INDEX

Note: Page numbers in italics and bold refers figures and tables.

A
acceptance-rejection technique, 57
assembly machine, 311–13, 312
Assistant toolbar, 92, 92–3
autocorrelation test, 217, 217
automated guided vehicles (AGVs) see project management
auto service center, 236–7, 237, 238
chi-square test, 240–42
inter-arrival times, 239–40, 240
service times, 241–2, 242
B
banking service model
layout, 410, 410
objectives, 409
performance measures, 411, 412
standard distribution, 411, 411
C
call center, 211
cellular manufacturing, 451, 453
central limit theorem (CLT), 278
chi-square statistics, 219–21
normal distribution, 221–2, 222, 223
Poisson distribution, 222–2
chi-square test, 240–42
clinical service model
comparison analysis, 416, 416–17
performance measure, 414–15
process map, 413, 413
standard distribution, 414, 415
validation, 415–16
WITNESS model, 413–14
clinic model
acute care, 292
assumptions, 292–4
DOE, 296
patient examination process, 295–6, 296
process map, 292, 293
queues and resources, 294
sampling distribution, 294, 294
simulation-based optimization, 296, 297
Clinic model (Continued)

Statistics and confidence interval, 294–5
Urgent care, 292
Validation, 295
Common random numbers (CRN), 269–70
Computer aided design (CAD) file, 28, 28–9
Confidence intervals, 184
Graphical and descriptive statistics, 273, 278–9, 279
Hypothesis testing
Analysis of variance, 282
Bonferroni approach, 282
Model validation, 279–80
Null hypothesis, 280–281
Process variance, 281
Production process, 280
Significance level, 282
Simulation analyst, jobs completed per hour, 283–5, 284
Test errors, 282, 282–3
Test power, 283
For population mean, 182–4
For population variance and standard deviation, 184–5
Conveyors, 150–151
Detail conveyor window, 154–5, 154
Downtime specification, 155, 156
Indexed fixed, 155, 157
Machine cycles summary window, 154, 154
Multi-cycle machine, 152–3, 153
Statistics report, 155, 157
Convolution method, 57
Cumulative distribution function (CDF), 57

D

Data collection, 202–3
Arrival/service times, 206
Call center, 211
Cycle times, 207, 208
Downtime data, 205–6
Line-level process, 208–10
Machine cycle time, 203–4
MHS, 210–211
Variable data, 204–5
WITNESS simulation, 203
Data independence, 215
Autocorrelation test, 217, 217
Run test, 218, 218
Scatter plot, 216–17, 217
Data representation, 211–12, 213, 214
Data requirements, 200–201
Factory model, 201
Service system model, 201–2
Data validation, 213–14
Filtering, 215, 216
Identical distribution, 218–19
Independence see Data independence
Design of experiment (DOE), 296
DFSS Six Sigma methodology
Clinic service model
DOE and lean techniques, 533–6, 534–6
P-Diagram and simulation, 531–3, 532, 533
Process mapping, 531, 532
QFDs, 530, 530, 531
Simulation and sensitivity analysis, 536, 537
IDOV approach
Designing, 500, 528–529
Identification, 500, 528
Optimization, 500, 529
Verification, 501, 529
Discrete event simulation (DES)
Continuous simulation
Applications, 68
Fluids model, 69
Hybrid simulation, 69–70
Pipe element, 69
Processor element, 69
Tanks, 69
Time steps, 68
Elements
Attributes, 71, 72
Buffers, 70–72, 71
Carriers, 70, 71, 72
Conveyors, 70, 71, 73
Entities, 45–6, 46
Event-driven systems, 47–8, 48
Fluids, 70, 71, 73
Labor, 71, 74
Machines, 71, 71, 74–5
NVA activities, 48, 49
Parts, 70, 71, 75
Paths, 70, 71, 75
pipes, 70, 71, 75
processors, 71, 71, 75
resources, 48–50, 49–50
sections, 71, 75
state variables, 46–7, 47, 47
stations, 71, 76
system delay, 50
system logic, 50–51, 51
system state, 46
tanks, 71, 71, 76
tracks, 70, 71, 76
value-added activities, 48, 49
vehicles, 70, 71, 76–7
long-term performances, 10–11, 11
MCS
constant return rate, 66–8, 67–8
randomness propagation, 65–6, 66
model variables, 12–13, 15
service process
animation, 59–60
assumptions, 60–61
characteristics, 51
event arrival, execution, 61, 62
event list creation, 52, 54, 54
flowchart, 52, 53
random sampling see random sampling
scheduled events, 61–3
simulation table, 63–4, 63–4
software tools, 51–2
statistical accumulation mechanism, 58–9, 64–5
time advancement and compression, 54–5, 55
system modeling
data collection, 43–4, 44
model logic, 44, 44
statistics, 45, 45
structural elements, 42, 42–3, 43
system layout, 43
Display Edit toolbar
aligning elements, 98–9
Fill Color button, 97
Font button, 97
Font Color button, 97
grid configuration, 98
layers and drawings, 98
Line Color button, 97
model animation display, 96, 96
reference point, 98
DMAIC Six Sigma methodology
LSS system see Lean Six Sigma (LSS) approach
phases
analysis, 498, 499
control strategy, 499, 499
definition, 497, 499
DES interaction, 520–2, 522
flowchart, 498
improvement, 498, 499
measurement, 497, 499
widget manufacturing
manufacturing lead time, 525–6, 526
number of defects, 524–5, 525
operating parameters, 522–3, 523
steps/process flow, 523–4, 524
downtime data, 205–6
E
Element toolbar
Copy Element Display button, 91
Defined Selection, 90–91
Force Breakdown button, 91
Force Repair button, 92
show/hide element selector button, 89, 89
standard/customized commands, 99–100, 100
emergency room (ER) simulation, 243–5, 244, 246–8
empirical distribution, 225, 226
Erlang distribution, 190, 192, 192, 193
Expode report, 322–3, 323
exponential distribution, 190, 191
F
factory model, 201
5S system, 453–4, 477
G
gamma distribution, 192–3, 194
gradient estimation algorithm, 426
H
harbor traffic model, 406–9, 407, 407, 408
hybrid simulation
assumptions, 360
baseline simulation, 367, 368, 369
experiments, 367–8, 370, 370–1
input data, 361, 362, 363, 364
KPI values, 373
hybrid simulation (Continued)

- macro-level process, 358, 359
- MgCl$_2$ histogram, 371, 372
- Mg production histogram, 371–2, 372
- modeling process, 358, 360
- outputs, 363, 365
- process logic, 360–1
- start-up conditions and model run length, 361
- VDP starts histogram, 371, 371
- verification and validation, 366–7
- WITNESS model, 363, 366

I

input modeling

- chi-square statistic, 219–21
- normal distribution, 221–2, 222, 223
- Poisson distribution, 222–5
- classification, 199–200
- data collection, 202–3
  - arrival/service times, 206
  - call center, 211
- cycle times, 207, 208
- downtime data, 205–6
- line-level process, 208–10
- machine cycle time, 203–4
- MHS, 210–211
- variable data, 204–5
- WITNESS simulation, 203
- data representation, 211–12, 213, 214
- data requirements, 200–201
  - factory model, 201
  - service system model, 201–2
- data validation, 213–14
- filtering, 215, 216
- identical distribution, 218–19
- independence see data independence
- empirical distribution, 225, 226
- input modeling, 234–6
  - auto service center see auto service center
- ER simulation, 243–5, 244, 246–8
- WITNESS input modeling, 226–7
  - continuous distribution, 231–3
  - databases with, 233–4
  - discrete distribution, 231
  - incorporating collected data, 229–30
  - normal distribution, 230–231
  - RNG, 227–9, 228
  - Interact Box, 322
  - inverse method, 57

J

just-in-time (JIT), 451, 454, 471

K

Kaizen “continuous improvement,” 451, 454, 477
Kanban lean technique, 451, 471, 472
lean manufacturing
  - benefits, 454, 454
  - cellular manufacturing, 453
  - 5S system, 453–4
  - inventory reduction, 453
  - just-in-time, 454
  - process waste, 452–3
  - pull system, 453, 479, 482–4
  - push system, 453, 479, 479–82
  - quality at the source, 453
  - results and goals, 450, 452
  - simulation-based approach
    - DES model, 463–5, 464, 465
    - dynamic VSM, 465–7, 466, 467
    - flowchart, 458, 459
    - future state VSM, 476, 476
    - improved process, 477
    - inventory control, 474–5
    - Kanban technique, 471–3, 472
    - lean measures, 460, 462, 467–8, 468, 476–7, 477
    - process mapping, 460, 461
    - process wastes, 468–470
    - SMED technique, 473–4, 474
    - static VSM, 462–3, 463
    - TPM technique, 475
  - Six Sigma see Lean Six Sigma (LSS) approach
  - SMED and TPM, 453, 454
  - terminologies, 451
  - value stream mapping, 454–7, 456, 458
  - WITNESS model, 478, 478
Lean Six Sigma (LSS) approach
  - analysis phase, 542–3
  - control strategy, 544–5
  - definition, 540
  - flowchart, 538, 539, 540
INDEX

improvement, 543–4, 544, 545
measurement, 540–1, 542
Lehmer’s multiplicative congruence method, 227
line-level process, 208–10
line Sigma rating, 511, 511–13

M
machine cycle time, 203–4
manufacturing process
defining elements, 114
detail window
Detail Buffer window, 116–17, 117
Input Rule Editor, 115–16, 116
Machine Detail window, 115, 116–18, 118
Output Rule window, 116, 116
part window, 114, 114
Display toolbar
Breakdown Mode, 124–5, 124
buffer HoldArea, 119–20, 121
Define Clock window, 119, 120, 119
Detail labor window, 123, 123
Detail Variable window, 121, 121
Edit Actions, 121, 122
Labor statistics report, 125, 126
model elements display, 121, 122
output report, Polisher, 120, 120
properties, 118, 118–19
grinding machine, 112, 113, 118
polishing machine, 112, 113
material handling systems (MHS)
conveyor, 149–50
add/remove cycles window, 153–4, 154
detail conveyor window, 154–5, 154
downtime specification, 155, 156
indexed fixed, 155, 157
machine cycles summary window, 154, 154
multi-cycle machine, 152–3, 153
statistics report, 155, 157
data collection, 210–11
labor and parts transit, 156–7
detail path window, 157, 158
error message, 159, 161
operation detail, 157–8, 159
preemption logic, 159–160, 160
statistics summary report, 158, 159
P&F systems, 167–8, 168
action station, 172, 173
carriers, 169, 170
loading station, 171, 171, 172
networks, 168, 169
reports, 174, 175, 176
sections, 169, 170
unloading station, 174, 174, 175
vehicles and tracks, 161–2
Chart States, 167, 167
detail track window, 163, 162–3
detail vehicle dialog window, 166, 166
downstream and upstream, WITNESS report, 166, 167
error message, 165
insertion, 162, 162
loading, 163–4, 165
unloading, 163, 164
WITNESS, 150–151
meteor trail, 326–8, 327, 328
MHS see material handling systems (MHS)
model options/run window, 325, 326
model validation
calibration process, 314
components, 305–6, 306
inputs validation, 316–8
model behavior, 318–9
output validation, 319–20
right model, 314
techniques, 314–16
model verification
components, 305–6, 306
definition, 306
inputs verification, 308–9
model logic
assembly machine, 311–13, 312
design and structure, 309
flow chart, 309
Percent Rule, 310–11
model outputs, 314
techniques, 307–8
WITNESS models
debugger, 328, 329
Explode report, 322–3, 323
fundamental capabilities, 320
Interact Box, 322
Meteor trail, 326–8, 327, 328
Model options/run window, 325, 326
Model watch window, 324–5, 325
Notepad®, 324–5
model verification (Continued)
processing steps, 322
Status report, 323–4, 324
Summary report, 321, 321
“Where Used” report, 321, 321
model watch window, 324–5, 325
Monte Carlo simulation (MCS)
constant return rate, 66–8, 67–8
randomness propagation, 65–6, 66
multi-attribute utility function (MAUF), 20, 22
multi-criteria decision-making (MCDM) techniques, 20, 22
N
non-value added (NVA) activities, 48, 49
normal distribution, 187, 189, 189–90, 190
O
optimization approach
design of experiments, 428–429
gradient estimation algorithm, 426
random search algorithm, 426–7, 429
response surface methodology, 428–429
tabu search approach, 427
WITNESS Optimizer model benefits, 442–3
control screen, 440, 441
examples, 443
experimenting techniques, 441–2
KPIs, 442
model parameters, 442
output results, 442, 442
TH and WIP, 443–7
WITNESS Scenario Manager see Scenario Manager
output analysis
clinic model
acute care, 292
assumptions, 292–4
DOE, 296
patient examination process, 295–6,
process map, 292, 293
queues and resources, 294
sampling distribution, 294, 294
simulation-based optimization, 296, 297
statistics and confidence interval, 294–5
urgent care, 292
validation, 295
experimental design
control factors, 285–7
factorial design, 287–9, 288, 289
fractional factorial design, 291–2
MINITAB analysis, 289–91, 290–291
parameter design, 286–7, 287
response variables, 285–6
structural changes, 286
treatments, 286
nonterminating simulation see
steady-state simulation
statistical analysis
central tendency, 274–5
confidence intervals see confidence intervals
dispersion measurement, 275–6
histogram and normal curve, 272–3, 273
inferential statistics, 276, 276–7
jobs completed per hour, 272–3, 273–4
modeling techniques, 271, 271
parameter estimation, 276, 277–8
population parameters, 272, 272
simulation experiments and optimization, 270–271
terminating simulation
bank operations, 255, 255
behavioral patterns, 255–6
initial model state, 256
peak performance, 255
replications, 257
terminating condition, selection, 256–7
transient period, 254
variability
controllable factors, 267–9, 268
random factors, 267–8
stochastic variability, 268
VRT, 269–70
WITNESS modules
costing and revenue, 299–300
Documentor, 301
Optimizer, 301–2
outputs and charts, 297–8, 297–8
Presentation Manager, 300–301
P
paint process (SP3)
airplane paint shop layout, 374
assumptions, 373, 375
data collection, 375, 376–7
KPI, 375, 379
standalone throughput, 375, 378
throughput improvement opportunities, 375
time-in-state chart, 375, 378
WITNESS model, 375, 377
Percent Rule, 310–11
pipeline facility, 376
base model, 381, 387, 388
description, 379
input parameters, 379
master data sheet, 381, 384–5
observations, 387, 389, 393
operation, 377–78
process flow diagram and data finishing lines, 381, 383
hot mill area, 379, 380
QA area, 381, 382
scheduled data, 381, 386
throughput results
  crane at 50%, 387, 391
  crane at 75%, 387, 392
line balanced schedule, 387, 390
TIS graph, 387, 389
WITNESS model, 381, 387
power-&-free (P&F) systems
MHS, 167–8, 168
action station, 172, 173
carriers, 169, 170
loading station, 171, 171, 172
networks, 168, 169
reports, 174, 175, 176, 176
sections, 169, 170
unloading station, 174, 174, 175
pre-determined time standards (PTS), 207
probability distributions, 186–7
probability mass function, 549–51
process Sigma rating
  stamping machine
  Part Statistics, 510

Rework Buffer/Machine, 509, 511
Rework module, 507–8
SigmaLevel module, 506
STAMPER output rule, 508
widget manufacturing
  manufacturing lead time, 525–6,
  526
  number of defects, 524–5, 525
  operating parameters, 522–3, 523
  steps/process flow, 523–4, 524
profile distributions, 232–3
project management
  conceptual model
    animation requirements, 343
    combined model, 342
    continuous model, 342
    control logic, 344
    decision-making process, 344
    discrete-event model, 342
    entities, 343
    level of detail, 343
    part-driven models, 342
    resource-driven models, 342–3
    simulation environment, selection, 341–2
    experimentation, 348–349
    model building, verification, and validation, 348
    model life cycle, 352–4
problem definition
  analytical models, 335
  client organization, 332–3, 333
  cost-benefit analysis, 335–6
  formal proposal, 336–7, 337
  Gantt chart, 336, 336
  issues, 334
  level of detail, 334–5
  model boundary/domain, 334
  resources, estimation, 335
process definition
  client validation, 347, 347
  dynamic elements, 344–5
  input data analysis, 344, 346
  level of detail, 344–6
  macro- and micro-level assumptions, 344, 346
  material handling specifications, 344,
  346
  operating philosophy, 344–5
project management (Continued)
operation specifications, 344, 346
physical constraints, 344–5
Project Functional Specifications, 344, 347
runtime parameters, 344, 347
project documentation
Final Project Report, 349, 351, 352
maintenance manual, 349, 351
model code, 349–50
model input, 349–50
model output, 349–50
parameters, 349, 351
presentation, 349, 351
Project Book, 349–50
Project Functional Specifications, 349–50
recommendations, 349, 351
User Manual, 349–50

teamwork
Alternate Model 1, 338
Alternate Model 2, 338
animation, 338–339
broad/macro-level assumptions, 338
data collection, 339
delivery dates, 340–1
human requirements, 339
levels of management, 340
milestone dates, 341
problem solving, 338
Project Functional Specifications, 341
tool selection, 339
training tool, 338

public service office model
data collection/analysis, 418, 419
design variables, 421, 421
document issuance process, 417, 417–8
key performance indices, 420, 420
optimization approach, 422, 422
performance improvement, 423, 423
response constraints, 421, 421
system model, 418–490, 420
pull production system, 451, 453, 471, 473, 479, 482–4
push production system, 451, 453, 479, 479–82

Q
quality at the source, 453

R
random number generation (RNG), 55–6
random sampling
exponential distribution, 58
model events, 55
RNG, 55–6
standard probability distribution, 57
random search algorithm, 426–7, 429
random variables (RVs), 179–80
continuous random variables, 181
discrete random variables, 180
Reporting toolbar, 95, 95–6
run test, 218, 218
Run toolbar, 95, 95–6

S
sample size
collected cycle times, 207
confidence level, 183
normal distribution, 189, 190
pilot simulation, 266
population mean, 185–6
scatter plot, 216–17, 217
Scenario Manager
grinder machine assessment
cycle time, 430–1, 431, 431
investigation, 431, 432
KPIs, 438, 439, 440
model browser, 433, 434
model run process, 434–5, 435
output charts, 435, 437
parameter specification, 433, 434
scenario definition, 432, 433
scenario results, 435, 436
start-up window, 431, 432
user-defined function, 438, 438
output analysis, 301
output tables and charts, 429, 430
service process, 137, 137

DES
animation, 59–60
assumptions, 60–61
characteristics, 51
event arrival, execution, 61, 62
event list creation, 52, 54, 54
flowchart, 52, 53
random sampling see random sampling
scheduled events, 61–3
simulation table, 63–4, 63–4
software tools, 51–2
statistical accumulation mechanism, 58–9, 64–5
time advancement and compression, 54–5, 55

tourists visiting museum
detail breakdown, definition, 124, 124, 132–3
detail distribution window, 128–9, 129
detail machine window, 115, 116, 117, 130–131
detail part window, 128–9, 128
detail shift window, 133, 134
elements selection, 137–8, 138
histogram, 139–40, 140–41, 144
process flow, 127–8, 127
projectionist, 132, 133, 134–5, 135, 135
reports/statistics, 137–9, 139
show_german and show_spanish machines, 130–31, 131
used report, machine, 138, 139
WITNESS functions, 135–6

service systems
characteristics, 398–399
customer service, 397
data requirements, 201–2
facility layout, 397–398
human resources, 397
operating policies, 398
physical structure, 397–398
service providers, 396–7
simulation model
applications, 402–4
banking sector, 409–12
car wash model, 405–6
clinical model see clinical service model
government offices see public service office model
harbor traffic model, 406–9, 407, 407, 407
staff members, 397
system entities, 396
system modeling
control factors, 401
elements, 401
modeling considerations, 399–401
performance measures, 402

Sigma rating
cycle time variability
conveyor network process, 513, 514
descriptive statistics, 513–14
improved process, 516–18, 518
normal process distribution, 513, 515
line operations, 511, 511–13
PartSigmaRating function, 504
process Sigma rating
Part Statistics, 510
rework buffer/machine, 509, 511
rework module, 507–8
SigmaLevel module, 506
STAMPER output rule, 508
SigmaRating function, 505
supply chains, 518, 518–20
simulated annealing optimization, 426–7 see also WITNESS Optimizer model
simulation-based LSS (S-LSS)
analysis phase, 542–3
control strategy, 544–5
definition, 540
flowchart, 538, 539, 540
improvement, 543–4, 544, 545
measurement, 540–1, 542
simulation clock, 54–5, 55
simulation modeling
analysis, 31, 31
applications, 16–17, 17–18
combined models, 12–13, 15
conceptual modeling, 25, 26
confidence intervals, 184
for population mean, 182–4
for population variance and standard deviation, 184–5
continuous models, 12–13, 15
cost-effective representation, 16
data collection, 26–7, 27
decision support, 16
definition, 11–12
DES, 12–13, 15
deterministic models, 13–14, 14–15
documentation, 32–3, 32–4
dynamic variables, 13–15, 14–15
Erlang distribution, 190, 192, 192, 193
exponential distribution, 190, 191
flowchart, 23, 24
gamma distribution, 192–3, 194
limitations, 17–19
INDEX

simulation modeling (Continued)
model building
  animation and graphical representation, 28, 29
  CAD file, 28, 28–9
  components, construction, 28, 29
  computer model, 27–8
  model logic, 28, 29
  model validation, 30–31
  model verification, 30
normal distribution, 187, 189, 189–90, 190
opportunities improvement, 20, 20–21
output analysis see output analysis
performance estimation, 15–16
point estimation, 182, 183
probability distributions, WITNESS, 186–7
problem formulation, 23
problem identification, 20, 20–21
random variables (RVs), 179–80
  continuous random variables, 181
  discrete random variables, 180
requirements, 12, 12
sample size determination, 185–6
software tools, 34–6
solution alternatives
  development, 20, 21
  evaluation, 20, 21–2
  implementation, 20, 22
  MAUF, 20, 22
  MCDM, 20, 22
  static variables, 13–14, 14–15
  stochastic models, 13, 15
study objectives, 23, 25
system modeling see system modeling
triangular distribution, 193, 196, 197
uniform distribution, 187, 188
Weibull distribution, 193, 195
simulation run length
  batch means method, 264, 265
  collection period, 263–4
  frequency and duration, 264
  independent multiple replications method, 265, 266
Single Minute Exchange of Die (SMED), 453, 473–4, 474
Six Sigma
  automatic Sigma calculator, 496
  DFSS see DFSS Six Sigma methodology
  DMAIC see DFSS Six Sigma methodology
  quality and capability
    highly capable process, 491, 491
    incapable process, 491, 492
    long-term shift, 493, 494
    marginally capable process, 491, 492
    short-term shift, 493, 493
S-LSS approach
  analysis phase, 542–3
  control strategy, 544–5
  definition, 540
  flowchart, 538, 539, 540
  improvement, 543–4, 544, 545
  measurement, 540–541, 542
stability and normality, 494–6
WITNESS model
  Hourly Shipped, 504
  Process Performance, 503
  Process Performance Pie Chart, 503–4
  Rework, 503
  Service Times, 504
Sigma Rating see Sigma rating
S-LSS see simulation-based LSS (S-LSS)
SMED see Single Minute Exchange of Die (SMED)
SP3 see paint process (SP3)
standard distribution, 229–30
standard tool bar, 86, 86–7
STARTUP.MOD model, 84, 84
static simulation see Monte Carlo simulation (MCS)
steady-state simulation
  long-term performance, 258
  model parameters, 258–9
model run controls
  independent observations, 259
  number of simulation runs, 266–7
  outcomes, 259
  simulation run length, 263–5, 266
  warm-up period see warm-up period
plant productivity, 257–8, 258
random numbers, 258
supply chain Sigma rating, 518, 518–20
system modeling
  automobile assembly plant, 4–5, 5
  bank transactions, 4–5, 5
  computer models, 6, 9–10, 10
data collection, 43–4, 44
definition, 2–3, 3, 12
DES, 10–11, 11
economy, attainability, and usefulness, 5, 5
entities, 2–3
graphical models, 6–7, 7
inputs, 2–4
logical relationships, 2–3
mathematical models, 6, 8, 8–9
model logic, 44, 44
outputs, 2–4
physical models, 5–7, 6
process controls, 2–4
statistics, 45, 45
structural elements, 42, 42–3, 43
system layout, 43

T
Tabu search approach, 427
titanium metal products (TMP), 358, 359, 361

Tool Bars
Assistant toolbar, 92, 92–3
Display Edit toolbar
aligning elements, 98–9
Fill Color button, 97
Font button, 97
Font Color button, 97
grid configuration, 98
layers and drawings, 98
Line Color button, 97
model animation display, 96, 96
reference point, 98
Element toolbar
Copy Element Display button, 91
Defined Selection, 90–91
Force Breakdown button, 91
Force Repair button, 92
show/hide element selector button, 89, 89
standard/customized commands, 99–100, 100
Model toolbar, 92, 92
Reporting toolbar, 95, 95–6
Run toolbar, 93, 93–5
standard tool bar, 86, 86–7
Views toolbar, 87, 87–9
total productive maintenance (TPM), 453, 475
triangular distribution, 193, 196, 197
Turing test, 319

U
uniform distribution, 187, 188
user-defined distributions, 231–2

V
value stream mapping (VSM), 451, 454–7, 456, 458
variable data, 204–5
variance reduction technique (VRT), 269–70
vehicle search method, 151
Views toolbar, 87, 87–9

W
warm-up period
eratic model response, 260
graphical method, 260–261, 262
moving average, 260–261
observations, 260
plant simulation, 260
units produced per hour, 262–3, 263
Weibull distribution, 193, 195
WITNESS editor
features, 103–4
manipulation, 105
Rules and Actions, 103, 104
WITNESS elements
Assistant toolbar, 92, 92–3
buffers/queues, 109
DES
attributes, 71, 72
buffers, 70–72, 71
carriers, 70, 71, 72
conveyors, 70, 71, 73
fluids, 70, 71, 73
labor, 71, 74
machines, 71, 71, 74–5
parts, 70, 71, 75
paths, 70, 71, 75
pipes, 70, 71, 75
processors, 71, 71, 75
sections, 71, 75
stations, 71, 76
tanks, 71, 71, 76
tracks, 70, 71, 76
WITNESS elements *(Continued)*

- vehicles, 70, 71, 76–7
- dialog box, 100–102, 101
- Display Edit toolbar
  - aligning elements, 98–9
  - Fill Color button, 97
  - Font button, 97
  - Font Color button, 97
  - grid configuration, 98
  - layers and drawings, 98
- Line Color button, 97
- model animation display, 96, 96
- reference point, 98
- drop-down menus, 85, 85–6
- Element toolbar
  - Copy Element Display button, 91
  - Defined Selection, 90–91
  - Force Breakdown button, 91
  - Force Repair button, 92
  - show/hide element selector button, 89, 89
- help system, 108–9, 108
- layers, 103
- machines/activities, 109
- Model toolbar, 92, 92
- parts/entities flow, 109
- Reporting toolbar, 95, 95–6
- Run toolbar, 93, 93–5
- standard/customized commands, 99–100, 100
- standard tool bar, 86, 86–7
- Views toolbar, 87, 87–9
- windows
  - Analog Clock, 107, 107
  - copying, cutting, and pasting, 107
  - digital time, 107, 107
  - Interact Box, 106–7, 106
  - options, 105–6, 105
  - physical screen, 103
  - virtual screen, 103
- WITNESS editor
  - features, 103–4
  - manipulation, 105
  - Rules and Actions, 103, 104
- WITNESS environment, 83–4, 84

WITNESS model

- data collection, 203
- downstream and upstream tracks, 166, 167
- features, 35
- input modeling, 226–7
  - continuous distribution, 231–3
  - databases with, 233–4
  - discrete distribution, 231
  - incorporating collected data, 229–30
  - normal distribution, 230–231
  - RNG, 227–9, 228
- intangible objects, 36
- manufacturing process see manufacturing process
- MHS, 150–151
- oil tankers
  - Buffer Berths, 142–3, 142
  - harbor traffic, 142, 142
  - quiescent and storming, 142–3
  - requirements, 141, 142
  - ShipType Attribute, 142–3
- paint process, 375, 377
- pipeline facility see pipeline facility
- service process see service process
- simulation products, 35
- tangible objects, 36
- WITNESS code, 141

WITNESS modules

- costing and revenue, 299–300
- Documentor, 301
- Optimizer, 301–2
- outputs and charts, 297–8, 297–8
- Presentation Manager, 300–301
- Scenario Manager, 301
- WITNESS XA, 298–9

WITNESS Optimizer model

- benefits, 442–3
- control screen, 440, 441
- examples, 443
- experimenting techniques, 441–2
- KPIs, 442
- model parameters, 442
- output results, 442, 442
- TH and WIP, 443–7
- work search method, 151, 152