34205 99 601-624 idx r4 mj.ps 10/4/06 5:44 PM Page 601

Index

Abbreviations, 595–596
Accelerated Life Testing (ALT), 500
Access dimension in quality, 102
Accuracy in measurement systems analysis, 306–307
Active listening, 149–150
Actual Factor Value in full factorial designs, 407
Advanced process control (APC), 564–565
Aesthetics dimension in quality, 101
After-tax profits
  calculating, 23–24
  in long term variation costs, 34
  in tightened specifications costs, 33
AIAG (Automotive Industry Action Group) scale, 265
Alarm and recording strategy, 563
Algorithm to Solve an Inventive Problem (ARIZ), 217–218
Aliasing in fractional factorial design, 413–416
Alkaline battery failures, 498
AlliedSignal Corporation, 5–6
ALT (Accelerated Life Testing), 500
Alternative approaches to robust design, 438–443
Alternative hypotheses, 344–346. *See also* Hypothesis testing
Altshuller, Genrich, 19–20, 214–215. *See also* TRIZ (Theory of Inventive Problem Solving) tool
Analysis of Variance (ANOVA)
  for mean comparisons
    from more than two samples, 370, 374
    one-way, 375–380
  for measurement system studies, 315
  for mixture experiments, 457–458
  for regression analysis, 387
Analytical data analysis, 343
Analytical Physics activity, 489
Analyze Factorial Design option, 401–403
Analyze phase in DMAIC, 8
Analyzing survey results, 179–181
Anderson-Darling statistic, 345–346
ANOVA. *See* Analysis of Variance (ANOVA)
APC (Advanced process control), 564–565
Apparent or Conventional Solution level in TRIZ, 215
ARIZ (Algorithm to Solve an Inventive Problem), 217–218
As-Is/Can-Be Process Maps, 243–244
Assume equal variances option, 360, 369
Assumptions in Process Capability Analysis, 336
Attribute data
  in DFMEA, 260
  Process Capability Analysis for, 339–340
  in statistics, 275–276
Attribute Sigma Calculator, 339–340
Augmented simplex centroid design, 456

34205 99 601-624 idx r4 mj.ps 10/4/06 5:44 PM Page 602

Automation evolutionary pattern in TRIZ, 216–217
Automotive Industry Action Group (AIAG) scale, 265
Average moving range, 335
Average performance in robust design, 430, 434–436
Axial points
in mixture designs, 450–451, 453
in response surface designs, 424–428

Bardeen, John, 14
Barrentine, Larry B., 310
Baseline, 28–30
Basic statistics, 275–278
Bathtub curves, 494–495
constant failure rates in, 496–498
decreasing failure rates in, 495–496
distributions for, 507–508
increasing failure rates in, 498–499, 510
for PDF, 506
Benefits received in product value, 99
Berry, Leonard L., 102
Best distribution fit
with Crystal Ball, 525, 527–529
with Minitab, 523–527
Best products, 274–275
BetaMax format vs. VHS, 4
Bias in measurement systems, 306–307
Big block process maps, 238–239
Blackbelt projects, 42–43
Blackbelts
in schedule development, 70, 73
selecting, 74
Borror, C. M., 439
Bossidy, Larry, 5
Box-Behnken designs
in response surface design, 426
in robust design, 439
Boxplots, 287–292
Brattain, Walter, 14
Broadcast programming, 14
Bullet-point interview objectives, 136–137
Burn-in, 496
Business case for DFSS, 11
dynamic markets, 15–18
product life cycle, 11–15
role of DFSS, 18–20
Business plans
developing, 75–77
Executive Summary section in, 78
financial plan, 79
Management and Organization section in, 79
Marketing Plan and Competitive Analysis section in, 78
Operating Plan section in, 78–79
reviewing, 75

Cameras, evolution of, 217
Can-Be Process Maps, 243–244
Cannibalization, product, 103, 105
Categorical data, 275–276
Cause and Effects (C&E) Matrix, 247
developing, 248–257
link from Process Variables Maps, 241, 243
vs. QFD3, 247–248
working with, 253
CDF (Cumulative Distribution Function), 506
CDOC (Concept, Design, Optimize, and Capability) implementation, 8–9
Censoring in reliability tests, 509
Center-cutting approach, 274–275
Center point runs, 420
Centering data
for multiple regression analysis, 391
in Process Capability Analysis, 327–328
Central Composite Designs
in response surface designs, 424–426
in robust design, 439
Centroid designs
augmented, 454, 456
with axial points, 453
constraints in, 463–464
for three components, 447–448
Chart defects tables, 294
Charters, project, 42–46
Chi Square statistical analysis, 276
Closed-ended questions, 141
Coded Factor Value in full factorial designs, 407
Coefficients
correlation, 383–384
for Crystal Ball, 481
in regression analysis, 384–385
for three-response optimization, 476

34205 99 601-624 idx r4 mj.ps 10/4/06 5:44 PM Page 603

Collection weaknesses in Process Variables Maps, 241
Commercialization delay costs, 25–26
Commercialization pipeline, 48
Common cause variation, 271–272
Communication dimension in quality, 102
Comparisons
  means
    to medians, 297–298
    more than two samples, 370–374
    one-way ANOVA, 375–380
    paired, 363–367
    t-tests for, 360–363
    to target values, 348–354
    two samples, 355–363
  medians
    Kruskal-Wallis test, 380–381
    Mann-Whitney test, 363–364
    to means, 297–298
    Wilcoxon Signed Rank test, 354–355
  standard deviation, 298
    more than two samples, 370–374
    two samples, 355–359
  variances
    three variances, 373–375
    two variances, 360–361
Competence dimension in quality, 102
Competitor analysis
  in Market Perceived Quality Profile, 122
  in market segmentation, 89–90
Competitors category for interview questions, 142
Components
  in mixture designs, 449–450
  of variation plots, 316
Composite desirability for Response Optimizer, 472–473
Concept, Design, Optimize, and Capability (CDOC) implementation, 8–9
Concept Development, 129
  advantages, 131, 133
  applications, 131–132
  process, 129–131
Concept Development tools, 133
Concept phase
  in Design for Reliability, 487
  in FMEA, 504
Concept Generation phase in Ideation process, 185, 188
Concept Selection Matrix
  in Pugh concept selection, 190–192
  rankings in, 192–194
Confidence intervals
  for difference between means, 369–370
  for means, 367–369
  for standard deviation, 369
Confirming products, 538–545
Conformance dimension in quality, 101
Confounding in fractional factorial design, 413–416
Constant failure rates in bathtub curve, 496–498
Constraints in mixture experiments, 459–462
Continuous data in statistics, 275–276
Contour plots
  for mixture experiments, 459–460
  for product scale-up, 554
  in response surface designs, 420, 423
  for three-response optimization, 475–476
Contradiction Matrix, 217–222, 225
Contradictions, technical. *See* TRIZ (Theory of Inventive Problem Solving) tool
Control charts
  creating, 285–287, 289
  of cycles between failures, 492, 494
Control plans, 555–556
  advanced process control in, 564
  alarm and recording strategy in, 563
  final documentation package, 568–569
  input variable shifts in, 557, 559–561
  out-of-control conditions in, 556–558
  link from Process Variables Maps, 241–242
  sampling plans for, 564
  standard operating procedures in, 568
  summary, 565–568
  time series analysis for, 557, 561–563
Cooper, Robert G., 20, 51
COPQ (Cost of Poor Quality), 28–30
Correlation
  analysis of, 381–384
  in Cause and Effects Matrix, 249, 253–254
  for control plans, 561–563
  in regression, 391
  in reliability modeling, 509
  for technical interaction, 201
  in TRIZ, 213–214
Correlation coefficient (r), 383–384

34205 99 601-624 idx r4 mj.ps 10/4/06 5:44 PM Page 604

Cost of Poor Quality (COPQ), 28–30
Costs
  commercialization delays, 25–26
  in financial value, 108–113
  long term variation, 33–35
    financial sensitivity analysis in, 35–39
    sigma levels in, 35–36
  not killing poor projects, 26–28
  process variation, 273–274
  tightened specifications, 32–33
  warranty, 512–513
Courtesy dimension in quality, 102
Cover letters for surveys, 175
C_p statistic
  adequacy of, 337, 339
  in short-term process capability analysis, 321–322
  in sigma level, 326–328
C_{pk} statistic, 328–331
Create Factorial Design option, 399–400
Create Mixture Design option, 447–452, 461–462
Credibility dimension in quality, 102
Critical input variables, 430
Critical output parameters, 465
Critical Parameter Management
  overview, 227–228
  scorecards in
    benefits, 232–233
    in DFM, 546–549
    information on, 230–231
    for minimizing product variation, 230, 232
    overview, 228–229
Critical path, 71–72
Cross correlation, 561–563
Crystal Ball program
  for best distribution fit, 525, 527–529
  for Monte Carlo simulation, 38, 115
  for optimal solutions, 479–485
  for variation optimization, 533–534
Cubic equations
  in mixture experiments, 447, 457
  for regression analysis, 385
Cumulative Distribution Function (CDF), 506
Customer dimension in quality, 102
Customer environment in Design for Reliability, 490
Customer interviews, 147
  active listening in, 149–150
  analysis of. *See* KJ Analysis tool
  debriefing, 151
  etiquette in, 150–151
  management of, 151–152
  open mindedness in, 150
  practice for, 152
  preparing for, 147–148
  team roles in, 148
Customer Interviews tool
  in concept development, 133
  for market segmentation, 55
  in Marketing Plan and Competitive Analysis section, 78
Customer needs and requirements
  in business case for DFSS, 19
  in market segmentation, 87–90
  optimizing variation to, 532–535
  in concept development, 131, 196–198
  in QFD, 197, 199–200
  reliability expectations, 491
Customer Selection Criteria characteristic, 140
Customer Selection Matrix tool
  in Interview Guides, 137–140
  in Marketing Plan and Competitive Analysis section, 78
Customer surveys, 578–579
Customers category for interview questions, 142

DART (Design Assessment Reliability Testing), 488, 502
Data analysis, 343
  confidence intervals, 367–370
  correlation analysis, 381–384
  general methods, 343–344
  hypothesis testing, 344–346
  mean comparisons
    more than two samples, 370–374
    one-way ANOVA, 375–380
    paired, 363–367
    t-tests for, 360–363
    to target values, 348–354
    two samples, 355–363
  median comparisons
    Kruskal-Wallis test, 380–381
    Mann-Whitney test, 363–364
    Wilcoxon Signed Rank test, 354–355

34205 99 601-624 idx r4 mj.ps 10/4/06 5:44 PM Page 605

regression analysis
multiple, 390–396
single input variable, 384–390
sample size calculations in, 346–348
standard deviations comparisons
more than two samples, 370–374
two samples, 355–359
tool summary, 381
variances comparisons
three variances, 373–375
two variances, 360–361
Data collection weaknesses, 241
Data mining
boxplots for, 287–292
dotplots for, 292–293
Death spiral, 109, 111–113
Debriefing customer interviews, 151
Decline stage in product life cycle, 11–12
Decreasing failure rates in bathtub curves, 495–496
Defects in Attribute Sigma Calculator process, 339
Defects per million opportunities (DPMO), 339–340
Defects per unit (DPU), 339–340
Define, Measure, Analyze, Improve, and Control (DMAIC)
characteristics, 6–7
overview, 7–9
Define phase in DMAIC, 7–8
DeForest, Lee, 13
Degrees of freedom for mean comparisons
one-way ANOVA, 378–379
two-sample t-test, 363
Delay costs, 25–26
Design Assessment Reliability Testing (DART), 488, 502
Design FMEA (DFMEA) tool, 259–260
conducting, 260–261
design controls in, 262–264
failures in
causes, 262–263
effects, 262
modes, 261–262
in concept development, 133
ratings in, 263–265
Risk Priority Number in, 266–267
Design for Manufacturability (DFM) assessment, 546–549
Design for Reliability (DfR), 487
distribution types in, 507–508
FMEA in, 502–505
Hazard Function in, 494–499
and Kano Model, 490–491
mathematical models in, 504–506
metrics for, 491–494
Minitab for, 508–512
reliability requirements in, 489–490
reliability tests in, 499–502
roadmap for, 487–489
warranty costs in, 512–514
Design For Six Sigma (DFSS)
defined, 3–4
history, 5–7
overview, 7–9
process, 580–582
vs. Operations Six Sigma, 6–7
tools, 9
Design Maturity Testing (DMT) plan, 488, 491, 502
Design of Experiment (DOE), 397
fractional factorial design. *See* Fractional factorial designs
full factorial designs. *See* Full factorial designs
response surface designs. *See* Response surface designs
selecting, 426
Desirability function, 468–473
Detection (DET) ratings in DFMEA, 264–265
Devices under test (DUT), 500
DFM (Design for Manufacturability) assessment, 546–549
DFMEA. *See* Design FMEA (DFMEA) tool
DfR. *See* Design for Reliability (DfR)
DFSS Tools Checklist, 232–233
Difference between means, 369–370
Dimensions of quality, 101–103
Direction of movement in QFD, 201
Direction of steepest ascent, 421, 423–424
Disciplined processes, 3
Discovery level in TRIZ, 215
Discrete data, 275–276
Discrimination in measurement systems, 305–306
Display Descriptive Statistics option, 297
Disruptive technologies, 11–12, 14–15
Distribution ID plots, 509
Distribution Overview Analysis, 524

34205 99 601-624 idx r4 mj.ps 10/4/06 5:44 PM Page 606

Distributions
bathtub curve modeling, 507–508
best distribution fit, 523–529
F
for mean comparisons, 379
for variance comparisons, 360–361
lognormal
for best distribution fit, 523
for wear-out mechanisms, 508
normal
for best distribution fit, 523
to estimate waste, 319–321
overview, 277–278
skewed, 282
t. *See* t-tests
Weibull
for best distribution fit, 523–524
for reliability, 509–510, 512
in statistical tolerancing, 529–530
DMAIC (Define, Measure, Analyze, Improve, and Control)
characteristics, 6–7
overview, 7–9
DMT (Design Maturity Testing) plan, 488, 491, 502
Documentation
final documentation package, 568–569
Interview Guides, 144–146
QFD critical information, 228
DOE (Design of Experiment)
fractional factorial design. *See* Fractional factorial designs
full factorial designs. *See* Full factorial designs
response surface designs. *See* Response surface designs
selecting, 426
Dotplots
data mining using, 292–293
overview, 279–281
DPMO (defects per million opportunities), 339–340
DPU (defects per unit), 339–340
Durability dimension in quality, 101
DUT (devices under test), 500
Dynamic markets, 15–18
Dynamic Model, 561
Dynamization evolutionary pattern in TRIZ, 216–217
Economic view of product life cycle, 17–18
Edison, Thomas, 13
Edison Effect, 13
Emerging trends, 19
Entitlement, 28–30
Environmental analysis in market segmentation, 89–90
Environmental stress screening (ESS)
for infant mortality failures, 496
purpose, 501
Environmental variables, 241
Errors
in hypothesis testing, 344
measurement. *See* Measurement systems analysis
ESS (environmental stress screening)
for infant mortality failures, 496
purpose, 501
Estimated variance in robust design, 443
Estimates of long-term variation, 325
Estimating wastes, 319–321
Etiquette in customer interviews, 150–151
Evolution in TRIZ, 216–217
Excel Solver tool, 475–478
Executive Summary section in business plans, 78
Expectations in Kano model, 17
Experimental runs, 397
Experiments, design. *See* Design of Experiment (DOE)
Exponential distribution, 523
Extreme Vertices Design, 461–462
Extreme Vertices Blend Design, 463

F-Tests
for mean comparisons, 379
for variance comparisons, 360–361
Factor regions for 3-component mixtures, 445–446
Failure Free Testing, 501
Failure Modes and Effects Analysis (FMEA) tool, 259
Cause and Effects Matrix for, 253
Design FMEA. *See* Design FMEA (DFMEA) tool
in Design for Reliability, 502–505
Market FMEA. *See* Market FMEA tool
in new product development, 259–260

34205 99 601-624 idx r4 mj.ps 10/4/06 5:44 PM Page 607

for post-mortem analysis, 580, 583
Process Manufacturing, 268–269
Product Design, 267–268
Failure rates
in bathtub curve
constant, 496–498
decreasing, 495–496
increasing, 498–499, 510
in Design for Reliability, 491–494
Failures in DFMEA
causes, 262–263
effects, 262
modes, 261–262
Fast Track projects
pipeline for, 48–49
in Stage-Gate systems, 62–66
Features dimension in quality, 101
Final Financial Value tool, 133
Final segmentation strategy, 87–90
Financial metrics, 21
commercialization delay costs, 25–26
killing poor project costs, 26–28
long term variation costs, 33–35
financial sensitivity analysis in, 35–39
sigma levels in, 35–36
poor quality costs, 28–30
sigma levels, 30–31
success, 22–25
tightened specifications costs, 32–33
Financial plan, 79
Financial results, projects linked to, 43–46
Financial sensitivity analysis, 35, 113
Monte Carlo simulation in, 38–39
single factor, 36–38, 116–117
Financial value, 107
fixed costs in, 108–113
market segmentation, 81–86
project returns, 113–120
project value, 107–108
First Order Dynamic Process, 561
First order equations in response surface designs, 423
Fitted line plot equations, 385, 387–388
Fitted models for three response variables, 474
Five-factor interaction effect, 412
Fixed costs in financial value, 108–113
Fleming, John Ambrose, 13
Flowdown process in QFD, 196, 202–208
FMEA. *See* Design FMEA (DFMEA) tool; Failure Modes and Effects Analysis (FMEA) tool; Market FMEA tool
Four-factor interaction effect, 414–416
Four in one ANOVA option, 377
Fractional factorial designs
available, 416
confounding in, 413–416
hierarchy of effects in, 416
in Minitab, 416–420
overview, 411–413
purpose, 426
Full factorial designs, 397–398
in Minitab
creating, 399–403
numerical output, 406–409
Pareto plots, 403–406
residual plots, 409–411
purpose, 426
randomization in, 398–399
Function Within Organization characteristic, 140
Functional product requirements, 197, 199–200
"Fuzzy front-end" of product development, 129

Gage R&R Study (Crossed) option, 313–314, 317
Galvin, Bob, 5
Gaps
in Market Perceived Quality Profile, 124–125
QFD process for, 195
in worst case analysis, 517–518
"Garbage in, garbage out"
in product commercialization, 41
with statistical analysis, 303
Garvin, David, 101
Gate 3 Review tool, 133
Gatekeeper, 51, 53
General Electric, Six Sigma at, 6
Geography characteristic, 140
Glossary, 585–593
Goal setting in Cost of Poor Quality, 28–30
Goodness-of-fit statistic, 345
Goodwill of customers, 514
Graphical analysis techniques, 278–279
boxplots, 287–292
control charts, 285–287, 289
dotplots, 279–281, 292–293
histogram plots, 279, 281–282

34205 99 601-624 idx r4 mj.ps 10/4/06 5:44 PM Page 608

Graphical analysis techniques (*continued*)
Normal Probability Plots, 283–286
Run Charts, 285, 288
scatterplots, 294–297
summary analysis, 282–283, 299
Greenbelt projects, 42
Greenbelts in schedule development
in schedule development, 70, 73
selecting, 74
Growth stage in product life cycle, 11–12

Half-fraction factorial design, 413
HALT (Highly Accelerated Life Testing), 489, 497, 500
HASS (Highly Accelerated Stress Screening), 489, 497, 500
HAST (Highly Accelerated Stress Testing), 501
Hazard Function, 494–495
constant failure rates in, 496–498
decreasing failure rates in, 495–496
distributions for, 507–508
increasing failure rates in, 498–499, 510
for PDF, 506
Hierarchy Location of Person characteristic, 140
Hierarchy of effects in fractional factorial design, 416
High-end market pricing, 83
High Factor Value in full factorial designs, 407
Highly Accelerated Life Testing (HALT), 489, 497, 500
Highly Accelerated Stress Screening (HASS), 489, 497, 500
Highly Accelerated Stress Testing (HAST), 501
Histogram plots, 279, 281–282
Historical failures for bathtub curve, 507
Hopper, project, 46–48
Humidity variable, 241
Hypothesis testing, 344–346
for correlation analysis, 383
for mean comparisons
confidence intervals for, 367–369
one-way ANOVA, 378
paired, 366–367
t-tests for, 362–363
to target values, 348–350, 353–354
two-sample, 355–357
for mean difference, 369
for median comparisons, 363–364
for regression analysis
multiple, 393
single input variable, 386, 390
sample size for, 347–348
for standard deviation comparisons, 355–357
for variances, 360–361

I-MR control charts, 357–358
Ideation process, 183
example, 186–188
problem statement in, 183
product concepts in, 185–186
solution generation in, 184–185
work area in, 183–184
Ideation tool, 78
Identify, Design, Optimize, and Validate (IDOV) implementation, 8–9
Images in KJ Analysis, 154–155
defining, 155–156
final selection, 160–161
in Marketing Plan and Competitive Analysis section, 78
in product development, 133
recording, 156–157
reducing, 157–160
scrubbing, 161–162
titling and positioning groups, 162–166
YO OH concept, 160–161
Importance parameter for Response Optimizer, 472
Improve phase in DMAIC, 8
Include center points in the model option, 420
Increasing failure rates in bathtub curve, 498–499, 510
Infant-mortality failures
in bathtub curve, 495
and Customer goodwill, 514
HASS for, 500
Infeasible manufacturing process mode, 98
Initial Financial Analysis tool, 55
Inner arrays in robust design, 431–435
Innovation levels in TRIZ, 215–216
Inputs and input variables
in Cause and Effects Matrix, 247–248, 252–253
in Crystal Ball, 481
in OptQuest, 483

34205 99 601-624 idx r4 mj.ps 10/4/06 5:44 PM Page 609

for out-of-control conditions, 556–558
for Process Variables Maps, 239–243
for three-response optimization, 476
Instability in product development process, 272–273
Instrument bias, 306
Interaction effects
five-factor, 412
four-factor, 414–416
in full factorial designs, 403–404, 406, 408
two-factor, 411, 414
Interaction plots
in full factorial designs, 404–406
in robust design, 436
Intercept in regression analysis, 384–385
Internal Rate of Return (IRR)
in financial plans, 79
in financial sensitivity analysis, 37, 113
in Monte Carlo simulation, 115
as success measure, 25
Interpretation in fractional factorial design, 413
Interview Guides, 135
bullet-point objectives, 136–137
Customer Selection Matrix in, 137–140
documenting, 144–146
finalizing, 144
Purpose Statements in, 135–136
for questions, 139
areas to be explored, 139, 141
developing, 141–143
Interviews, customer, 147
active listening in, 149–150
analysis of. *See* KJ Analysis tool
debriefing, 151
etiquette in, 150–151
management of, 151–152
open mindedness in, 150
practice for, 152
preparing for, 147–148
team roles in, 148
Introduction stage in product life cycle, 11–12
Invention Outside Technology level in TRIZ, 215
iPod, 4–5
IRR (Internal Rate of Return)
in financial plans, 79
in financial sensitivity analysis, 37, 113
in Monte Carlo simulation, 115
as success measure, 25
Jobs, Steve, 4
Kano Model, 15–16
economic view of product life cycle, 17–18
implications, 16–17
reliability expectations in, 490–491
Kawakita, Jiro, 153
Key assumptions in Process Capability Analysis, 336
Key inventive principles in TRIZ, 217–220, 222
Key Items area for voice translation, 168–169
Key Process Input Variables (KPIVs)
in APC, 565
in control plans, 555, 557, 559–561, 567
in DFM, 546–547
in DOE, 397
in FMEA, 259
in optimal solutions, 479–481
in PFMEA, 269
process maps for, 237
for Process Variables Maps, 239–241
in product scale-up, 552–553
in QFD, 205
Key Process Output Variables (KPOVs)
in APC, 565
in control plans, 555–556, 558, 567
in DFM, 547
in DOE, 397
for Process Variables Maps, 239, 241
in product scale-up, 552
Key requirements in Market Perceived Quality Profile, 122
Killing projects, costs of not, 26–28
KJ Analysis, 153
images, 154–155
defining, 155–156
final selection, 160–161
in Marketing Plan and Competitive Analysis section, 78
in concept development, 133
recording, 156–157
reducing, 157–160
scrubbing, 161–162
titling and positioning groups, 162–166
YO OH, 160–161
overview, 154

34205 99 601-624 idx r4 mj.ps 10/4/06 5:44 PM Page 610

KJ Analysis (*continued*)
in concept confirmation, 540
in concept development, 131
requirement, 164
in concept development, 133
conclusion, 172, 174
final selection round, 170–171
identifying, 172–173
in Marketing Plan and Competitive Analysis section, 78
reducing, 170
scrubbing, 171
theme, 164, 169–170
titling and positioning groups, 171
voice recording, 166–167
voice reduction, 166–167
voice translating, 167–169
in Stage-Gate systems, 55
Knowledge gaps, QFD process for, 195
KPIVs. *See* Key Process Input Variables (KPIVs)
KPOVs. *See* Key Process Output Variables (KPOVs)
Kruskal-Wallis Test, 380–381

"Ladder of abstraction" in customer interviews, 149
Lapsed Customers, 139
Launch plans
product, 573–579
in Stage-Gate systems, 60–61
Law of Ideality in TRIZ, 216
LCLs (Lower Control Limits) for control charts, 286–287
Least squares in regression analysis, 385
Level of variation in performance, 325–326
Levels of innovation in TRIZ, 215–216
Levene's Test, 360–361
Lidstone, John, 91
Life cycles, product
in business case for DFSS, 11–15
economic view of, 17–18
vacuum tube example, 13–15
Life hazards in Design for Reliability, 487
Linear relationships, correlation analysis for, 381–384
Linearity problems in measurement systems, 318
Linking
customer needs to product development, 196–198
Process Variables Maps to downstream DFSS tools, 241, 243
projects
to financial results, 43–46
to strategy, 41–42
Listening, active, 149–150
Lognormal distributions
for best distribution fit, 523
for wear-out mechanisms, 508
Long-term measurement system assessments, 318
Long-term process capability analysis, 322–325, 331–332
Long-term reliability, 490
Long term variation
costs, 33–35
financial sensitivity analysis in, 35–39
sigma levels in, 35–36
statistical tools for, 274–275
standard deviation, 319–320
Low-end market pricing, 83
Low Factor Value in full factorial designs, 407
Lower Control Limits (LCLs) for control charts, 286–287
Lower Specification Limit (LSL) values
in C_p, 327
in C_{pk}, 328, 330–331
in long-term process capability analysis, 322–324
in measurement system error, 305
in short-term process capability analysis, 321–322
in sigma levels, 30–32

Maclennan, Janice, 91
Main effects plots, 434–437
Management and Organization section in business plans, 79
Mann-Whitney test, 363–364
Manufacturing processes in QFD
identifying, 205
in Stage-Gate systems, 58–59
Maps
Process Variables Maps, 237–238
big block process maps, 238–239
input variables for, 239–243
output variables for, 239
product positioning, 127–128
value chain, 103–106

34205 99 601-624 idx r4 mj.ps 10/4/06 5:44 PM Page 611

Market analysis in Stage-Gate systems, 55
Market FMEA tool, 96, 259
  developing, 96–98
  in Marketing Plan and Competitive Analysis section, 78
  results, 98
  in Stage-Gate systems, 55
Market opportunities, 91
  Market FMEA, 96–98
  SWOT analysis. *See* SWOT Analysis tool
Market Perceived Quality Profile tool, 105, 121–123
  competitive position and market share analysis in, 122
  gap in, 124–125
  key requirements in, 122
  in Marketing Plan and Competitive Analysis section, 78
  output interpretation in, 124–126
  price and quality sensitivity in, 122
  in production scale-up, 540
Market segmentation, 81
  customer interviews for, 55
  financial value of, 81–86
  ratings by, 93–95
  strategy for, 86–90
  value chain mapping in, 105–106
Market Segmentation tool, 78
Market share analysis, 122
Marketing Plan and Competitive Analysis section in business plans, 78
Mathematical models in reliability, 504–506
Maturity stage in product life cycle, 11–12
Mean Cycles Between Failure (MCBF), 492, 494
Mean shift variation, 336
Mean square of residuals (MS) error, 385
Mean Squared Deviation (MSD), 430
Mean squares for mean comparisons, 378
Mean Time Between Failures (MTBF), 492, 494
Means
  comparing
    to medians, 297–298
    more than two samples, 370–374
    one-way ANOVA, 375–380
    paired, 363–367
    t-tests for, 360–363
    to target values, 348–354
    two samples, 355–363
  confidence intervals for, 367–369
  for control charts, 287
  difference between, 369–370
  for normal distributions, 277–278
Measure phase in DMAIC, 8
Measurement System Assessment, 253
Measurement systems analysis, 303
  accuracy in, 306–307
  discrimination in, 305–306
  errors in, 303–305
  long-term, 318
  precision in, 307–308
  in Process Capability Analysis, 337, 339
  samples in, 311
  studies in, 312–318
  variation quantification in, 309–311
Medians
  in boxplots, 290
  comparing
    Kruskal-Wallis test, 380–381
    Mann-Whitney test, 363–364
    to means, 297–298
    Wilcoxon Signed Rank test, 354–355
  confidence intervals for, 367
  for normal distributions, 278
Metrics
  financial. *See* Financial metrics
  for reliability, 491–494
Mid-range market pricing, 83
Milestones, 70–71
Minitab program, 278
  best distribution fit, 523–527
  boxplots, 287–292
  confidence intervals
    means, 367–369
    standard deviation, 369
  control charts, 285–287, 289
  control plans, 561–562
  correlation analysis, 383–384
  descriptive statistics, 298–300
  dotplots, 279–281, 292–293
  fractional factorial design, 414–420
  full factorial designs
    creating, 399–403
    numerical output, 406–409
    Pareto plots, 403–406
    residual plots, 409–411
  histogram plots, 279, 281–282

34205 99 601-624 idx r4 mj.ps 10/4/06 5:44 PM Page 612

Minitab program (*continued*)
hypothesis tests, 346
long-term process capability analysis, 322–324
mean comparisons
one-way ANOVA, 378–380
paired, 364–367
sample size, 356
to target values, 349–350
two-sample, 360–363
measurement system studies, 312–318
medians
comparing, 363–364
testing, 354–355
mixture designs
analyzing, 451–454
creating, 447–451
multiple response optimization process, 466–473, 475
Normal Probability Plots, 283–286
out-of-control conditions, 556
Process Capability Analysis, 333–337
product scale-up, 553–554
regression analysis
multiple, 391–396
single variable, 385
reliability, 508–512
robust design, 434, 439, 441–443
Run Charts, 285, 288
sample size, 347–348
scatterplots, 294–297
standard deviation
comparisons, 356
confidence intervals, 369
variance comparisons
three variances, 373–375
two variances, 360–361
Mistake proofing opportunities, 568
Mixture experiments, 445
constraints in, 459–462
mixture designs, 447
analyzing, 451–454
choosing, 462–464
in Minitab, 447–451
mixture equations, 445–447
response surface study for, 454–462
Monitoring inputs and outputs for out-of-control conditions, 556–558
Monte Carlo Risk Analysis tool, 133
Monte Carlo simulation, 113, 117–120
for best distribution fit, 524
in financial sensitivity analysis, 38–39
in optimal solutions, 477–485
in statistical tolerancing, 529–532, 535
Montgomery, D. C., 439
Mood's median test, 380
Motorola, Six Sigma at, 5–6
MS (mean square of residuals) error, 385
MSD (Mean Squared Deviation), 430
MTBF (Mean Time Between Failures), 492, 494
Multi-State Picking Method, 157–158, 166
Multiple regression analysis, 390–396
Multiple response optimization process, 466
Minitab for, 475
reduced model for, 466–467
Response Optimizer for, 467–468
composite desirability for, 472–473
desirability function, 468–472
setup for, 468, 470
Multivalued responses in customer interviews, 150
Murphy's Analysis, 580
Myers, R. H., 439
Mystery shoppers, 579

Net Present Value (NPV)
in commercialization delay costs, 26
in Cost of Poor Quality, 29–30
in financial plans, 79
in financial sensitivity analysis, 36–38, 113
in long term variation costs, 34–35
in Monte Carlo simulation, 38, 115
in pipeline management, 46–48
as success measure, 24–25
in tightened specifications costs, 32–33
New product concept finalized stage, 55–57
New product design stage, 58–59
Nominal gap values, 517–518
Non-normal data, statistical analysis tools for, 277
Non-Value-Added step, 244
Non-Value-Added but Necessary step, 244
Nonparametric median tests, 354
Normal distributions
for best distribution fit, 523
overview, 277–278
for waste estimates, 319–321

34205 99 601-624 idx r4 mj.ps 10/4/06 5:44 PM Page 613

Normal probability plots
creating, 283–286
in hypothesis testing, 345
Normality
in mean comparisons, 351, 370–372
in standard deviation comparisons, 357, 359, 370–372
statistical analysis tools for, 277
NPV. *See* Net Present Value (NPV)
Null hypotheses, 344–346. *See also* Hypothesis testing
Numerical descriptive statistics, 297–300

Objectives section in Interview Guides, 145–146
Observer role for customer interviews, 148
Occur (OCC) ratings in DFMEA, 264
1-sample t-tests, 351–354
1-sample Wilcoxon tests, 354–355
One-sided 2-sample t-tests, 362
One-sided significance tests, 350
One-way ANOVA
for mean comparisons, 375–380
for regression analysis, 387
Open-ended questions, 141
Open mindedness in customer interviews, 150
Operating Plan section in business plans, 78–79
Operations Six Sigma, 6–7
Operator bias, 306
Operator-sample interaction, 316, 318
Opportunities, 91
Market FMEA, 96–98
in Stage-Gate systems, 53–55
SWOT analysis. *See* SWOT Analysis tool
Optimal solutions, 465–466
in control plans, 565
Monte Carlo simulation in, 477–485
multiple response optimization process, 466–473
three-response optimization, 473–478
Optimize phase
in Design for Reliability, 488
in FMEA, 504
Optimizing variation, 532–535
OptQuest program
for variation optimization, 533–534
for variation requirements, 480–484
Out-of-control conditions, 556–558
Outer arrays in robust design, 431–435
Outputs and output variables
in Cause and Effects Matrix, 247–251
in Market Perceived Quality Profile, 124–126
for out-of-control conditions, 556–558
for Process Variables Maps, 239
Overlay Contour Plots, 554

P/T ratio (Precision to Tolerance Ratio), 309–310
p-values
for correlation analysis, 383–384
in hypothesis tests, 345–346
for means
one-way ANOVA, 378
paired comparisons, 366
testing, 354
two-sample t-test, 363
for medians, 355
for regression analysis, 386–387
multiple, 393–395
single input variable, 390
in response surface designs, 420
Paired mean comparisons, 363–367
Parameter management. *See* Critical Parameter Management
Pareto analysis for TRIZ, 222
Pareto plots
for dotplots, 292, 294
in fractional factorial design, 418
in full factorial designs, 403–406
in robust design, 436, 438
Partnering relationships, 87–88
Patent analysis in TRIZ, 216
Path of steepest ascent, 421, 423–424
PDF (Probability Density Function), 504–506
Perceived Quality dimension, 101
Percent Repeatability and Reproducibility (% R&R) value, 310–311, 313–314, 316–317
Performance
Process Capability Analysis for, 325–326
in quality, 101
in robust design, 429–431, 434–436
PFMEA (Process FMEA), 259–260, 268–269
Photography, camera evolution in, 217
Physical reactions in customer interviews, 148
PID (Proportional-Integral-Derivative) control calculations, 564
Pipeline management, 46–50

34205 99 601-624 idx r4 mj.ps 10/4/06 5:44 PM Page 614

Plans
business
developing, 75–77
Executive Summary section in, 78
financial plan, 79
Management and Organization section in, 79
Marketing Plan and Competitive Analysis section in, 78
Operating Plan section in, 78–79
reviewing, 75
control, 555–556
advanced process control in, 564
alarm and recording strategy in, 563
final documentation package, 568–569
input variable shifts in, 557, 559–561
out-of-control conditions in, 556–558
for Process Variables Maps, 241–242
sampling plans for, 564
standard operating procedures in, 568
summary, 565–568
time series analysis for, 557, 561–563
Pooled standard deviation
for mean comparisons, 362
in Process Capability Analysis, 336
Portfolio scorecards, 48, 50
Position in Value Chain characteristic, 140
Positioning
in KJ Analysis
image groups, 162–166
requirements, 171
product, 121
maps, 127–128
Market Perceived Quality Profile, 121–126
Post-mortem analysis, 579–583
Power of hypothesis tests, 344
P_p statistic, 331–332
P_{pk} statistic, 331–332
Practical data analysis, 343
Precision in measurement systems analysis, 307–308
Precision to Tolerance Ratio (P/T ratio), 309–310
Predictive process control approach, 562
Price
in financial sensitivity analysis, 38
in Market Perceived Quality Profile, 122
in segmentation, 81–86
Probability Density Function (PDF), 504–506
Probing in customer interviews, 149–150
Problem statement in Ideation process, 183
Process, 3
in QFD, 205
sigma levels of, 30–31
Process Capability Analysis, 319
for attribute data, 339–340
capability index interpretations in, 332–333
Cause and Effects Matrix for, 253
C_{pk} statistic for, 328–331
importance of, 340–341
long-term, 322–325, 331–332
measurement system adequacy in, 337, 339
Minitab tools for, 333–337
normal distribution curves for waste estimates, 319–321
short-term, 321–322
for Six Sigma performance, 325–326
Process Control Plans, 253
Process Design FMEA, 259
Process design in Stage-Gate systems, 58, 60
Process Design Package, 549–554
Process FMEA (PFMEA), 259–260, 268–269
Process Hazards Analysis reviews, 551
Process maps, 237
As-Is/Can-Be Process Maps, 243–244
final thoughts, 245
Process Variables Maps. *See* Process Variables Maps
Process optimization in control plans, 565
Process stability in product development, 272–273
Process variables in mixture designs, 450
Process Variables Maps, 237–238
big block process maps, 238–239
input variables for, 239–243
output variables for, 239
Product cannibalization, 103, 105
Product Design FMEA, 267–268
Product Development
in Design for Reliability, 488
in FMEA, 504
linking customer needs to, 196–198
measurement error impact in, 304–305
in product life cycle, 11–12
risk, 4–5
Product development cycle time, 195–197
Product Positioning Maps tool, 78

34205 99 601-624 idx r4 mj.ps 10/4/06 5:44 PM Page 615

Product scale-up, 537
Design for Manufacturability assessment, 546–549
Process Design Package, 549–554
product confirmation in, 538–545
Product value, 99
quality in, 100–103
tools for, 105
value chain mapping in, 103–106
value concept, 99–100
Products, 3
confirming, 538–545
developing. *See* Development
in Ideation process, 185–186
life cycle
in business case for DFSS, 11–15
economic view of, 17–18
vacuum tube example, 13–15
positioning, 121
maps, 127–128
Market Perceived Quality Profile, 121–126
in QFD, 197, 199–201
in Stage-Gate systems, 55, 60–61
variation in. *See* Variation
Profit, after-tax
calculating, 23–24
in long term variation costs, 34
in tightened specifications costs, 33
Project Construction phase, 552
Project cycle time, 195–197
Project Detailed Engineering and Procurement phase, 552
Project management, 67
customer interviews, 151–152
roadmaps, 67–69
schedules
developing, 69–73
managing, 73–74
overview, 74
Project Plans, 549, 551
Project returns
financial sensitivity analysis, 113, 116–117
Monte Carlo simulation, 113, 117–120
Project Scope Definition phase, 551
Project value, 107–108
Projects
charter, 42–46
death spiral, 109, 111–113
hopper, 46–48
killing, 26–28
launch plans, 573–579
linking
to financial results, 43–46
to strategy, 41–42
loser, 41
post-mortem analysis, 579–583
risk
development, 4–5
quantifying, 25
Proportional-Integral-Derivative (PID) control calculations, 564
Pugh, Stuart, 190
Pugh Concept Selection tool, 189
in concept development, 133
example, 194
in FMEA, 504
follow-up, 194
in Marketing Plan and Competitive Analysis section, 78
process, 190–194
in Stage-Gate systems, 55
Purpose Statements in Interview Guides, 135–136, 145

QFD (Quality Function Deployment) process, 195
critical information documentation, 228
in DFM, 546
executing, 197–202
flowdown in, 202–208
parameters from. *See* Critical Parameter Management
roof, 213–214
summary, 211–212
across value chain, 205, 209–211
value of, 195–198
QFD1 tool
in concept development, 133
in Operating Plan section, 78
overview, 202–203
in Stage-Gate systems, 55
QFD1.5 tool
in concept development, 133
in Operating Plan section, 78
overview, 203–204

34205 99 601-624 idx r4 mj.ps 10/4/06 5:44 PM Page 616

QFD2 tool
in Operating Plan section, 79
overview, 204–206
QFD2.5 tool
in Operating Plan section, 79
overview, 205, 207
QFD3 tool
vs. Cause and Effects Matrix, 247–248, 253
in Operating Plan section, 79
overview, 205, 208
for Process Variables Maps, 241
Quadratic equations, 385, 389–390
Quadratic model output, 456
Quality
dimensions of, 101–103
in Market Perceived Quality Profile, 122
in product value, 100–103
for services, 102–103
Quality Function Deployment. *See* QFD (Quality Function Deployment) process
Quality system failures in bathtub curve, 495
Quantifying
measurement system variation, 309–311
performance in robust design, 429–431
Questions for Interview Guides, 139
areas to be explored, 139, 141
developing, 141–143

R Chart by Operator graphs, 316
R-Sq value, 387
RACI (Resource, Accountable, Consulted, and Informed) approach, 71
Randomization in full factorial designs, 398–399
Ranges for normal distributions, 278
Rankings
in Concept Selection Matrix, 192–194
in QFD, 197
competing products, 197
functional product requirements, 200
Wilcoxon Signed Rank tests, 354–355
Ratings
in Cause and Effects Matrix, 249, 255
in DFMEA, 263–265
by market segment, 93–95
Reaction plans, 568
Recording
in control plans, 563
KJ images, 156–157
voices, 166–167
Reduced models, 466–467
Reducing
in KJ Analysis
images, 157–160
requirements, 170
voices, 164, 166–167
Reduction targets, variation, 274
Regression analysis, 276
multiple, 390–396
single input variable, 384–390
Regulatory category for interview selection, 142
Relationship between variables
regression analysis for, 276
multiple, 390–396
single input variable, 384–390
scatterplots for, 294–297
Relationship characteristic, 140
Relative Importance Surveys, 175
analyzing, 179–181
in concept development, 131, 133
designing and conducting, 175–178
in Marketing Plan and Competitive Analysis section, 78
in production scale-up, 540
for requirements identification, 181
Relative value, 100
Reliability, 101–102. *See also* Design for Reliability (DfR)
Reliability Monitoring Program, 489
Reliability Verification activity, 489
Repeatability (Rpt) in measurement systems analysis, 307–308, 315
Replacement of Human evolutionary pattern in TRIZ, 216–217
Reproducibility (Rpd) in measurement systems analysis, 307–308, 315
Requirements
KJ Analysis, 164
in concept development, 133
conclusion, 172, 174
final selection round, 170–171
identifying, 172–173
in Marketing Plan and Competitive Analysis section, 78
reducing, 170
scrubbing, 171

34205 99 601-624 idx r4 mj.ps 10/4/06 5:44 PM Page 617

themes, 164, 169–170
titling and positioning groups, 171
voice recording, 166–167
voice reduction, 166–167
voice translating, 167–169
in QFD, 197, 199–201
Relative Importance Surveys for, 181
Requirements Management system. *See* Critical Parameter Management
Residual plots
in fractional factorial design, 418–419
in full factorial designs, 409–411
for mean comparisons, 377
for mixture experiments, 452, 455, 457
for regression analysis
multiple, 394–395
single input variable, 387–388, 390
in response surface designs, 420, 422
Residuals checks for mean comparisons, 379–380
Resource, Accountable, Consulted, and Informed (RACI) approach, 71
Resource assignment in schedule development, 71
Response Optimizer option, 467–468
composite desirability for, 472–473
desirability function, 468–472
setup for, 468, 470
Response surface designs, 420–422
axial points in, 424–428
for mixture experiments, 454–462
path of steepest ascent in, 421, 423–424
purpose, 426
in robust design, 439–443
Response variables in full factorial designs, 397
Responsiveness dimension in quality, 102
Rewards and recognition, 582
Risk
development, 4
BetaMax vs. VHS, 4
iPod, 4–5
minimizing, 5
quantifying, 25
Risk Priority Number (RPN), 266–267
Roadmap for Reliability, 487–489
Roadmaps, project, 67–69
Robust design, 429
alternative approaches to, 438–443
example, 434–438
quantifying performance in, 429–431
response surface techniques in, 439–443
Taguchi approach to, 431–434
variation analysis in, 436–438
Robust tests, 354
Roof, QFD, 213–214
Root Sum of Squares (RSS) analysis, 517, 519–521
RPN (Risk Priority Number), 266–267
Run Charts, 285, 288
Runs, experimental, 397

S-curves, spending, 27
Sales volume after launch, 573–579
Sample statistics, 277
Samples and sample size
for control plans, 564
in data analysis, 346–348
in mean comparisons, 349–350, 355–359
for measurement system studies, 311
in standard deviation comparisons, 355–359
Scatterplots, 294–297
for correlation analysis, 381–382
for regression analysis, 387–388
Schedules
developing, 69–70
critical paths in, 71–72
milestones in, 70–71
resource assigning in, 71
task definitions in, 70
managing, 73–74
Scorecards
in Critical Parameter Management
benefits, 232–233
in DFM, 546–549
information on, 230–231
for minimizing product variation, 230, 232
overview, 228–229
portfolio, 48, 50
Scoring guidelines in Stage-Gate systems, 53
Screening failures in bathtub curve, 495
Screening studies in fractional factorial design, 418
Scribe role for customer interviews, 148
Scrubbing
KJ Analysis images, 161–162
KJ Analysis requirements, 171
Security dimension in quality, 102

34205 99 601-624 idx r4 mj.ps 10/4/06 5:44 PM Page 618

Segmentation, market, 81
customer interviews for, 55
financial value of, 81–86
ratings by, 93–95
strategy for, 86–90
value chain mapping in, 105–106
Serviceability dimension in quality, 101
Services
defined, 3
quality characteristics for, 102–103
Severity (SEV) ratings in DFMEA, 264
Shifts in long-term process variation, 322–325
Shockley, William, 14
Short-term process capability analysis, 321–322
Short-term variation standard deviation, 319–320
Siadat, Barry, 6
Sigma levels
C_p index in, 326–328
in long term variation costs, 35–36
of processes, 30–31
Sigma shift in long-term process variation, 322–325
Significance levels in hypothesis tests, 348
Significance tests, 348–349
Simple histogram option, 279, 281
Simple Set of Numbers option, 312
Simplex centroid designs
augmented, 454, 456
with axial points, 453
constraints in, 463–464
for three components, 447–448
Simplex Design Plot option, 450, 462
Single factor financial sensitivity, 36–38, 116–117
Single input variable, regression analysis for, 384–390
Skewed distributions, 282
Slope coefficients, 384–385
Small Invention Inside Paradigm invention level in TRIZ, 215
Smith, Bill, 5
Solution generation in Ideation process, 184–185
Solver tool, 475–478
SOPs (standard operating procedures) in control plans, 568
Sorting Cause and Effects Matrix input variables, 253, 257
Special cause variation
in Process Capability Analysis, 336
in product development, 271–272
Special cubic equations, 447, 457
Specifications, tightened, 32–33
Spending S-curves, 27
SS (sum of squares), 378, 385, 387
SST (Step-Stress Testing), 500–502
Stability
in data comparisons, 350–351, 357–358, 370, 373–374
in product development process, 272–273
Stability of object composition in TRIZ example, 225
Stage-Gate systems, 20, 51
in business plans, 75–76
managing, 62–66
market analysis and product definition in, 55
monitoring points for, 46
new product concept finalized in, 55–57
new product design and supporting manufacturing process in, 58–59
opportunity assessment in, 53–55
product launch plan in, 60–61
structure in, 51–53
validate product and process design in, 58, 60
Standard deviations
comparing, 298
more than two samples, 370–374
two samples, 355–359
confidence intervals for, 369
for control charts, 287
in hypothesis tests, 348
long-term and short-term, 319–320
for normal distributions, 277–278
in OptQuest, 483–484
pooled, 336, 362
in Process Capability Analysis, 335–336
in stability, 350–351
in tolerance analysis, 521–522
Standard operating procedures (SOPs) in control plans, 568
Standard order in mixture designs, 450
Star points, 424–428
Start-up, product, 537
Statistical analysis tools, 271, 275–276
graphical analysis techniques. *See* Graphical analysis techniques

34205 99 601-624 idx r4 mj.ps 10/4/06 5:44 PM Page 619

measurement systems analysis. *See* Measurement systems analysis
for non-normal data, 277
for normality, 277
numerical descriptive statistics, 297–300
sample statistics for, 277
selecting, 276–277
for variation, 271–275
Statistical Process Control techniques, 269
Statistical tolerancing, 515
analysis, 521
best distribution fit
with Crystal Ball, 525, 527–529
with Minitab, 523–527
Monte Carlo Simulation in, 529–532, 535
optimizing variation in, 532–535
Root Sum of Squares analysis, 517, 519–521
variation levels in, 522
worst case analysis, 516–518
Steady State Model, 561
Steady-state portion of bathtub curve, 507
Steepest ascent, 421, 423–424
Step-Stress Testing (SST), 500–502
Straight line equations, 385, 387
Strategy
linking projects to, 41–42
for market segmentation, 86–90
Stress conditions
in Design Maturity Testing, 488
in Step Stress tests, 500
Structured methodology, 3, 20
Subgroup analysis, 335–336
Substantial Invention Inside Technology level in TRIZ, 215
Substitutes in product life cycle, 17–18
Success measures
after-tax profit, 23–24
Internal Rate of Return, 25
money, 22–23
Net Present Value, 24–25
Successes in post-mortem analysis, 582
Sum of squares (SS), 378, 385, 387
Supply-demand system in product life cycle, 17–18
Supporting manufacturing process in Stage-Gate systems, 58–59
"Surprised and delighted" attribute, 16
Surveys. *See* Relative Importance Surveys
Survival Function for reliability, 510
SWOT Analysis tool, 91
in Marketing Plan and Competitive Analysis section, 78
opportunities and threats, 92
ratings by market segment, 93–95
results of, 95–96
in Stage-Gate systems, 55
strengths and weaknesses, 92–93
System evolution in TRIZ, 216–217

t-tests
for mean comparisons
one-sample, 351–354
paired, 365–367
two-sample, 356, 360–363
Taguchi, Genichi, 431, 434
Taguchi approach to robust design, 431–434
"Taken for granted" attribute, 15–16
Tangibles dimension in quality, 102
Tape recorders in customer interviews, 148
Target ranges in QFD, 202
Target values, comparing means to, 348–354
Tasks in schedule development, 70
Team roles in customer interviews, 148
Teaming relationships in market segmentation, 87–88
Technical contradictions
description, 214
TRIZ for. *See* TRIZ (Theory of Inventive Problem Solving) tool
Technical interactions in QFD, 201
Technical support, 578
Technical system evolution in TRIZ, 216–217
Technology
in Customer Selection Matrix, 140
in market segmentation, 89–90
Technology category for interview questions, 142
Technology Platform Projects, 48
Terminology, glossary for, 585–593
Test for Equal Variances option, 374–375
Testimonials, 579
Tests, hypothesis. *See* Hypothesis testing
"The more the better" attribute, 16
Theme
for Requirements KJ, 169–170
for voice reduction, 164, 166

34205 99 601-624 idx r4 mj.ps 10/4/06 5:44 PM Page 620

Theory of Inventive Problem Solving. *See* TRIZ (Theory of Inventive Problem Solving) tool
Three-response optimization, 473–478
Tightened specifications, 32–33
Time Lagged Cross Correlation, 561
Time series analysis, 557, 561–563
Titling
  KJ Analysis image groups, 162–166
  KJ Analysis requirements, 171
Tolerance, statistical. *See* Statistical tolerancing
Total Sum of Squares value
  for mean comparisons, 378
  in Process Capability Analysis, 336
Trace plots, 459–460
Trade-off analyses, 214
Training, product, 578
Transactional customers, 87–88
Transforming Properties principle in TRIZ, 225
Transistors, 14–15
Transitioning from Macro to Micro Level using Energy Fields evolutionary pattern in TRIZ, 216–217
Translating voices, 167–169
TRIZ (Theory of Inventive Problem Solving) tool, 214–215
  in business case for DFSS, 19–20
  Contradiction Matrix in, 217–222, 225
  example, 223–225
  final thoughts, 225
  key inventive principles in, 217–220, 222
  Law of Ideality in, 216
  levels of innovation in, 215–216
  for QFD, 201
  technical system evolution in, 216–217
Two-factor interaction effects, 411, 414
2-level Fractional Factorial Design, 416–417, 426
2-sample t-tests, 356, 360–363
Two-sided confidence intervals, 367
Type I errors, 344, 346
Type II errors, 344
Type of Customer characteristic, 140

UCL (Upper Control Limits) for control charts, 286–287
Uncontrolled variables for Process Variables Maps, 241
Unit variable cost projections, 107, 109
Units in Attribute Sigma Calculator process, 339
Unstable product development processes, 272–273
Upper Control Limits (UCL) for control charts, 286–287
Upper Specification Limit (USL) values
  in C_p, 327
  in C_{pk}, 328, 330–331
  in long-term process capability analysis, 322–324
  in measurement system error, 305
  in short-term process capability analysis, 321–322
  in sigma levels, 30–32

Vacuum tubes, 13–15
Validating product in Stage-Gate systems, 58, 60
Value, product, 99
  quality in, 100–103
  tools for, 105
  value chain mapping in, 103–106
  value concept, 99–100
Value-Added step for As-Is Process Maps, 244
Value Chain Mapping tool, 78
Value chains
  mapping, 103–106
  QFDs across, 205, 209–211
Value Proposition Identification tool, 78
Variable cost projections, 107, 109
Variable relationships
  regression analysis for, 276
    multiple, 390–396
    single input variable, 384–390
  scatterplots for, 294–297
Variables
  in Cause and Effects Matrix, 247–253
  descriptive statistics for, 298–299
  for out-of-control conditions, 556–558
  Process Variables Maps, 237–238
    big block process maps, 238–239
    input variables, 239–243
    output variables, 239
Variances
  ANOVA. *See* Analysis of Variance (ANOVA)
  comparing
    three variances, 373–375
    two variances, 360–361

34205 99 601-624 idx r4 mj.ps 10/4/06 5:44 PM Page 621

in mixture experiments, 457–458
in robust design, 443
Variation
measurement. *See* Measurement systems analysis
optimization, 532–535
in OptQuest, 480–484, 533–534
performance, 325–326, 430–431
in product development, 271–275
in robust design, 430–431, 436–438
scorecards for, 230, 232
in statistical tolerancing, 522
worst case, 519
VCRs, BetaMax vs. VHS, 4
Verification phase
in Design for Reliability, 489
in FMEA, 504
Vertex points in mixture designs, 450
VHS format vs. BetaMax, 4
Voice of the Customer (VOC)
in Design for Reliability, 489–490
in post-mortem analysis, 580
in product confirmation, 540
for variation, 274
Voices in KJ Analysis, 154
recording, 166–167
reducing, 164, 166–167
theme for, 164, 166
translating, 167–169
Volume in financial sensitivity analysis, 38
Volume of Use characteristic, 140

Warranty costs, 512–514
Waste estimates, 319–321
Wear-out area in bathtub curve, 498–499, 507
Weibull distribution
for best distribution fit, 523–524
for reliability, 509–510, 512
in statistical tolerancing, 529–530
Weibull power law, 494–495
Weibull shape factor, 533–534
Weight parameter for desirability function, 471–472
Welch, Jack, 6
White, T. K., 310
Wilcoxon Signed Rank tests, 354–355
Within Group Sum of Squares value, 336
Work area in Ideation process, 183–184
Worst case analysis, 516–518
Worst case gap values, 517–518
Worst case variation, 519
"Wow" factor, 16

Xbar Chart by Operator graph, 318
Xbar values for control charts, 286–287

YO OH, 160–161

Zero Failure Testing, 501

34205 99 601-624 idx r4 mj.ps 10/4/06 5:44 PM Page 622