>behavioral sampling, 119</td>
<td>assembly, 208</td>
</tr>
<tr>
<td>behavior-based</td>
<td>organizational, 208</td>
</tr>
<tr>
<td>coaching, 702</td>
<td>product, 208</td>
</tr>
<tr>
<td>feedback, 678</td>
<td>broad perspectives, 720</td>
</tr>
<tr>
<td>goal-setting, 678</td>
<td>Buchanan, Richard, 169–170</td>
</tr>
<tr>
<td>incentives and rewards, 678</td>
<td>capability, 718</td>
</tr>
<tr>
<td>incident analysis, 678</td>
<td>capacititation, 4</td>
</tr>
<tr>
<td>leadership development, 678</td>
<td>capacity, 718</td>
</tr>
<tr>
<td>safety, 21, 119, 158–159, 300, 677–679,</td>
<td>causality credo, 27, 34</td>
</tr>
<tr>
<td>686, 689, 691, 693, 695, 699, 701–706,</td>
<td>causal primacy, 173</td>
</tr>
<tr>
<td>748</td>
<td>Challenger Space Shuttle accident, 176, 647,</td>
</tr>
<tr>
<td>safety, benefits of, 701</td>
<td>651, 655, 751, 757, 761, 765, 772</td>
</tr>
<tr>
<td>safety, criticisms of, 703</td>
<td>check-lists, 485</td>
</tr>
<tr>
<td>safety-training, 678, 704–705</td>
<td>of critical behavior, 691, 693</td>
</tr>
<tr>
<td>behaviorism, 150</td>
<td></td>
</tr>
</tbody>
</table>
INDEX

chemistry, green, 394, 608
Chernobyl accident, xxviii, 20, 120, 394, 647, 649, 652–653, 656, 715, 717, 751, 757, 761
cholera, 259–260
Clapham Junction accident, 763
climate change, 251
close-call reporting, 685
cognitive resources, 16
Columbia Space Shuttle accident, 647
common cause
analysis, 736
failure, 45, 54, 80, 213, 222
hypothesis, 149
communicative function, 179
community of practice, 125–127, 132–133
completeness, 206, 219, 222–223, 225, 371, 440, 583
complex reliability models, 446
compliance, 372
crputer aided
design, 220
manufacturing, 220
confidentiality, 225
configuration management, 205, 207, 210–211, 218, 221
consequence categories, 443
consequence-probability matrix, 470, 487
consistency, 181, 209, 219, 222–223, 225, 582, 735, 763
construction safety, 133
contextual analysis of activity, 175–176
contingency plan, 711
control chart, 339, 341
control, digital, 204
c ontrol engineering, 202, 220
control, and instrumentation, 196–202, 204–206, 209–211, 216, 218, 220–222, 227, 229
analog and digital, 204, 227
application of, 226
architecture of, 216, 218, 222, 225–226
digital, 218, 220, 228
failures of, 226
functions of, 218
platforms, 205, 215–216, 222
systems of, 14, 199, 202, 204–205, 217, 220, 224
vendors of, 216
control, internal, 118, 120, 137
controller action reliability analysis, 571
ex ante, 496
ex post, 496
methodology of, 497
quantitative, 496, 507
cost-benefit framework, 430
cost-benefit optimization, 2, 4–5, 19, 267, 541, 544, 547, 556, 558
cost-benefit ratio, 498–499, 503
cost-benefit rationale, 540, 559
cost-effectiveness, 661
countervailing risks, 107
CPS, 168, 178, 190
critical behavior checklist, 691, 693
critical risk, 454
cultural framework, 661
cultural-historical activity theory, 178, 184
culture, 660, 669
delineation of, 661
interpretive approach to, 660
national, 648
organizational, 648–649, 652, 665–666
subcultures, 649
cyber-physical systems, 168, 178, 190
cyber security, 224–225, 229, 247
decision
criteria, 453
theory, 436
deductive argument, 368
default toxicity, 276
defense, 69
fallacy, 763
Delphi technique, 467
demand, physical, 312
Deming, Edwards W., 701
design
core-task, 172, 178–179, 183–184, 188–189
detailed, 43, 209, 217, 219, 226, 374
fail-safe, 59, 388
industrial, 168, 185, 204
inherently safe, 6, 16, 355, 386–388, 390, 393–394, 478, 560
parameter, 344
pattern, 214, 228
safety in, 135, 137
of systems, xxxiv, 59, 132, 202, 215, 479
thinking, 14, 167–171, 190
development assurance level, 733–734
diagnostic process, 125–126
digital control, 204
digitalization, 408
direct behaviors, 690
disasters
Katrina, Hurricane, 722, 724–725
Piper Alpha, 32, 120, 145, 361, 363, 398, 410, 494, 647, 761
Texas City Refinery, 145, 157, 495
displays, 317
disproportion factor, 505–506, 511
distribution arbitrariness, 96
diverse redundancy, 45
diversity, 59
divided attention, 317
Doorn, Neelke, xxvii, 12, 87
double-loop learning, 122, 138
Downer, John, 760
Dynes, Russell, 717
economic
rate of return, 501
risk, 465
ecotoxicity, 274–275
ecotoxicology, 268
efficacy of indicators, 155
Ellul, Jacques, 22, 754, 756
embryonic theories, 720
emergency management, 718
emergency operations plan, 711
emergency plan, 711–713, 718, 721–722, 724
components of, 712
operations, 711
response, 711
emergency response cycle, 720
emergency response plan, 711
emission
limit values, 602
lowest achievable rate, 603
employee participation, 684
Enander, Ann, xxviii, 711
energy
analysis, 76
model, 119–130
engineering
decision complexity, 298
design, 92, 168, 201–202, 220
ensurance principles, 158
environmental safety culture, 669
epistemic primacy, 173
equipment under control, 479
error, human, 688
analysis of, 706
assessment and reduction technique, 567, 570–575, 578–580
European Treaty, 261
event tree analysis, 76, 445, 543
INDEX

| evolutionary algorithm, 515, 521, 526, 530, 532 |
| multi-objective, 526, 530, 536 |
| single-objective, 526–527 |
| expected consequence, 690 |
| developer, 288 |
| end user, 288 |
| utility, 457 |
| utility principle, 441 |
| value-based calculations, 541 |
| experience carrier, 131–135 |
| explicit, 131 |
| feedback, 13, 117–138, 121–122, 124, 131, 747 |
| explosion, in the port of Tianjin, 239 |
| extended parallel process model, 247 |
| external hazard, 417 |
| regulation, 637, 640, 642 |
| Exxon Valdez oil spill, 757 |
| factionalism, 2 |
| fail-safe design, 59, 388 |
| failure active, 69 |
| concept of, 669 |
| failure mode effect analysis, 79, 454, 477 |
| effects and criticality analysis, 543 |
| Falzon, Pierre, 168 |
| fatality risk of groups, 442 |
| fault hazard analysis, 475 |
| fault-tolerant system, 688 |
| fault tree analysis, 77, 446, 475, 543 |
| Federal Aviation Administration, 736, 768 |
| feedback control, 122, 137, 201–202 |
| cycle, 13, 122 |
| field instrument, 218 |
| programmable gate arrays, 224 |
| Findeli, A., 169–170 |
| Flage, Roger, xxviii, 19, 540 |
| floating point, 204, 216 |
| focused attention, 316 |
| formative intervention, 186 |
| fractional contribution, 447 |
| Fukushima accident, 572, 583, 647–649, 653, 758 |
| function, instrumental, 179 |
| functional barriers, 150 |
| block, 204, 218–219 |
| hazard assessment, 736 |
| safety engineering, 478 |
| safety standard, 735 |
| Geller, Scott E., xxviii, 677 |
| general quality principles, 2 |
| generational distance, 523, 532–533 |
| genetic algorithm, 521–522, 531 |
| vector evaluated, 522 |
| Giddens, Anthony, 751 |
| Gilbert, T. F., 700 |
| goal structuring notation, xxx–xxxi, 368–369, 380, 740 |
| good programming technique, 219 |
| governance process, 752 |
| graded approach to safety, 212, 215, 222–223 |
| green chemistry, 394, 608 |
| Grice, H. P., 327 |
| Grote, Gudela, xxix, 20, 627 |
| group fatality risk, 442 |
| GSN, xxx–xxxi, 368–369, 380, 740 |
| Gutteling, Jan, xxix, 15, 235 |
| Habli, Ibrahim, xxix, 21, 732 |
| Hansson, Sven Ove, xxx, 12, 15, 19, 87, 258, 593 |
| hard defenses, 69 |
| hardware, 204–205, 211, 216–219, 224–225, 229 |
| harmonization, 222, 225, 458, 628 |
| Harms-Ringdahl, Lars, xxx, 12, 63 |
| marine, 454 |
hazard (Continued)
operability, 18, 454, 467, 469–470, 475, 477, 480, 482–483, 486, 489–490, 543, 577
operating analysis, 467–469, 482–483, 489–490
preliminary analysis, 467–468, 475, 486, 489–490
preliminary list, 482
HAZOP, 18, 454, 467, 469–470, 475, 477, 480, 482–483, 486, 489–490, 543, 577
Heinrich, H. W., 65, 144
Heinrich model, 66
Heinrich’s Pyramid, 144
hierarchical task analysis, 469, 576
high reliability organization, 323–324, 658, 726
Holmgren, C. S., 26
Hollnagel, Erik, 12, 25, 174, 179, 182, 764, 772
Holmberg, Jan-Erik, xxxi, 12, 17, 42, 434, 618
Hughes, Thomas, 756
human error, 688
analysis, 706
assessment and reduction technique, 567, 570–575, 578–580
human factor, 14, 32, 747
models, 752
resilience-oriented engineering, 182–183
human-machine system, 306–307
human performance, 78, 166, 284, 299, 313, 570–571, 573, 584, 586, 666
human reliability analysis, xxxii, 19, 84, 159, 166, 300, 439, 453, 458, 565–586, 706
applications, 566
prospective, 566
retrospective, 566
human technology interaction, 469
ideal safety culture, 677
incident reporting and analysis, 683, 685
incremental safety case development, 373
indicators
efficacy of, 155
lagging, 146
individual risk, 429, 432
and fatality, 42
inductive argument, 368
industrial design, 168, 185, 204
influenza, A(H1N1), 725
information and control, 13
information technology security, 55
inherently safe design, 6, 16, 355, 386–388, 390, 393–394, 478, 560
inherent reliability, 410
inherent safety, 388, 607
sub-principles of, 16
injury
lost time frequency, 146–148
rate, recordable, 129, 146
Institute of Nuclear Power Operations, 664
instrumental function, 179
instrumentation and control, 196–202, 204–206, 209–211, 216, 218, 220–222, 227, 229
analog and digital, 204, 227
application of, 226
architecture of, 216, 218, 222, 225–226
digital, 218, 220, 228
failures of, 226
functions of, 218
platforms, 205, 215–216, 222
systems of, 14, 199, 202, 204–205, 217, 220, 224
vendors of, 216
integrated system validation, 166
integration, 209
integrity, 225, 383, 402, 450, 452–453, 717, 733–734, 740
interim safety case report, 373
internal control, 118, 120, 137
internal rate of return, 501–503
International Atomic Energy Agency, 664
interpretive work, 176–177, 183
intervention hierarchy, 694–695
Iqbal, Moh Umair, xxxi, 16, 386
ISO 9000, 120, 333–335, 352
INDEX

Katrina, Hurricane, 722, 724–725
Keinonen, Turkka, 185
Kelly, Tim, xxxi, 16, 361
Kjellén, Urban, xxxi, 13, 117
knowledge, 127, 132, 135
   engineering, 752
   improvement, 350
   management, 13, 126
   professional, 350
   tacit, 127, 132
   theory, 345
Kolmogrov axioms, 436
Kuhn, Thomas, 22, 754–755, 759–760
Kuutti, Kari, 168
lagging indicators, 146
latent conditions, 69
layered argument model, 741
leadership, 666
leading indicators, 146
learning
   double-loop, 122, 138
   spiral, 126, 132, 135
Le Coze, Jean-Christophe, xxxii, 22, 747, 772
Lewis, Clarence I., 345
Lindell, Bo, 600
Lisbon earthquake, 716
local circumstances, 69
logic, multi-valued, 445
Lord Cullen, 363
lost-time injury frequency rate, 146–148
lowest achievable emissions rate, 603
LTI-rate, 129–130
maintainability, 399–400, 404, 406, 514, 517, 542
   field, 399
   age-based, 541
   barriers, 80
   clock-based, 541
   condition-based, 401, 541
corrective, 210, 398, 400, 404, 409, 542, 549
   efficiency of, 402
   errors of, 398
   failure-finding, 542
   lean, 406–407
   management of, 684
   opportunistic, 542
   optimization, 19, 540–541, 556, 559
   planned, 401, 451
   predictive, 210, 541
   preventive, 541–543, 548
   reactive, 401
   risk-based, 401
   supportability, 405
   total productive, 17, 402
   types, 402
   value driven, 406
management
   air-traffic, 204, 364
   barrier, 69, 71, 79–82
   configuration, 205, 207, 210–211, 218, 221
   emergency, 718
   industrial safety, 119
   integrated risk, 2
   maintenance, 684
   oversight and risk tree, 78, 119, 749
   predictive safety, 32–33
   proactive safety, 32–33
   project, 15, 133, 201, 203–204, 212, 214, 484
   quality, xxvii, 13, 16, 117, 119–120, 125–126, 144, 333, 335, 349, 355, 560, 617, 629
   resilience, 37–39
   safety principles, 627, 648
   scientific, 193, 333, 636
   system factors, 78
   systems engineering, 472
   and systems of occupational heath, 135
managing the unexpected, 22, 595, 747, 766
marine hazards, 454
Markov models, 447
Marx, Karl, 22, 754–755, 758
maximin, 276
maximum achievable control technology, 603
McRae, Carl, 770
mean time between failures, 403
mean time to failure, 403
mean time to repair, 404
mental demand, 312
mental workload, 312
metaprinciples, 5, 9
of safety, 3, 11
methodological pluralism, 5
microprocessor, 204, 224
minimum safety requirements, 475
min-max method, 524
modality, 317
spatial, 317
visual, 317
Möller, Niklas, xxxii, 279
Monte Carlo, 436
MOO, 515–523, 525–527, 530, 536
motivation, extrinsic, 348
Motor Industry Reliability Association, 744
operational amplifier, 202
definition, 145
limiting conditions, 211
safety case report, 373
operationalization, 145
operational breakdown, 208
culture, 648–649, 652, 655–666
deficiencies, 663
principles and practices, 20
structures, 661
Osvalder, Anna-Lisa, xxxii, 15, 305
National Transport Safety Board, 767
national risk criteria, 449
net present value, 497–504, 507, 512, 559
niched Pareto genetic algorithm, 522
Nicolini, D., 178
non-probabilistic (deterministic) safety
management framework, 456
normative theories, 720
Obama, Barack, 753
occupational exposure limit, 103
organizational breakdown, 208
occupation health and safety management systems, 135
offshore domain, 204
O’Hara, J., 166
OHSAS (18001), 120, 126, 137
ontological diversity of the human being, 173
operating hazard analysis, 467–469, 482–483, 489–490
operating procedures, 15
operations research, 436
optimization principles, 18
overall safety goals, 51
INDEX

paradigm, 759
  shifts, 749
parameter design, 344
Pareto
  dominance, 518
  efficiency, 443
  efficiency principle, 443
  optimality, 517–519
Park, Jinkuyn, xxxiii, 15, 284
payback period, 503
people, actively caring for, 680
performance improvement potential, 700
personal
  protective equipment, 691, 695
  risks, 641
  safety, 146, 638–639
physical demand, 312
PID-controller, 202
Pierce, Charles Sanders, 176
Piper Alpha disaster, 32, 120, 145, 361, 363,
  398, 410, 494, 647, 761
Plan-Do-Check-Act cycle, 119
Podofillini, Luca, xxxiii, 19, 565
potential failure interval, 405
precautionary principle, 15, 258–266, 271,
  273, 275–276, 544, 618
  argumentative version, 263
  prescriptive version, 263
precursor events, 148
preliminary
  aircraft safety assessment, 736
  hazard analysis, 467–468, 475, 486,
    489–490
  hazard list, 482
  safety case report, 373
  system safety assessment, 736
prescriptive safety cases, 379
principles
  of accident prevention and mitigation, 47
    of applying detailed step-by-step
      instructions, 8
  of assurance safety, 737
  of automation, 8
  of behavior-based safety, 21
  of diversified safety systems, 8
  of ensurance, 158
  of expected utility, 274, 441
  of expected value, 441
  of experience feedback, 4
  of general quality, 2
  of human factors engineering, 14
  metaprinciples, 3, 5, 9, 11
  of optimization, 18
  of Pareto efficiency, 443
  precautionary, 15, 258–266, 271, 273,
    275–276, 544, 617
  of qualitative risk analysis, 464–465
  of quality, 333–334
  of rams optimization, 514
  of reducing consequences, 47
  of redundancy, 45
  of safety, 7
  of safety management, 627, 648
  of simplicity in designs, 8
  of simplification, 410
  of striving for oversight and simplicity,
    8
  of substitution, 2, 19, 593–594, 609,
    611–612, 614–618
  of successive barriers, 46
prioritization, 4
proactive behavior, 320
proactive safety management, 32–33
probabilistic
  risk analysis, 435, 452
  risk assessment, 419, 453, 455, 543
  safety assessment, 435, 452, 566,
    568–569, 571–573, 580–583, 585
  safety criteria, 436
probability
  branch, 446
  categories, 443
  consequence matrix, 470, 487
  estimates, 438
  sequence, 446
  subjective, 436
procedures
  event-based (or event-oriented), 292
  symptom-based (or symptom-oriented),
    292
process safety, 146, 638–639, 668
  culture of, 669
INDEX

product breakdown, 208
safety culture, 669
productive safety, 34
programming
  good technique, 219
  object oriented, 219
project management, 15, 133, 201, 203–204, 212, 214, 484
protection
  layers, 70
  motivation theory, 247
protective safety, 34
psychological function, 179

qualitative
  analysis, 575
  approach, 476
  properties, 466
  requirements, 452
  risk analysis, 435, 463–467, 491, 706
  risk analysis methods, 464
  risk analysis principles, 464–465
  risk assessment, 476, 489
  risk identification, 491

quality
  management, xxvii, 13, 16, 117, 119–120, 125–126, 144, 333, 335, 349, 355, 560, 617, 629
  principles, 333–334
  values, 334
quantitative analysis, 517
quantitative indicators, 142
quantitative risk assessment, 144, 543
Quarantelli, Henry, 717

Rae, Andrew, xxxiii, 13, 142
railway safety, 56
rams optimization principles, 514
randomness, 440
Rasmussen, Jens, 176, 179, 184, 760, 772
rate of return, economic, 501
reactive behavior, 320
real time, 218–219, 249, 771
reasonably achievable control technology, 603
Reason, James, 761
recordable injury rate, 146
redundancy, 44–45, 49, 58–59
  diverse, 45
  principle of, 45
regulatory oversight, 203, 212, 215, 222
Reiman, Teemu, xxxiii, 20, 647, 772
reliability, 514
  centered maintenance, 17, 353, 355, 402
  characteristics of, 552
  complex models, 446
  constraints of, 552
  engineering, 211–213
  optimization of, 515
  techniques of, 78
  theory of, 436
reliability engineering, 211–213
renewal theory, 436
Reniers, Genserik, xxxiv, 18, 493
requirements specification, 207, 214, 219, 221, 225, 373
requisite variety, 123, 223, 308, 670, 762
  analysis grid, 31
  community, 719
  concept of, 12, 28, 174, 182, 718
  ecological, 26
  management, 37–39
  performance, 29, 35
reusability, 213
rhize, 436
risk, 389, 465
  acceptable, 17, 435
  acceptable level, 457
INDEX

<table>
<thead>
<tr>
<th>Term</th>
<th>Page Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>acceptance criteria</td>
<td>51, 441, 453</td>
</tr>
<tr>
<td>achievement worth</td>
<td>447</td>
</tr>
<tr>
<td>analysis</td>
<td>434, 436, 349, 441, 463–467, 489</td>
</tr>
<tr>
<td>analysis, principles</td>
<td>435, 463–467, 491, 706</td>
</tr>
<tr>
<td>analysis, probabilistic</td>
<td>435, 452</td>
</tr>
<tr>
<td>argument</td>
<td>371</td>
</tr>
<tr>
<td>assessment, probabilistic</td>
<td>419, 453, 455, 543</td>
</tr>
<tr>
<td>business</td>
<td>565</td>
</tr>
<tr>
<td>characterization</td>
<td>434, 466</td>
</tr>
<tr>
<td>communication</td>
<td>xxix, 15, 159, 235, 237–252, 434, 456, 726, 748</td>
</tr>
<tr>
<td>countervailing</td>
<td>107</td>
</tr>
<tr>
<td>criteria</td>
<td>442, 453</td>
</tr>
<tr>
<td>criteria, nuclear</td>
<td>449</td>
</tr>
<tr>
<td>criteria, subsidiary</td>
<td>445</td>
</tr>
<tr>
<td>critical</td>
<td>454</td>
</tr>
<tr>
<td>economic</td>
<td>465</td>
</tr>
<tr>
<td>estimation</td>
<td>477–478, 491</td>
</tr>
<tr>
<td>evaluation</td>
<td>464, 466, 477–478</td>
</tr>
<tr>
<td>group fatality</td>
<td>442</td>
</tr>
<tr>
<td>identification</td>
<td>464, 466–467</td>
</tr>
<tr>
<td>increase factor</td>
<td>447–448</td>
</tr>
<tr>
<td>indicators</td>
<td>146</td>
</tr>
<tr>
<td>individual</td>
<td>429, 432</td>
</tr>
<tr>
<td>influencing factors</td>
<td>557</td>
</tr>
<tr>
<td>information</td>
<td>237</td>
</tr>
<tr>
<td>investment</td>
<td>465</td>
</tr>
<tr>
<td>management</td>
<td>2, 17, 100, 235–238, 434, 483, 540, 543–544, 618, 630</td>
</tr>
<tr>
<td>matrix</td>
<td>470, 487</td>
</tr>
<tr>
<td>military</td>
<td>465</td>
</tr>
<tr>
<td>models of</td>
<td>148–149</td>
</tr>
<tr>
<td>perception</td>
<td>15, 237</td>
</tr>
<tr>
<td>personal</td>
<td>641</td>
</tr>
<tr>
<td>political</td>
<td>465</td>
</tr>
<tr>
<td>probabilistic analysis</td>
<td>435, 452</td>
</tr>
<tr>
<td>probabilistic assessment</td>
<td>419, 453, 455, 543</td>
</tr>
<tr>
<td>process, of governance</td>
<td>752</td>
</tr>
<tr>
<td>professional analysis</td>
<td>436</td>
</tr>
<tr>
<td>programming, good technique</td>
<td>219</td>
</tr>
<tr>
<td>qualitative analysis</td>
<td>464</td>
</tr>
<tr>
<td>quantification of</td>
<td>465–465</td>
</tr>
<tr>
<td>quantitative analysis</td>
<td>17, 144, 151, 434–435, 438–441, 443, 445, 449, 452, 454, 456, 458, 464–466, 491, 543, 706</td>
</tr>
<tr>
<td>quantitative assessment</td>
<td>144, 543</td>
</tr>
<tr>
<td>reduction of</td>
<td>477, 540</td>
</tr>
<tr>
<td>safety assessment</td>
<td>435, 452, 566, 568–569, 571–573, 580–583, 585</td>
</tr>
<tr>
<td>social</td>
<td>465</td>
</tr>
<tr>
<td>spatial</td>
<td>426</td>
</tr>
<tr>
<td>subsidiary criteria</td>
<td>445</td>
</tr>
<tr>
<td>temporal</td>
<td>429</td>
</tr>
<tr>
<td>treatment of</td>
<td>466</td>
</tr>
<tr>
<td>types</td>
<td>494</td>
</tr>
<tr>
<td>undesirable</td>
<td>484</td>
</tr>
<tr>
<td>Risk Assessment Committee</td>
<td>453</td>
</tr>
<tr>
<td>risk communication</td>
<td>xxix, 15, 159, 235, 237–252, 434, 456, 726, 748</td>
</tr>
<tr>
<td>democratic view of</td>
<td>240</td>
</tr>
<tr>
<td>technical view of</td>
<td>240</td>
</tr>
<tr>
<td>risk-informed regulation</td>
<td>17, 417, 419</td>
</tr>
<tr>
<td>riskometer</td>
<td>432</td>
</tr>
<tr>
<td>Roberts, Steve</td>
<td>xxxiv, 21, 677</td>
</tr>
<tr>
<td>robustness</td>
<td>60</td>
</tr>
<tr>
<td>robust portfolio modeling</td>
<td>550</td>
</tr>
<tr>
<td>Rollenhagen, Carl</td>
<td>xxxiv, 12, 20, 63, 108, 647, 772</td>
</tr>
<tr>
<td>Rosseau, Jean-Jacques</td>
<td>716</td>
</tr>
<tr>
<td>Rossi, Harald H.</td>
<td>600</td>
</tr>
<tr>
<td>Rudén, Christina</td>
<td>618</td>
</tr>
<tr>
<td>safety assessment</td>
<td>60</td>
</tr>
<tr>
<td>of aircraft</td>
<td>736</td>
</tr>
<tr>
<td>of systems</td>
<td>736</td>
</tr>
<tr>
<td>probabilistic</td>
<td>435, 452, 566, 568–569, 571–573, 580–583, 585</td>
</tr>
<tr>
<td>reports</td>
<td>367</td>
</tr>
<tr>
<td>safety automation</td>
<td>14, 196–197, 201, 206, 218, 225, 228–229</td>
</tr>
<tr>
<td>roots of</td>
<td>201</td>
</tr>
<tr>
<td>safety barrier</td>
<td>59, 63, 68, 74–75, 83–84, 158, 223, 226, 410, 536, 747</td>
</tr>
<tr>
<td>diagrams</td>
<td>77</td>
</tr>
</tbody>
</table>
confidence of, 376
evaluation of, 375
maintenance, 374
report, 366
shelf-ware, 380
safety classification, 50–51, 54
safety climate, 649, 652, 654, 656, 663
safety communication, 683
safety constraint, 551
safety criticality, 21
safety-critical systems, 21
environmental, 669
ideal, 677
occupational, 669
predictive validity of, 662
studies of, 662
safety engineering, 107
safety factor, 87–93, 97, 100, 102–104, 107, 536
margins, 87
safety first, 641
safety function, 70–71
analysis of, 78
safety in design, 135, 137
safety indicator, 138, 142, 146, 153, 156, 158–159
safety information systems, 124–125, 138
safety integrity level, 450, 453, 733–734
safety, intrinsic, 388
safety investments, 511–512
safety justification report, 367
safety lifecycle models, 735
commercial aviation, 628
framework, non-probabilistic (deterministic), 456
mountaineering, 628
principles of, 627, 648
proactive, 32–33
system, 31, 34, 144, 685, 772
safety margin, 94, 103, 158, 226, 536
safety metrics, 156
safety, occupational, 668
safety, operational, 284
safety, passive, 389
safety performance monitoring, 642
safety, personal, 146, 638–639
safety philosophy, 53, 188, 218, 222
safety principles, conflicts between, 7
safety reserve, 12, 87–88, 91–92, 99, 105, 226
safety risk, 465
safety standards, 21, 732, 734
procedures, 638
safety strategy, 57
safety training, 639
SARS, 722
Savioja, Paula, xxxiv, 14, 164
scenario analysis, 487
scientific management, 119, 333, 636
Second World War, 119, 144, 274, 400, 405, 436, 595, 716
self-regulation, 629, 635, 637, 639–640, 642
semantic primacy, 173
sensitivity to environment, 286, 288
sequence probabilities, 446
Shewart, Walter A., 338
Simon, Herbert, 169
single-loop learning, 122–123
single-objective evolutionary algorithm, 526–527
single-objective genetic algorithm, 521–522, 530, 532
site acceptance tests, 210
situation awareness, 8, 80, 173, 310, 313, 315, 328, 770
Skinner, B. F., 678
Skoogh, Anders, xxxv, 17, 397
social construct, 145
social constructivism, 655, 661
sociotechnical system, 663
soft defenses, 69
**INDEX**

<table>
<thead>
<tr>
<th>Page</th>
<th>software, 201–202, 204–205, 214, 216–226, 228–229</th>
<th>789</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>software safety, 733, 737</td>
<td></td>
</tr>
<tr>
<td></td>
<td>assurance principles, 737</td>
<td></td>
</tr>
<tr>
<td></td>
<td>so far as is reasonably practicable, 596</td>
<td></td>
</tr>
<tr>
<td></td>
<td>spatial risk, 426</td>
<td></td>
</tr>
<tr>
<td></td>
<td>spurious behavior, 206</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Srinivasan, Rajagopalan, xxxv, 16, 386</td>
<td></td>
</tr>
<tr>
<td></td>
<td>stability, 26</td>
<td></td>
</tr>
<tr>
<td></td>
<td>step information complexity, 298</td>
<td></td>
</tr>
<tr>
<td></td>
<td>step logic complexity, 298</td>
<td></td>
</tr>
<tr>
<td></td>
<td>step size complexity, 298</td>
<td></td>
</tr>
<tr>
<td></td>
<td>stressors, 314</td>
<td></td>
</tr>
<tr>
<td></td>
<td>subcultures, 649</td>
<td></td>
</tr>
<tr>
<td></td>
<td>subjective probability, 436</td>
<td></td>
</tr>
<tr>
<td></td>
<td>subsidiary criterion, 443</td>
<td></td>
</tr>
<tr>
<td></td>
<td>subsidiary risk criteria, 445</td>
<td></td>
</tr>
<tr>
<td></td>
<td>substitution principle, 2, 19, 593–594, 609, 611–616, 618</td>
<td></td>
</tr>
<tr>
<td></td>
<td>surrogate criterion, 444</td>
<td></td>
</tr>
<tr>
<td></td>
<td>sustainability, 394</td>
<td></td>
</tr>
<tr>
<td></td>
<td>sustained attention, 317</td>
<td></td>
</tr>
<tr>
<td></td>
<td>systematic human error reduction and prediction approach, 570</td>
<td></td>
</tr>
<tr>
<td></td>
<td>system, integrated validation, 166</td>
<td></td>
</tr>
<tr>
<td></td>
<td>system life cycles, 205</td>
<td></td>
</tr>
<tr>
<td></td>
<td>system safety, 540</td>
<td></td>
</tr>
<tr>
<td></td>
<td>assessments of, 736</td>
<td></td>
</tr>
<tr>
<td></td>
<td>systems design, xxxiv, 59, 132, 202, 215, 479</td>
<td></td>
</tr>
<tr>
<td></td>
<td>systems engineering approach, 472</td>
<td></td>
</tr>
<tr>
<td></td>
<td>systems engineering management, 472</td>
<td></td>
</tr>
<tr>
<td></td>
<td>systems of systems, xxxi, 211–212</td>
<td></td>
</tr>
<tr>
<td></td>
<td>systems usability, 180–183, 188–189</td>
<td></td>
</tr>
<tr>
<td></td>
<td>tacit experience, 132</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Talarico, Luca, xxxv, 18, 493</td>
<td></td>
</tr>
<tr>
<td></td>
<td>task complexity, 298–301</td>
<td></td>
</tr>
<tr>
<td></td>
<td>task scope, 298</td>
<td></td>
</tr>
<tr>
<td></td>
<td>technical support organizations, 171</td>
<td></td>
</tr>
<tr>
<td></td>
<td>technique for human error rate prediction, 569, 572–575, 577, 579, 585</td>
<td></td>
</tr>
<tr>
<td></td>
<td>technological determinism, 756, 767, 772</td>
<td></td>
</tr>
<tr>
<td></td>
<td>technology</td>
<td></td>
</tr>
<tr>
<td></td>
<td>allowed best, 606</td>
<td></td>
</tr>
<tr>
<td></td>
<td>best available, 593–594, 601–606, 615–618</td>
<td></td>
</tr>
<tr>
<td></td>
<td>best available control, 603</td>
<td></td>
</tr>
<tr>
<td></td>
<td>best practicable control, 603–604 control, 603–604</td>
<td></td>
</tr>
<tr>
<td></td>
<td>of human interaction, 469</td>
<td></td>
</tr>
<tr>
<td></td>
<td>of information security, 55</td>
<td></td>
</tr>
<tr>
<td></td>
<td>temporal risk, 429</td>
<td></td>
</tr>
<tr>
<td></td>
<td>test-operate-test-exit unit, 632</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Texas City Refinery disaster, 145, 157, 495, 647–648</td>
<td></td>
</tr>
<tr>
<td></td>
<td>theorem</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bayes’, 310</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Blackwell’s, 554</td>
<td></td>
</tr>
<tr>
<td></td>
<td>theories</td>
<td></td>
</tr>
<tr>
<td></td>
<td>cultural-historical activity, 178, 184</td>
<td></td>
</tr>
<tr>
<td></td>
<td>decision, 436</td>
<td></td>
</tr>
<tr>
<td></td>
<td>embryonic, 720</td>
<td></td>
</tr>
<tr>
<td></td>
<td>micro, 720</td>
<td></td>
</tr>
<tr>
<td></td>
<td>normative, 720</td>
<td></td>
</tr>
<tr>
<td></td>
<td>protection motivation, 247</td>
<td></td>
</tr>
<tr>
<td></td>
<td>renewal, 436</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Three Mile Island accident, 717, 756</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tiusanen, Risto, xxxv, 18, 463</td>
<td></td>
</tr>
<tr>
<td></td>
<td>tolerability criteria, 453</td>
<td></td>
</tr>
<tr>
<td></td>
<td>tolerable hazard rate, 444, 455</td>
<td></td>
</tr>
<tr>
<td></td>
<td>total productive maintenance, 17, 402</td>
<td></td>
</tr>
<tr>
<td></td>
<td>total quality management, 144, 333–334, 355</td>
<td></td>
</tr>
<tr>
<td></td>
<td>total recordable incident rate, 147</td>
<td></td>
</tr>
<tr>
<td></td>
<td>total recordable injury frequency rate, 129</td>
<td></td>
</tr>
<tr>
<td></td>
<td>toxicity, 611</td>
<td></td>
</tr>
<tr>
<td></td>
<td>default, 276</td>
<td></td>
</tr>
<tr>
<td></td>
<td>eco-, 274–275</td>
<td></td>
</tr>
<tr>
<td></td>
<td>toxicology, 97, 102, 268</td>
<td></td>
</tr>
<tr>
<td></td>
<td>eco-, 268</td>
<td></td>
</tr>
<tr>
<td></td>
<td>traffic management, 56</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Treaty on the Functioning of the European Union, 261</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Treaty of Rome, 261</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TRI-rate, 129</td>
<td></td>
</tr>
<tr>
<td></td>
<td>tsunami, 750, 752</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Turing machine, 223</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Turner, Barry, 772</td>
<td></td>
</tr>
<tr>
<td></td>
<td>types of risk, 494</td>
<td></td>
</tr>
</tbody>
</table>
INDEX

ultra-resilient systems, 633
coping with, 635, 639–641
epistemic, 96
increases, 633
maintaining, 633
minimization of, 635, 639, 642
modeling of, 440
parametric, 440
reducing, 633
user experience, 176
validation, 209
value of preventing a fatality, 542, 547, 551, 554–555, 557
value of a statistical life, 509–511
Van Gelder, Pieter, xxviii, 17, 417
Vaughan, Diane, 760
verification, 209
Vicente, Kim, 179
Virilio, Paul, 751
Vision Zero, 27, 616–617
visual displays, 317–320
Voltaire, 716
von Bertalanffy, Ludwig, 349
von Wright, G. H., 172
Wahlström, Björn, xxxvi, 14, 196
Wanda, Orlikowski J., 178
warning signals, 665
way of acting, 176–177, 180
Weber, Max, 758
Weick, Karl, 760, 766
Westrum, Ron, 759
Windscale accident, 361–362
workload, 312, 314
World Association of Nuclear Operators, 664
world class, 212, 214, 696
World Trade Center, 717
World War II, 119, 144, 274, 400, 405, 436, 595, 716
Ylipää, Torbjörn, xxxvi, 17, 397
zero accident vision, 27, 616–617
zero injuries, 705
Zio, Enrico, xxxvi, 18, 514