

Index

A

- Acoustic analysis, 226
- Acrobat (Adobe) 9 Pro Extended, 95
- AE BIM Manager, title, 355
- AGC BIM Guidelines for Contractors*, 278
- Aggregation, 57, 292
 - levels, 18
- Air flow simulations, 226
- AISC, 295–296
- Alquist Hospital Facilities' Seismic Safety Act of 1983, 432–433
- American Institute of Architects (AIA), 175
 - IPD guidelines publication, 357
- American Institute of Steel Construction (Steel Design Guide)*, 52–53
- American Society of Testing and Materials (ASTM) data, property set approximation, 58–59
- Analysis interfaces, integration (increase), 373–374
- Analysis/simulation applications, exchange capabilities, 227t
- Analysis/simulation software, 223–226
- Analysis types, integration (research), 378
- Analytic structural models, types, 104f
- ANSI-BOMA space area, derivation (example), 228f
- ANSYS CFS, usage, 551–552
- AP 225, 111
- AP 241, 111
- Application Program Interface (API), usage, 107
- Application Programming Interface (API), C# (usage), 405
- Applications, geometry exchanges, 101
- Application-to-application exchange, support, 101
- ArchiCAD, 68, 82–84, 374, 571
 - objects, display, 240f
 - parametric object support, 83
 - strengths/weaknesses, 84
- Architects
 - BIM adoption, 356
 - BIM usage, 193
- Architectural BIM design applications, 32–40
 - differences, 68–69
- Architectural design, construction (contrast), 194–195
- Architectural Desktop (ADT), 92–93
- Architectural drawings, orthographic projections (impact), 61
- Architectural Graphic Standards* (Ramsey/Sleeper), 54
- Architectural precast facade panels, design/detailing engineering (production lead time benchmark), 315f
- Architectural precast panel, parametric model, 52f
- Architectural services, 196
- Architecture, engineering, and construction (AEC), 17
 - activity, sectors (changes), 28
 - aecXML, 133
 - BIM, usage, 1
 - business model, 2–10
 - project team, conceptual diagram representation, 3f
 - revolution, 152–153
 - tools, 375
 - XML schemas, 133–134
- Architecture, engineering, and construction, facility management (AEC/FM), 9
- Architecture firms, workplace roles/activities (change), 366
- Army Corps of Engineers, 175
- Artificial intelligence, 381
- As-built changes, 6
 - Assembly operations, development, 37
- Asset management tools, 170–172
 - usage, 168
- Assigned action items, 141
- Associated data/rules, 17
- Associated General Contractors (AGC)
 - agcXML, 133–134
 - BIM implications, 301
- Associated geometries, automatic modification, 17–18
- Association of General Contractors (AGC), 175
- Attribute handling, 58–60
- AutoCAD
 - ARCHITECTURE, 53
 - AutoCAD-based applications, 92–94
 - MEP, 53
 - strengths, 93
 - 3D, usage, 37
 - weaknesses, 93–94
- Autodesk Collaborative Project Management, 144
- Autodesk Design Review, 95
- Autodesk Ecotect, 373
- Autodesk Navisworks Manage software, 316
- Autodesk QTO, 278
- Autodesk Seek, 249
- AutoDesSys form Z, 79
- Automated clash detections, examples, 531f
- Automated code-checking, 386
- Automated design review software, development, 362–363
- Automated manufacturing technologies, usage (increase), 319, 321
- Automated model verification tools, 358–359
- Automated quantity takeoff, 534f
- Automatic partial updates, 141

- AutoView, 147
- Aviva Stadium
 - aluminum panel frames/brackets, fabrication, 410
 - architectural form, 399–400
 - case study, 397
 - cladding design/optimization, 408–409
 - cladding fabrication/erection, 409–412
 - cladding façade
 - components, design-to-manufacturing process, 411f
 - final assembly, 412f
 - collaboration, 403
 - concept development, 399–402
 - construction process, 407
 - criteria, 400
 - daylight studies, series, 400f
 - design requirements, 399–402
 - divide and conquer strategy, implementation, 408
 - envelope, setup, 404f
 - envelope detailing, 406–412
 - erection, 406–412
 - evaluation/lessons, 412–414
 - fabrication, 406–412
 - final onsite assembly, 411–412
 - hierarchical structural layout, diagram, 402f
 - horseshoe truss construction process, 407f
 - Louver opening layout, 409f
 - panel/brackets, detailing, 410f
 - panelization pattern/opening layout, 408
 - parametric approach, technical implementation, 403–405
 - parametric design/collaboration, 402–403
 - participant companies, 399t
 - project overview, 398–399
 - rigging table, sketch, 412f
 - Robot Millenium structural model, input loading data, 406f
 - roof fabrication, 406–408
 - roof horseshoe truss, release, 407–408
 - structural analysis/feedback, 405
 - structural layout, 401–402
 - views, 401f
- B**
- Barcode format, usage, 486f
- Barcode identities, 486–487
- Barriers technology, 188–189
- Bartender software, recordation, 486
- Base objects, usage, 47, 49
- Base parts, 55
- Beck Group, digital modeling effort, 558
- Behavior, support (absence), 19
- Bentley Generative Components (GC) software, 402
- Bentley ProjectWise
 - Collaboration System, snapshot, 461f
 - Integration Server, 144
 - online Model/Document Management/Collaboration System, usage, 458
 - system, usage, 459
- Bentley structures, 225
- Bentley Systems, 80–82
 - additions, 81
 - strengths/weaknesses, 82
- Bidirectional editing, top-level drawing functionality support, 63
- Big boxes, 200
- BIM Applications Support Engineer title, 355
- BIM Specialist, title, 355
- BOCAD
 - fabrication, 406–407
 - macros, customization, 407
- Bonzai (FormZ), 67
- Bonzai3d, 205, 210–211
- Boolean operations
 - combination, 36
 - definition, 586
 - usage, 34f
- BooCamp (Windows), 77
- Boundary representation (B-rep), 585
- BPMN, 104
- B-reps, usage, 34f, 36
- Bridge projects, differences, 497
- Budget/actual cost, variances (tracking), 293
- Building
 - commissioning, efficiency, 168
 - components
 - expertise, embedding, 241–246
 - information, 269
 - computer modeling, concept, 354
 - construction, 100–101
 - ISO-STEP, usage, 111–113
 - core, layout (detail), 243f
 - design, 100–101
 - element, 3D CAD (usage), 41–42
 - future, BIM (usage), 29
 - hi-rise cores, set (sample), 242f
 - information
 - detail, 269
 - models, creation/sign-off, 161
 - infrastructure/environment, complexity, 160–161
 - modeler, 366
 - role, issue, 368
 - modeling
 - 3D solid modeling basis, 36–37
 - tools, functional difference, 49
 - object-based parametric modeling, 40–43
 - object models/libraries, 240–253
 - objects, definition, 18, 587
 - parametric modeling, 45–57
 - part information modeling applications, 321
 - performance/quality, increase, 21, 151
 - procurement, BIM (usage), 9–10
 - product manufacturers
 - 3D catalogs, 359
 - intelligent product specs, 385–386
 - subassemblies (fabrication), BIM (impact), 360
 - type, 559
- Building Automation and Control networks (BACnet), 106
- Building code requirements/regulations, conformance (analysis), 226, 228
- Building Data Model, definition, 586
- Building element models (BEMs), issues, 374–375
- Building Information Modeling (BIM)
 - activity, 353
 - adoption, 15
 - guidelines/issues, 189–191
 - approaches, inefficiencies, 10–15
 - architectural design applications, built-in base object families, 47t
 - architectural design tools, 46
 - asset management tools, usage, 168
 - associated processes, 20f
 - authoring tool, analysis application (interface), 224
 - benefits, 19–26, 396–397
 - BIM-based concept design, 204
 - BIM-based deliverables, 153f
 - BIM-based facility management products, usage/maturation (increase), 365
 - BIM-based planning, usage, 166
 - BIM-based scenario planning implementation, metrics, 580f
 - system, requirements, 577

- BIM-based takeoff, 280
- BIM Collaboration Format (BCF), 134
- BIM-enabled process change, 324–328
- BIM-integrated 4D Cad tools, commonness, 358
- BIM-related services, adaption/expansion, 361
- BIM-related skills/expertise, inclusion, 178
- BIM-specific prequalification criteria, inclusion, 178
- BIM-supported planning/scheduling issues/guidelines, 290–293
- CAD, contrast, 2
- challenges, 26–28
- change, obstacles, 382–385
- component definitions, relationship, 280f
- construction/fabrication benefits, 23–25
- database structure, 532f
- definition, 586
- development, 236, 353–354
 - societal/technical/economic drivers, 352
- drivers, 155
- economic drivers, 380–382
- effort, 187
 - participation, 190–191
- elements, libraries, 75
- energy efficiency/sustainability, improvement, 23
- environments, 32, 70–71, 76
 - definition, 586
- estimating tools, 170
- handbook instruction, 1
- impact, 380–389
- implementation, 302–303, 357
 - barriers, 185–189
 - issues, 27–28
 - process, post-tender stage, 534–537
- importance, 152–155
- import capabilities, 287, 290
- lean construction
 - relationship, 386–387
 - synergies, 297–300
- legal barriers, 187
- leveraging, 311–312
- modeling
 - applications, 94–95
 - technology, definition, 16
- NBIMS Initiative categorization, 16
- objects, built-in behaviors, 46–47
- onsite, use, 296–297
- owner demand, 354–355
- platforms, 56, 70–71, 77–94
 - default, 59
 - definition, 585
 - usage, 74–76
- post construction benefits, 25–26
- practice, changes, 27
- preliminary concept design, 214–215
- processes, 15–19, 356
 - definition, 586
- process flow, 271f
- quantity takeoff
 - estimating process, conceptual diagram, 279f
 - tools, usage, 164–165
- questions, 67–69
- repository, base requirements, 137
- risks, 185–189
- scope, 16
- service providers, network
 - construction/education, 179–180
- skills/employment, 382–389
- societal drivers, 380–382
- software, 276
 - suites, vendor, construction, 373–374
 - tools, definition, 154
- space modeling, example, 159f
- standard efforts, 352
- system
 - definition, 586
 - usage, 28
- teams, measurement, 364
- technological capabilities, 363
- technological drivers, 380–382
- transition, 354
- trends, 354–361
- usage, 9–10, 26, 351, 369
 - owner demand, 351
- value, 268–269
- vendors, scope (expansion), 359
- Building Information Modeling (BIM)
 - applications, 156f
 - definition, 585
 - distinction, 101
 - parametric tree representation, 38f
 - relationship, 173f, 182f
- Building Information Modeling (BIM)
 - case studies, 29, 391
 - benefits checklist, 393t–394t
 - participant index, 393t
 - projects, description, 392t
 - software, checklist, 395t–396t
- Building Information Modeling (BIM) design
 - assessment, 157–160
 - benefits, 21–23
 - construction planning, synchronization, 24
 - disciplines, collaboration, 22
 - errors/omissions, preconstruction discovery, 24
 - intent
 - applications, 50
 - consistency, verification, 22
 - platforms, overview, 71–76
 - productivity benefits, 255–256
 - stage, cost estimates (extraction), 22–23
- Building Information Modeling (BIM) design applications, 44–45
- adoption, 72
- capability, 49–50
- manufacturing-oriented
 - parametric modeling tools, differences, 69
- set, development, 50–51
- support, 38
- Building Information Modeling (BIM) design tools, 31, 54, 72–74
- complex curved surface modeling, 73
- core, 49
- custom parametric objects, development (ease), 73
- extensibility, 75
- interface, 74–75
- interoperability, 75–76
- multiuser environment, 76
- properties management
 - support, 76
- support, absence, 39
- tool-level capabilities, 74
- types, 57
- user interface, 72–73
- Building Information Modeling (BIM) model
 - creation tools, 15–17
 - detail, 291
 - scope, 291
- Building Information Modeling (BIM) servers, 145
- definition, 586
- demand, increase, 374
- functionality, 141–143
- review, 144–148

- Building Information Modeling (BIM)
 - technology, 20f
 - definition, 15–16
 - development, 354
 - exploitation, 11
 - parameters, 19
 - trends, 356
 - usage, 264
- Building Information Modeling (BIM)
 - tools, 15–19, 70–71
 - construction management functions, integration, 359–360
 - definition, 586
 - development, 383–384
 - 4D capability, 286–290, 288t
 - impact, 373–376
 - problems, 43
- Building model
 - authoring tools, 375
 - definition, 587
 - geometric shapes, 336
 - information, richness/availability, 368
 - initial section, sketch, 62f
 - repositories, 100
 - definition, 587
 - evolution, 136–148
 - usage, example, 169f
- Building Object Model (BOM)
 - definition, 587
 - libraries, 60
 - portals, 249–252
 - product portals, comparison, 250t–251t
 - 2D/3D geometric representations, 247
- Building Process Modeling Notation (BPMN), 122, 124
- Building Services Life Cycle Analysis (BSLCA)
 - BSLCA-Integrated LCA tool, structure, 549f
 - software package, integration, 549–550
- buildingSMART
 - IFC, relationship, 113–114
 - International Implementation Support Group (ISG), 126
- Building system, 55
 - cost estimation, 229–230
 - design/analysis, 222–230
 - BIM, usage, 205–204
 - layout, 233–234
 - applications, 233t
 - simulation/checking, 222–230
- Built-in base object families, 47t
- Built-in structural analysis capabilities, 333–334
- Business goals, clarity/focus, 190
- Business practices, adoption, 12
- C**
- CADDUCT, 53
- CADPipe, 53, 102
- California State Senate Bill 1953, 433
- CAMduct, 102
- Campus-wide project, 4D
 - snapshots, 284f
- Capital Facilities Information Handover Guide, 175
- Cast-in-place (CIP) concrete, layout/framework detailing, 338
- Cast-in-place (CIP) reinforced concrete, 337–338
- Castro Valley Medical Center case study, 316
- Ceiling, clerestory wall, 43f
- Celestory wall, 43f
- Center for Integrated Facility Engineering (CIFE)
 - field productivity illustration, 10, 10f
 - Working Paper on Virtual Design and Construction, 190
- Change, drivers, 380–389
- Change Order (CO), 255
 - issuance, 6
- CIMsteel Integration Standard Version 2 (CIS/2), 100, 111, 295
 - definition, 587
- City Geography Markup Language (cityGML), 106
- CityGML, 134
- Clad Engineering, 409
- Clash detection
 - design/planning, 503–505
 - illustration, 537f
 - layout, combination, 555f
- Closeout maintenance, BIM
 - usage, 484
- Cloudworx, 421
- Code conformance/constructability, automated checking (development), 352
- Collaboration
 - challenges, 26–27
 - improvement, IPD (usage), 21
- Colocation, 239
- Commitment tracking, 461
- Communication, two-way cycle, 307
- Company best practices, incorporation, 55
- Company Way, 387
- Complex curved surface modeling, 73
- Component-based simulation, 363f
- Components
 - reorganization, 291
 - reporting, 329–330
 - temporary components, 292
 - virtual construction, 306
- Composite systems, 338, 339
- Computational Fluid Dynamics (CFD), 46, 226
 - model, input, 378
 - simulation, 550–554
- Computer-aided design (CAD)
 - behavior, unlearning, 344–345
 - BIM, contrast, 2
 - CAD-based applications, drawback, 342
 - MEP/Revit, interoperability (absence), 457
 - public domain exchange format, 105
 - systems, 31
 - plotted drawing production, 15
 - technologies, production, 362
 - workstations, phase replacement, 346
- Computer-aided design and drafting (CADD), 195, 366
- Computer-controlled production
 - machinery, technical progress, 381
- Computerized Maintenance Management System (CMMS), 484
 - tool, 172
- Computer modeling, concept, 354
- Computer numerically controlled (CNC) machinery, 319, 321
 - instruction output, 334
- Computing power, technical progress, 381
- Concept design, 205
 - circulation analysis, abstraction, 219f
 - summary, 222
- Concepts, 124–126
 - example, 125f
- Conceptual design, 193–194
 - issues, 221–222
- Conceptual estimating workflow, DProfiler (usage), 560f
- Concrete printing, 378
- Construction
 - activities, verification/guidance/tracking, 296–297
 - analysis/planning, 281–293
 - BIM design applications, differences, 68–69
 - BIM implementation, 357
 - BIM tools, predefined objects, 48t
 - clients, impact, 362–363

- companies
 - impact, 367–369
 - information integration, 387–388
- contracting, impact, 369–371
- design, integration, 254
- education, impact, 371
- estimated costs (labor cost), 11
- firms, types, 265–268
- 4D view, 283f
- hourly workers, real wages (trends), 13f
- labor productivity indexes, 10f
- management functions, BIM tools (integration), 359–360
- paperwork, reduction, 327
- parametric modeling, 50–54
- planning
 - 4D CAD requirements, 24
 - support, 4D models (usage), 283–284
- process, 237
 - visualization, BIM (usage), 299–300
- procurement/design, synchronization, 25
- productivity, decrease (reasons), 12–13
- products (visualization), BIM (usage), 299–300
- regulation, 386
- review, 196
- schedule, Gantt chart (sample), 282f
- workers, benefit packages, 12
- Construction detailing (CD), 196, 201
- Construction industry
 - analysts, process changes, 353
 - efficiency, construction cost (NIST study), 13–15
 - interoperability inadequacy, costs (addition), 14t
 - labor productivity, CIFE study, 10–13
- Construction-level building models, 230–236
 - building systems layout, 233–234
 - collaboration, 239
 - design review, 238–240
 - drawing/document production, 234–236
 - human interaction level, 239
 - integration, benefits, 237–238
 - specifications, 236
- Construction-level information, development, 204
- Construction-level model development, 230–231
- Construction-level modeling, 194
- Construction Management at Risk (CM at Risk), 4, 8
- Construction management (CM) information, 54
- Construction manager (CM) oversight, 187–188
- Construction Operations Building information exchange (COBie), 120–121, 131–132, 175
 - COBie2 data sections, 132
 - objectives, 131
 - updating, 131–132
- Construction sites
 - BIM, usage, 367–369
 - offices, BIM/4D CAD (usage), 369
 - work face, 378–379
- Construction Users Roundtable (CURT), 190
- Constructive Solid Geometry (CSG), 34–36
 - CSG-based CAD systems, 43
 - definition, 587
 - expressions, shape parameters, 3c
 - operation/primitive shapes, 35f
- Contour crafting, 378
- Contractors
 - BIM adoption, 356
 - BIM coordination, usage, 364–365
 - BIM development processes, 270–272
 - BIM usage, 263
 - coordination/scheduling, Navisworks model, 429f
 - cost estimating, 275–281
 - designers, collaborations, 369–371
 - economic interests, 382
 - 4D, usage, 364–365
 - offsite components, usage, 10
 - quantity takeoff, 275–281
 - success, 5
- Contractors' Guide to Building Information Modeling*, 301–302
- Contracts
 - changes, implications, 300–302
 - deliverables, 183f
 - language, modification, 180–185
- Coordination/collaboration, communication (requirement), 195, 197
- CORENET, 228
- Core thermal zone modeling, example, 219f
- Cost estimates
 - obtaining, 152
 - reliability, impact, 162–163
- Cost estimating, 275–281
 - process, automation (upfront work), 472f
- Cost estimation, output (example), 221f
- Cost management, 162–165
 - BIM applications, usage, 163
- Cost reliability, 162–165
- Cost/schedule control, integration, 293–295
- Courthouse circulation path, access (security), 364f
- Courts Design Guide*, 218
- Courtyard by Marriott
 - air quality, 426
 - aspect models synchronization, 430
 - building process, sequence, 419f
 - case study, 415
 - contractors coordination/scheduling, Navisworks model, 429f
 - design approach, 418–419
 - design/evaluation interaction, 430
 - design workflow, 419f
 - energy model, 426–427
 - analysis results, 427f
 - façade design, 418
 - façade precast panels, 423–425
 - floor-by-floor modeling process, 421f
 - integrated 3D scan, 420f
 - LEED analysis results, 427–428
 - LEED certification, 425–426
 - LEED standards, achievement, 428f
 - LEED/Sustainability ROI analysis, costs, 428f
 - lessons, 430–431
 - main entrance visualization, 416f
 - multi-hotel model, Revit (usage), 416f
 - point grid correction, 422–423
 - point grid generation, 422f
 - precast façade panels installation, 424–425
 - precast panel installation
 - process, 425f
 - project goals, 417–418
 - project overview, 417t
 - reality layer, 424
 - resource efficiency, 418
 - scanning, 430
 - process, 420–421
 - sloping slab, slab edge detail, 424f
 - structure recycling, 417–418
 - structure scanning, 419–423
 - subcontractor coordination, 429–430
 - surface generation, 421–422
 - surface modeling, 421–422
 - sustainable design, 418
 - team coordination, 429–430

- Courtyard by Marriott (*Continued*)
 3D solid model, 2D profiles, 423–424
 urban impact, 417
 water savings, 426
- Critical Path Method (CPM) scheduling software, 281
- Crown House Technologies, hospital project system, 322
- Crusell Bridge
 BIM software provider, 498
 bridge deck, architectural rendering, 495f
 case study, 494
 clash, example, 505f
 clash detection, design/planning, 503–505
 construction
 phase, BIM usage, 502–512
 planning, 4D (interaction), 505–507
 stage, 497–498
 cut section views, 504f
 data, 496t
 design, solicitation, 496
 file transfer, information exchange, 500f
 final product, initial model (preparation), 505
 information exchange, synchronization (usage), 501f
 in-house fabricator software, screenshots, 508f
 interoperability, 498–500
 laser scanning, 510–511
 Last Planner System, BIM support, 511–512
 learning experience, 497–498
 lessons, 512–513
 model synchronization, 500–502
 point cloud, photograph/scan, 510f
 project phases, BIM/applications (usage), 499t
 project team, 496t
 project timeline, 497f
 rebar
 detailing/fabrication/installation, 507–510
 material takeoffs, Tekla Structures provision, 508–509
 workflow, 509
 rendering, 494f
 schedule, 4D video animations, 505–506
 structural steel
 components, fabrication/installation, 507
 onsite erection, 507
 structure, building model, 495f
 synchronization
 performing, 501
 requirement, 501–502
 temporary structures, design/planning, 503–505
 visualization, 503
 work sections, 506f
- CSI Masterformat, 253
- Curtain walls, 338–339, 547f
 importance, 339
 modeling, 339
 popularity, 547
- Curved surface modeling, complexity, 73
- Custom component libraries, preparation, 345
- Customizable parts/relationships, 328–329
- Custom numerical control (CNC) fabrication, support, 378
- Custom parametric objects, development (ease), 73
- Custom tags, defining, 135
- Cutting instructions, output, 334
- Cycle times, reduction, 314–315
 BIM, usage, 298
- D**
- Data exchange, complexity, 110f
- Data eXchange Format (DXF), 108
- Data models, 99
- Daylight studies, series, 400f
- Decision-making, quality (empowerment), 205
- Decomposition, 292
- Deliverables
 requirements, change, 180–185
- Deliverables, COBie specification, 131
- Delta BIM (ArchiCAD), 66
- DELTA-server technology, 374
- Design
 alternatives (development/assessment), Onuma System (usage), 158f
 BIM, impact, 193–194
 construction
 integration, 254
 planning, synchronization, 24
 coordination
 conflicts, avoidance, 316–317
 errors, reduction, 315–317
 detailing/integration, collaborative process (BIM support), 307
 disciplines, collaboration, 22
 errors
 preconstruction discovery, 24
 reduction, clash detection (usage), 272–275
 firms
 change, 365–366
 staffing, change, 258–260
 intent, 199
 consistency, 22
 model
 integrity, maintenance, 377
 usage, 23
 omissions, preconstruction discovery, 24
 processes, BIM (usage), 203
 procurement/construction synchronization, 25
 professions
 impact, 365–367
 services, 384–385
 scenarios, reconfiguration/exploration, 158, 160
 team, collaboration, 231
 technical services, range, 202
 visualizations, 21
- Design-bid-build (DBB)
 approach, 4–7, 10–11
 process, requirements, 6
 procurement process, 199
 schematic diagram, 4f
- Design-build (DB)
 construction projects, 381
 contractor, contractual relationship (establishment), 8
 delivery, modification, 184–185
 owner/client, commercial relationship, 199–200
 process, 4, 7–8
 projects, LACCD BIM standard workflow/deliverables, 7f
- Design Build Institute of America (DBIA) estimates, 8
- Design changes
 automatic low-level corrections, 21
 reaction, 23–24
- Design-construction integration, 237–238
- Design development (DD), 196, 201
 collaborative process, BIM support, 307
- Design-engineering-construction project-oriented market, 142
- Designers
 contractors, collaborations, 369–371
 cost estimation, importance, 229–230
 economic interests, 382

- services/roles, shift, 365–367
 - top-down design development approach, 319
 - Design for fabrication, 204
 - Design-for-manufacturing (DfM) rules, 46
 - Designing (future), BIM (usage), 29
 - Design practice
 - adoption, 253–258
 - BIM justification, 253–256
 - phased utilization, 257–258
 - training/deployment, 256–257
 - Design services
 - changes, value added cost, 198f
 - compensation/distribution, 198f
 - concept design development, 254
 - providers, 309–310
 - scope, 197–203
 - specialization/commoditization, economic driver, 380
 - Desktop/LAN libraries, 252–253
 - Detailing
 - costs, reduction, 317–319
 - production phases, automation (increase), 366
 - Detailing for Steel Construction* (AISC), 54
 - Devenney, 447
 - Dictionaries, international framework, 129–130
 - Digital interoperability, resolution, 455
 - Digital model, signing, 373
 - Digital Project (DP) (Gehry Technology), 40, 68, 84–86, 522
 - scalability, 85
 - strengths/weaknesses, 86
 - Direct links, API usage, 107
 - Distributed computing, technical progress, 381
 - Divide and conquer strategy, implementation, 408
 - Documentation
 - production phases, automation (increase), 366
 - Documentation ownership/production, legal changes, 27
 - Document production, 234–236
 - Document Type Declarations (DTDs), 135
 - Domain Committees, 113
 - DPR Construction, 465–467
 - DPR model-based cost estimating solution, 468–469
 - DProfiler, 91–92, 276, 373
 - strengths/weaknesses, 92
 - system, 229
 - usage, 560f
 - DPR self-perform work, 468f
 - Drafting productivity (improvement), BIM systems (usage), 342–343
 - Drawing eXchange Format (DXF), 99
 - Drawing generation, 60–64, 73
 - plan/section/elevation, usage, 62
 - Drawing production, 234–236
 - process, automation, 63–64
 - weak level, 62–63
 - Drawings
 - importance, 372–373
 - production automation, 235–236
 - role, 384
 - Drawing sheets, inclusion, 61
 - Drilling instructions, output, 334
 - Drofus, 145
 - Duct sections, fabrication, 341
 - DWF format, 102
- E**
- Early concept design
 - assessment, space names, 216–217
 - Early concept design, BIM models, 215f
 - Economic drivers, 380–382
 - ElementWall, 117
 - ELPOS, 338
 - Employee-owner NURES
 - geometric surface modeling tool, 207–208
 - Energy analysis, 226
 - Energy consumption (reduction), energy analysis (usage), 151–162
 - Energy model analysis results, 427f
 - Engineered to order (ETO) building components, annual market volume, 309t
 - Engineered to order (ETO) components, 305, 308
 - fabrication, 370–371
 - fabricator product flow/information, 311f
 - prefabrication, 329
 - producers, 309
 - RFID tracking, 323
 - systems, types, 339
 - Engineered to order (ETO) products, manufacturer application, 324
 - Engineering
 - costs, reduction, 317–319
 - firms, workplace roles/activities (change), 366
 - productivity (improvement), BIM systems (usage), 342–343
 - services, integration, 194
 - staff, training, 344–345
 - Engineers
 - BIM adoption, 356
 - BIM usage, 193
 - Enterprise resource planning (ERP), 330
 - applications, usage, 388
 - systems, extensions, 388
 - Envelope detailing, 406–412
 - Envelope skin/structure, geometric definition, 404–405
 - Environmental analysis tools, non-project-specific information, 213
 - Environmental Sketch Suite, building model (analyses), 212t
 - Equipment installation process, phases, 488
 - Estimate accuracy, BIM quantity takeoff tools (usage), 164–165
 - ETABS design analysis, 456
 - EnyoSTEP Share-A-Space Model Server, 146
 - Evaluated shape, 36
 - Exactal CostX Version 3.01, 278
 - Exchange formats
 - definition, 587
 - proprietary exchange format, 107–108
 - schema, basis, 106f
 - types, 105–110
 - Exchange Models (EMs), 124
 - Exchanges
 - internal structure, support, 143f
 - process map, 123f
 - protocols, language support, 104
 - Exchange schema, definition, 588
 - EXPRESS, 104, 106
 - usage, 110–111
 - Express elevators, 246f
 - eXtensible Markup Language (XML), 104, 106
 - formats, 135
 - XML-based schemas, 132, 135
 - External catalog files, links, 67
 - External parameter management, 66–67
 - External Reference Files (XREF), 93
- F**
- Fabricated components, design model (usage), 23
 - Fabrication
 - BIM design applications, differences, 68–69
 - BIM tools, predefined objects, 48t
 - change, pace (planning), 345–347
 - components, reporting, 329–330
 - detailing, 306

- Fabrication (*Continued*)
 human resources, considerations, 347
 modeling, 53
 operation, BIM adoption, 342–347
 activities, 344–345
 goals, setting, 343–344
 tasks, automation, 333
- Fabrication-level BIM modeling
 systems, 63
- Fabricators
 BIM software, 334t–335t
 BIM system requirements, 328–333
 BIM usage, 305
 classes, needs, 333–342
 drawing sets, inconsistencies, 317
 engineering department,
 BIM workstations (staged
 adoption), 346t
 information visualization, 331, 333
 in-house software, screenshots, 508f
 interoperability, 351
 software systems, 328–329
 types, 308–310
- Facilities
 assets management, BIM asset
 management tools (usage), 168
 information, commissioning/
 handover (improvement), 25
 maintenance
 BIM usage, 484
 optimization, 152
 management database, 484–485
 managers
 BIM, usage, 151
 building model, 172–175
 operations, simulation, 160
 organizational performance,
 simulation, 230
 retrofit/maintenance work, impact
 (evaluation), 168
- Facilities management (FM),
 167–169, 482
 database, population, 168
 optimization, 152
 tools, 170–172
- Facilities management/operation
 improvement, 25
 product, 142
 system, integration, 25–26
- Facility condition index, 569
- Facility Information Council (FIC), BIM
 technology (definition), 15–16
- Feasibility studies, 196
- Feature, definition, 588
- Federated document collaboration
 system, usage, 458–459
- Federated Model Management
 architecture, 460f
- Feedback cycles, reduction, 403
- Fenestration, 338–339
- Field conditions (reaction), 4D-
 coordinated BIM models
 (usage), 166–167
- Field database access, 485–487
- Field personnel, PC usage, 332f
- Field scanning equipment tags, tablet
 computer (usage), 488f
- File-based exchange, evolution, 136–148
- Financial risk, reduction, 151
- Finite element analysis, 333–334
- Finite element model (FEM), mesh
 (representation), 103
- Form Fonts EdgeServer product, 249
- 4D CAD, 282
 schedule analysis, 264
 techniques, usage (examples), 331
 usage, 369
- 4D-coordinated BIM models, usage,
 166–167
- 4D financial model, 159f
- 4D model
 benefits, 285–286
 communication, 285
 data interfaces, diagram, 289f
 scaffolding, 292f
 site logistics, 285
 snapshot, 284f
 stakeholder input, 285
 views, 166f
- 4D modeling processes, 286–290
 diagram, 289f
 manual CAD-base methods, 286
- 4D scheduling software, support, 384
- Four-dimensional (4D) CAD,
 requirements, 24
- Framework model, 114
- Freeform Concrete Construction
 research project, 379f
- Freeform design, Bonzai (usage), 210f
- Freeform design, Rhino (usage), 208f
- Freeform façade, partial assembly, 40f
- Fully informed set, delivery, 447
- G**
- Gantt chart, sample, 282f
- Gases, supply/disposal (piping), 340
- Gehry Technologies (GT), 243
- General contractors, bids, 5
- General Motors Production Plant case
 study, 314–315
- General Packet Radio Service (GPRS),
 106–107
- General Service Administration
 (GSA), 213
 BIM model usage demand, 354–355
 Preliminary Concept Design
 Assessment Tool, general
 configuration, 214f
- Generative Components
 cladding, initial modeling, 408
 usage, 39
- Geographical Information Systems
 (GIS), 372
- Geometry
 acquisition, laser scanning
 (usage), 379
 IFC representation, 118
 Geometry Gym, 209
- Ghosting, 345
- Globalization, impact, 380
- Global positioning systems (GPS)
 technologies, 297, 388
- Global Unique ID (GUID)
 creation/reading, 140
 object identification, 139
- Google 3D Warehouse, 249, 252
- Google Earth, 372, 572
- GoToMeeting, 440, 452
 usage, 459f
- Graphisoft ArchiCAD, 40
 BIM Server, 146
- Green building, demand (increase), 358
- Green Building XML (gbXML),
 133, 372
- Green construction practices, 372
- Groupe Spécial Mobile (GSM), 106
- GT-STRUDL, 223
- Guaranteed Maximum Price (GMP), 8
 construction manager, 481
- H**
- Hand-built models/datasets, 241
- Helsinki Music Center
 advanced simulations, BIM
 (usage), 546
 applications/models, 545f
 BIM development/application, 543
 BIM flow/interoperability, 554–555
 BIM tools, usage, 545–546
 BSLCA-Integrated LCA tool,
 structure, 549
 case study, 539
 clash detections, combined
 model, 554
 concert hall shell, computer building
 model, 542f
 curtain walls, 547f
 popularity, 547

- design alternatives
 - comparison, energy simulation (usage), 546–549
 - comparison, LCA analysis, 551f
 - design quality/productivity (improvement), BIM (usage), 553–554
 - design team, BSLCA (usage), 550
 - energy consumption/cost comparison, 548f
 - glazing alternatives, simulation results, 548–549
 - Glazing Type One, 547
 - Glazing Type Two, 548
 - high-quality indoor environment design, CFD simulation, 550–554
 - hourly simulation, 548
 - HVAC/sprinkler network model, MagiCAD (usage), 554f
 - HVAC system design assessment, CFD usage, 552
 - IFC files, BSPRO COM-Server, 556f
 - layout/clash detection, model (combination), 555f
 - lessons, 555–556
 - lifecycle assessment (LCA), 549–550
 - lobby area
 - air temperature distribution, 552f
 - air velocity distribution, 553f
 - MagiCAD, usage, 553
 - model-based analysis, 544–545
 - musical instrument, tuning, 542
 - one-tenth scale model, 541f
 - project design, competition, 541
 - project team, 543–545
 - list, 543t
 - rendering, 540f
 - schematic design energy consumption simulation results, 547f
 - schematic design stage, energy simulation, 546
 - working process, efficacy/competency (architect focus), 544
 - Hierarchical relations, 64–65
 - Hierarchical structural layout, diagram, 402f
 - High-quality indoor environmental design, CFD simulation, 550–554
 - Hillwood Commercial Project
 - benefits, realization, 564–565
 - BIM estimating process, overview, 559–562
 - Building Type, 559
 - case study, 557
 - conceptual estimating process, 558
 - support, BIM technology (overview), 559
 - workflow, DProfiler (usage), 560f
 - cost estimate
 - accuracy, 564
 - DProfiler snapshot, 562f
 - visual representation, 564–565
 - design alternatives, 562–564
 - design option, 562
 - details, overview, 558f
 - exterior window wall system, glazing frit film (usage), 562–563
 - information, DProfiler snapshot, 561f
 - labor-hours, estimation, 564
 - model, snapshot, 563f
 - preconstruction, reduction, 564
 - 3D site rendering, 557
 - 2D spatial view, DProfiler system screenshot, 563f
 - Horizontal Glue, 146–147
 - HVAC systems, ducts, 339
- I**
- IES VE, plug-in, 207
 - IfcElement, relationships, 117
 - IfcObject level, usage, 117
 - IfcRoot, assignment, 116–117
 - i-Model, 144
 - Independent quantity survey, 5
 - Industry Alliance for Interoperability (IAI), 113
 - Industry Foundation Class (IFC), 18, 106
 - building product data model, 99–100
 - buildingSMART, relationship, 113–114
 - coverage, 118–119
 - data format, usage, 216
 - defining, 114–117
 - definition, 588
 - export/import, user interface buttons, 120
 - files, BSPRO COM-Server, 556f
 - ifcXML, 135
 - interfaces, 209–210
 - interoperability, implications, 128–129
 - project, domain uses, 115f
 - Solutions Factory, 127
 - standardization, support, 129–135
 - structure, 116f
 - subschemas, system architecture, 115f
 - usage, 119–128
 - Inflation-adjusted wages, 12
 - Information
 - asset management, 167–169
 - contractors, BIM (usage), 268–270
 - development, concept, 200–203
 - exchange, interoperability (relationship), 522–523
 - exchange technologies, technical progress, 381
 - increase, 373–376
 - integration, 387–388
 - standardization, driver, 381
 - usage, 27
 - visualization, 331, 333
 - Information Delivery Manual (IDM), 124, 126
 - Information technology (IT)
 - reevaluation, BIM support, 17
 - Infrastructure coordination, integrated 3D MEP models (usage), 160–161
 - Initial Graphic Exchange Specification (IGES), 99
 - Innovator phase, 185–186
 - Innovaya, 277–278
 - Input room information, OPS
 - interfaces, 573f
 - Institute for Advanced Building Informatics (IABI), 126
 - Integrated Agreement for Lean Project Delivery (IFOA), 154
 - Integrated conceptual design
 - single model, multiple assessments, 217–221
 - Integrated conceptual design, example, 213–222
 - Integrated design-build services/agreements, 385
 - Integrated education, 371
 - Integrated Form of Agreement (IFOA), 357
 - Integrated practice, benefits, 357
 - Integrated Project Delivery (IPD), 9
 - approach, 153–154
 - arrangements, 369
 - guidelines, AIA publication, 357
 - option, 200
 - owner (primary beneficiary), 9
 - Integrated project team,
 - development, 436f
 - Integration, increase, 373–376
 - Interaction information
 - workspaces, 358
 - Internal leadership/knowledge, building, 176–177

- International Construction Information Society (ICIS), OmniClass development, 130
 - International Implementation Support Group (ISG), 126
 - International Organization for Standardization (ISO)
 - ISO 15926, 112
 - OmniClass development, 130
 - International Standards Organization-Standard for the Technical Exchange of Product (ISO-STEP) model data, definition, 588
 - Internet, impact, 376
 - Interoperability, 99, 331
 - definition, 588
 - importance, 105–106
 - information exchange, relationship, 522–523
 - model information, mapping, 104–105
 - tools, technical barrier, 382–383
 - ISC Project, planning system (usage), 574–576
 - ISO-STEP, EXPRESS (usage), 110, 114
 - ISO-STEP-based formats, 108
 - ISO-STEP-development data modeling language, 106
- J**
- Job skill requirements
 - examples, 179
 - modification, 178
 - Jotne EDM Model Server, 147
- K**
- KanBIM systems, 369
 - KanBIM user interface, example, 370f
 - Keogh McConnell Spence (KMCS), 398
 - Knowledge embedding tool, 56–57
- L**
- Labor productivity, indexes, 10f
 - LADAR, usage, 323, 388
 - LANDCADD, 79
 - Lansdowne Road Stadium Development Company (LRSDC), 398
 - Laser scanning
 - point cloud data, mapping, 360f
 - usage, trend, 379
 - Laser scanning technologies, 296–297
 - Last Planner System (LPS)
 - BIM support, 511–512
 - meetings, 505–506
 - Last responsible moment (LRM), 450
 - milestones, 447
 - Leadership in Energy and Environmental Design (LEED)
 - analysis results, 427–428
 - certification
 - requirements, conformance, 366
 - schemes, 372
 - compliance, 358, 385
 - evaluation, feature (addition), 294
 - Gold certification, 415–416, 427
 - standards, achievement, 428f
 - Sustainability ROI analysis, costs, 428f
 - Lean construction
 - BIM, relationship, 386–387
 - BIM, synergies, 297–300
 - techniques, 24–25
 - Leaner construction, 325–326
 - processes, BIM facilitation, 326
 - Lean principles, 299t
 - BIM support, 300
 - Learning curve, difficulty, 186–187
 - Legion Studio, visual/analytical outputs (examples), 167f
 - Leica Geosystems HDS Worldwide User Conference, 423
 - Letterman Digital Arts Center (LDAC), model completion, 295
 - Letterman Lucas Digital Arts center team, model usage, 172
 - Level of detail (LOD), 291
 - issuance, 254
 - Lifecycle assessment (LCA), 549
 - Lifecycle maintenance, 322–324
 - Lighting simulation, 226
 - Limited Liability Corporations (LCCs), 357
 - Line-by-line layout, change, 195
 - Liquids, supply/disposal (piping), 340
 - Lite BIM tools, 383
 - Local area network (LAN)
 - environments, usage, 439–440
 - Long transactions, 138
 - Look-ahead network plan, 462f
 - Los Angeles Community College District (LACCD), 176
 - BIM DB project standard, 7f
 - BIM usage guidelines, 8
 - Louver opening layout, 409f
 - Low-cost CAVEs, 384
- M**
- Machine-guidance technologies, 297
 - Made-to-order components, 308
 - Made-to-order plant-management market, 142
 - Made-to-stock components, 308
 - MagiCAD, usage, 554f
 - Maintenance work orders, usage, 490–491
 - Management functions, 293–295
 - Management information systems, interface, 330–331
 - Manual CAD-based methods, 286
 - Manufacturers, long-term agreements, 12–13
 - Manufacturing hourly workers, real wages (trends), 13f
 - Manufacturing-oriented parametric modeling tools, BIM design applications (differences), 69
 - Maryland General Hospital (MGH)
 - barcode format, usage, 486f
 - BIM usage, 487f
 - Building Information Systems, 483–487
 - case study, 323–324, 480
 - closeout, BIM usage (reasons), 481–483
 - closeout maintenance, BIM usage, 484
 - construction/closeout/ commissioning, 487–489
 - equipment
 - addition/replacement, 489–490
 - addition/replacement processes, 490f
 - data, Tekla software (custom tabs), 489f
 - equipment installation process, phases, 488
 - facility maintenance
 - BIM usage, 484
 - workflows, 489–491
 - facility management
 - BIM integration, 487f
 - BIM usage, 481–482
 - database, 484–485
 - field database access, 485–487
 - field scanning equipment tags, table computer (usage), 488f
 - Guaranteed Maximum Price (GMP)
 - construction manager, 481
 - lessons, 492–493
 - maintenance work orders, 490–491
 - processes, 491f
 - MEP systems, modeling, 483
 - process, shortcomings, 482
 - rendering, 481f
 - service calls, 491
 - Masonry, parametric model, 56f
 - Mass customization, 307
 - Massing studies, generation, 216f

- Mass objects, 211
- Masterformat, 130
- Material takeoffs, generation, 313–314
- Mechanical, electrical, and plumbing (MEP) systems, 305
 - model view, 340f
 - requirement, 235–234
 - usage, 61
- Mechanical parts (generation), B-reps/ Boolean operations (usage), 34f
- Mega-panels, 518
 - shop drawing, 524f
 - structural analysis, Robot (usage), 523f
 - support, 519
- Memory-based systems, 65
- Memory-swapping, occurrence, 65
- Merck Research Laboratories, auditorium (layout detail), 235f
- Metadata, 119, 330
 - term, coinage, 139
- Microstation CAD files, usage, 404
- Mission dependency index, 569
- Mobile computing, power (increase), 382
- Model analysis, 376–379
- Model-based cost estimating, 462–475
 - benefits, 473–474
 - lessons, 474–475
 - options, DPR identification, 466–467
 - process, 466f, 469f
- Model-based estimating, nonintegration, 467
- Model geometry, requirement, 377–378
- Model information
 - organization, 181, 183
 - scope/detail, 181
 - uses, 181
- Modeling applications, 94–95
- Model manager, 260, 366
 - role, 385
- Model ownership/management, issues, 187–188
- Model synchronization, definition, 588
- Model View Definition (MVD), 120
 - preparation, 358
 - uses, 128–129
- Model viewer software, 374
- Model views, importance, 120–122
- Model View Validation, 126
- Modified design-build delivery, 184–185
- Module pattern, 246f
- Moore's Law, 382–383
- Multicriteria optimization methods, availability, 378
- Multidisplay environments, 358
- Multidisplay workspace, 359f
- Multi-home model, Revit (usage), 416f
- Multiple BEM platforms, 374–375
- N**
- National 3D/4D BIM Program, establishment, 180
- National Building Information Modeling Standard (NBIMS), 122, 181, 295–296
 - Committee of the National Institute of Building Sciences (NIBS), BIM technology definition, 15–16
 - construct phase (phase three), 126–127
 - defining/implementing, steps, 121f
 - deploy phase (phase four), 127
 - design phase (phase two), 124–126
 - Initiative, BIM categorization, 16
 - methodologies, 17
 - phases, 122–127
 - program phase (phase one), 122, 124
 - tools, commonness, 352
 - usage, 100
- National Institute of Building Science (NIBS), 120
- National Institute of Standards and Technology (NIST)
 - construction industry inefficiency cost study, 13–15
- National Institute of Standards and Technology (NIST), information flow/redundancy study, 10
- Navicant, 447
- Navisworks, 239
 - model, 429f
 - combination, 458f
- Neutral format building models, 228
- Nondomain specific/extensible schema, 94
- Nonfarm industries, labor productivity indexes, 10f
- Nonmodified objects, elimination, 66
- Nonuniform B-splines (NURBS), 38
 - surfaces, 118
 - surfaces, limitation, 206
- O**
- Object-based parametric modeling
 - definition, 589
 - evolution, 32–45
 - strengths/limitations, 67–68
- Object libraries, 246–249
 - organization/access, 248–249
- Objects
 - class, definition, 588
 - definitions, 247–248
- feasibility, violation, 18
 - grouping, requirements, 340–341
 - management, links, 65–66
 - metadata, synchronization, 140t
 - model, support, 99
 - parameters, cost assemblies (matching), 472f
- Off-Cycle Crew Support Units (OCCSU), 568t
 - benefits, 583
 - lessons, 582–583
 - Planner system, workflow, 578f
 - system, 581–584
 - implementation, 582
 - requirements, 581–582
- Office of Statewide Health Planning and Development (OSHPD), 431–432
 - phased plan review process, 442
- Onsite fabrication, planning/design information, 295–296
- OmniClass, 130
- On-demand drawings, 372–373
- 100 11th Avenue (New York City) BIM skill set, requirement, 525
 - case study, 514
 - condominium project, 514f
 - cross-section view, 521f
 - curtain wall assembly, 518–519
 - drawings, FormZ model, 517f
 - fabrication activities, 519–520
 - fabrication team, 519
 - glass pane variation, master spreadsheet (usage), 517f
 - information exchange, interoperability (relationship), 522–523
 - innovation/challenges, BIM process, 516–521
 - lessons, 523–525
 - material selection, 516
 - mega-panel
 - assembly, 516, 518
 - parametric Powercopy, 518f
 - shop drawing, 524f
 - structural analysis, Robot (usage), 523f
 - parametric modeling, 516–519
 - parametric panels, 516
 - performance mock-up, 520–521
 - project team, 515t
 - slab edge detail, 521f
 - sound transmission class (STC), prescription, 515
 - visual mock-up, 519–520
 - photo, 520f

- One Island East (OIE) Office Tower, case study, 177, 181, 185, 276–277
- One Island East (OIE) Project, Hong Kong
 automated clash detections, examples, 531f
 automated quantity takeoff, 534f
 BIM creation/coordination, 529–530
 building information model creation/coordination, 529–530
 database structure, 532f
 data structure, 533f
 elements, usage, 535–536
 implementation process, post-tender stage, 534–537
 organization/structure, 531–533
 structure, 532–533
 case study, 526
 clash detection, illustration, 537f
 computer rendering, 528f
 construction sequence, illustration, 536f
 developer, Swire Properties, 527–528
 information, summary, 527t
 lessons, 537–539
 Podium, BIM data structure, 533f
 pretender stage BIM implementation stage, 528–534
 product structure, 531–532
 project elements, three-dimensional coordination, 537f–538f
 project organizations, 528–529
 project team, BIM integration, 529f
 schedule integration/visualization, 536f
 site progress, 535f
 tendering, 533–534
 2D/3D translation, 530f
- Online access/review, initiation, 371–372
- ONUMA Planning System (OPS), 571
 input room information, interfaces, 573f
- Onuma System (OS), usage, 158f
- OpenBIM Collaboration Format, 275
- Open Geospatial Consortium (OGC), 175
- OpenGIS (XML schema), 133
- Open Standards Consortium for Real Estate (OSCRE), 174–175
- Operating room, component-based simulation, 363f
- Operational productivity, improvement, 162
- Operation simulation tools, 172
- Operations & maintenance (O&M), 131
 square footage, 14
- Oracle Primavera, 147
- Organizational boundaries, 3f
- Organizational changes, implications, 300–302
- Output only third-party plug-ins, 374
- Outsourcing, impact, 185
- Owners
 BIM adoption, guidelines/issues, 189–191
 BIM application areas, 155–168
 BIM example, 174t
 BIM tool guide, 169–172
 BIM usage, 151
 building model, 172–175
 impact, 361–365
 postconstruction, 365
 preconstruction benefits, 20–21
 upper/lower limits addition, 163f
- P**
- Paper-based practices, 20
- Paper-centric processes, task automation, 17
- Paper drawings, usage, 380
- Parameter lists, external spreadsheets (usage), 66–67
- Parameter setting, input panel, 245f
- Parametric 3D model, insertion, 232
- Parametric 3D modeling, development, 354
- Parametric approach, technical implementation, 403–405
- Parametric assemblies, development, 242
- Parametric collaboration, 402–403
- Parametric Cost Engineering System (PACES) (EarthTech), 220
- Parametric design, 46–50, 402–403
- Parametric graph, rules (range), 38
- Parametric modelers, model exchange problems, 68
- Parametric modeling, 31, 45–57
 degrees, 44–45
 evolution, 37
 example, 44f
 importance, 50
 systems, 45
- Parametric model platform, 139
- Parametric models, usage, 165
- Parametric object
 capability, existence (absence), 55
 customization, development (ease), 73
 definition, 17–18, 589
 provision, 39
 families, definition, 38
 modeling, usage, 39
- Parametric parts/relationships, 328–329
- Parametric shapes, 57–69
- Parametric Technologies Corporation (PTC), 40–41
- Parametric Technology Corporation (PTC), 558
- Parametric tree representation, 38f
- Parametric wall, definition, 42–43
- Parts, configuration, 54–55
- Pass-through lobbies, 246f
- PCI Design Handbook* (Prestressed Concrete Institute), 52–54
- Peer object relations, 64
- Performance-based acquisition (PBA), 184
- Performance-based contracts, 184
- Performance-based design contracts, commonness, 385
- PERI CAD, 358
- Perimeter modeling, example, 219f
- Peripheral hardware, technology developments, 360
- Person-to-person collaboration, requirement, 139
- Phased utilization, 257–258
- Physical clash detection, 340–341
- Physical products, 2D/3D geometric representations, 247
- Pinned connections, fixed connections (differences), 224
- Piping spools, 341
- Planning matrix, solver generation, 246f
- Platform-to-tool data exchange, complexity, 102
- Platform-to-tool exchange, basis, 101
- Platform user interface consistency, 75
- PlumbingWall, 117
- Podium, 532
 BIM data structure, 533f
- Point cloud surveys, production, 360–361
- Point grid correction, 422–423
- Polyhedral forms, composition, 33
- Post construction benefits, 25–26
- Powercopy, 518
- Preassembly
 degrees, increase, 326
 increase, 321
- Precast concrete, 335–336
 automated reinforcing layout/connections (Tekla Structures), 51f
 beam, drawings, 317
 fabrication, needs, 335–336

- spandrel beam, drawing
 - inconsistency, 318f
- Precast fabrication-level architectural façade, 51–52
- Precast façade panels installation, 424–425
- Precast panel installation process, 425f
- Precast parts, grouping, 336
- Preconstruction benefits, 20–21
- Predesign, 196
- Prefabricated ceiling services
 - modules, 323f
- Prefabricated ETO components, requirements, 330
- Prefabricated solutions, viability, 314
- Prefabrication
 - degrees, increase, 326
 - increase, 321–322
 - trend, 322
- Preliminary circulation/security assessment, 218
- Preliminary cost estimate, 220–221
- Preliminary energy analysis, 219–220
- Pretender stage BIM implementation process, 528–534
- Primitive shapes, 34
 - definitions/compositions, 35f
- Process barriers, 185–188
- Process Map, 122
- Process mapping, 461
 - network, 462f
- Procurement, purchasing/tracking, 294
- Product
 - exchanges, support, 99
 - data models, 110
 - life cycle time, reduction, 326
 - structure, 531
- Production
 - building code checkers, development, 377
 - cycle times, reduction, 313–315
 - detailing systems, vendors, 387–388
 - lead time, benchmark, 315f
- Product Lifecycle Management (PLM) systems market, 142
- Program compliance
 - assurance, 152
 - checking, automated model
 - verification tools (usage), 358–359
 - improvement, 157–158
- Programmatic requirements, development (integration), 157
- Progress assessment, metrics establishment, 190
- Project
 - axonometric views, 320f
 - BIM guidelines, development, 176
 - BIM implementation, leading, 175–185
 - collaborative single unit
 - contracting, 200
 - construction schedule, Gantt chart (sample), 282f
 - delivery, collaborative forms, 198–200
 - design
 - completion, 186
 - skills, demand (shift), 259t
 - documentation, impact, 372–373
 - elements, three-dimensional
 - coordination, 537f–538f
 - financing, 186
 - ghosting, 345
 - information, embedded views, 94–95
 - lifecycle, project cost (impact), 164f
 - management techniques, description, 434–442
 - phases, 362
 - illustration, 392f
 - processes, task automation, 17
 - process flow, 271f
 - representations, management, 103
 - return on investment (ROI), 165
 - risk, management, 154
 - schedule, reduction, 151
 - stakeholders, input (receiving), 158
 - status, 293
 - team collaboration, support, 18
 - transactions/synchronization, 136–141
- Project (Microsoft), 281
- Project data management (PDM) systems, 136
- ProjectWise Navigator, 144–145
- ProjectWise system, 439–440
- Properties
 - handling, 58–60
 - long-term solution, 60
 - management support, 76
 - stages, 58
- Property sets (P-sets), 118–119
- Proprietary exchange format, 107–108
- Proxy objects, 211
- PSetWallCommon, 117
- Public product data model exchange formats, 108
- Pull flow control, 325
- Pull production system, enabling, 313–314
- Purpose-built applications, maturation, 387–388
- Q**
 - Quality control, 325–325
- Quantity takeoff (QTO), 102, 275–281
 - estimating, support, 279–281
 - support, guidelines/BIM implementation issues, 279–281
 - tool, 278–279
- R**
 - Radio Frequency Identification (RFID) tagging, 361
 - tags, 297, 388
 - usage, 323, 341
 - technology, 360
 - feasibility, 330–331
- Real wages, trends, 13f
- Rebar
 - shapes, output, 336
 - workflow, 509
- Reconstruction work, 12
- Reinforced concrete building projects, experimental data, 320t
- Relational structures, 57–58
- Relations
 - information, types, 58
 - object linkage, 118
- Remote sensing technologies, technical progress, 381
- Request for Information (RFI), 255
 - involvement, 6
 - number, impact, 364
- Research
 - impact, 376–379
 - requirement, 377–378
- Revit, 68, 77–80, 209
 - architecture, support, 79
 - CAD MEP models, interoperability (absence), 457
 - MEP, 78
 - product libraries, 78
 - strengths, 79–80
 - structures, 78, 225
 - Tekla model, interoperability (absence), 457
 - weaknesses, 80
- Rhino, 67
- Rhinoceros (McNeel), 79, 205, 207–209
- Rigging table, sketch, 412f
- Robot Millenium structural model, input loading data, 406f
- RSMean cost data, 559
- RUCAPS, 36–37
- S**
 - Safety management, 294–295
- Sage Timberline, 277–278

- Scaffolding, 292f
- Scalability, 64–65, 74
 - definition, 589
- Scenario planning, BIM (usage), 577–581
- Schedule
 - duration (reduction), 3D
 - coordination/prefabrication (usage), 165
 - management, 165–167
 - properties, 292–293
- Schedule-related risk (reduction), BIM-based planning (usage), 166
- Schema, definition, 589
- Schematic design (SD), 196
- SDS/2 (Design Data), 51, 102
- Sector Command Center Planning (SCCP) Tool, 581
- SEEK (object library), 80
- Self-perform work, DPR model-based
 - cost estimating solution, 468–469
- Semantic searches, customization (development), 375
- Semantic searching, 374–375
- Sensor/control monitoring, 171
- Servers, cloud configurations, 138
- Service provider
 - impact, 173–174
 - interview, 178–179
 - network construction/education, 179–180
 - selection, 177–179
- Shapes, generation, 33f
- Shared incentive plans, 184
- Shop drawings
 - generation, 313–314
 - production, 314–315
- Shore Facility Capital Asset Management (SFCAM) Roadmap, 567
- Signing, notion, 373
- Simulation, 376–379
- Single-discipline design, 188–189
- Single-stage drawing-based deliverables, 153f
- Sketching
 - BIM applications, usage, 211
 - function-specific applications, usage, 212–213
- SketchUp (Google), 19, 67, 79, 205–209
 - capability, 206
 - layout, 207f
 - System Development Kit (SDK), 206
- SketchUp Pro (Google), 2D drawing generation, 206–207
- Skills, demand, 355
- Skinning, 211
- SmartBIM Library (SBL), 252–253, 359
 - multilevel structure, 252f
- Smart owners, demands, 363–364
- SMOG (space modeling package), 550
- Societal drivers, 380–382
- Software
 - customization, 345
 - estimation
 - BIM components, linkage, 277–278
 - quantity data, exportation, 277
 - package, acquisition, 77
 - wizards, 369
- Software tools
 - mixture/usage, 108–109
 - support, 205–206
- Solibri Model Checker and Issue Locator, 275
- Solid modeling, 33
 - CAD systems, power, 37
 - definition, 589
 - forms, 33–34
- Solutions Production Manager (SPS), usage, 461
- Space names, mapping relation, 217f
- Space object support, 171
- Space program validation, 217–218
 - reports, 218f
- Space utilization index, 569
- Spatial union, operations, 34
- Specialist coordinators, 310
- Specialization, increase, 373–376
- Specialized structural analyses, 336
- Splines, usage, 38
- Spreadsheet-based solver, development, 244
- Standardization, support, 129–135
- Statutory authorities, impact, 371–372
- Steel connections, automated/customizable detailing, 333
- Stick systems, 338
- Strategic project solutions production manager, usage, 461
- Streamline, 95
- StruCad (AceCad), 51, 102
- Structural steel, 333–334
 - connection (Tekla Structures), 329f
- Structured design, Bonzai (usage), 210f
- Structured design, Rhino (usage), 208f
- Structured Query Language (SQL), 105–106
- Stud layouts, assignation, 42
- Subcontractor fabricators
 - BIM process benefits, 310–324
 - marketing/tendering, 312–313
- Subcontractors
 - BIM software, 334t–335t
 - BIM usage, 305
 - types, 308–310
- Supply chain management, 322–324
- SureTrak (Primavera), 281
- Surface finishes/treatments, 336
- Sustainability, 161–162
 - impact, 380–381
- Sustainable construction practices, 372
- Sutter Health, Integrated Form of Agreement (IFOA), 357
- Sutter Medical Center, Castro Valley (SMCCV)
 - Autodesk Navisworks model/site, 458f
 - baseline schedule, 443f
 - Bentley ProjectWise Collaboration System, snapshot, 461f
 - BIM, usage, 456f
 - BIM planning, extent, 449f
 - biweekly meetings format, 451
 - case study, 431
 - commitment tracking, strategic
 - project solutions production manager (usage), 461
 - committed cost, graph, 471f
 - computer-generated image, 432f
 - construction approaches, 437t
 - contract method, 434–441
 - cost estimating process, automation (upfront work), 472f
 - costs, cluster, 470–471
 - design/construction alternatives, cost comparison, 474f
 - design/construction problems, list, 463t–464t
 - design plan, BIM fit, 449
 - design planning strategies, 447
 - design process
 - mapping, 445f, 448f
 - rework risk, elimination, 445–446
 - design team/builders, collaboration, 469–473
 - digital interoperability, resolution, 455
 - drywall, detail model, 456
 - elevator
 - design review, 452f
 - detailed design/coordination, 452–453
 - estimated cost, graph, 470f

- facility, computer assembly, 440f
 federated document collaboration
 system, usage, 458–459
 Federated Model Management
 architecture, 460f
 final structural design model, 450f
 IFOA, 434–441
 Integrated Project Delivery
 (IPD), 435
 team, members, 436t
 integrated project team,
 development, 436f
 lean design approaches, 437t
 lessons, 476–479
 look-ahead network plan, 462f
 manual estimating process flow, 465f
 MEP designer/subcontractor,
 collaboration, 456
 MEP/FP system model, 451f
 milestone schedule, 444f
 model-based cost estimating, 462–475
 benefits, 473–474
 implementation, challenges, 473
 lessons, 474–475
 necessity, 464–465
 process, 466f, 469f
 solutions, 465–467
 model-based estimating
 creation, 469–473
 preparation, 471–473
 model servers, location, 460f
 model size issues, 457
 Navisworks model, combination, 458f
 object parameters/cost assemblies,
 matching, 472f
 opportunity issues, 461–462
 OSHPD approval milestones, 446
 OSHPD permit documents, creation,
 456f
 OSHPD phased plan review, 442
 owner goals, 435, 434t
 owner goods, 432
 painshare/gainshare plan, 441–442
 preliminary/detailed design, 442–449
 problems, 456–457
 process mapping
 network, 462f
 strategic project solutions
 production manager, usage, 461
 project description, 432–434
 project management techniques,
 description, 434–442
 project milestones, 433t
 project team support, technologies
 (usage), 454–462
- Revit/Tekla models, interoperability
 (absence), 457
 risks
 avoidance/minimization, 446
 tracking, 461–462
 self-perform work, DPR model-
 based cost estimating solution,
 468–469
 software, usage, 438t–439t
 stairs
 design/coordination, 453–454
 model review, 453f
 subgroup, 443–444
 sustainability goals, 475–476
 design/construction modifications,
 examples, 476t
 target value design (TVD), 462, 464
 team collaboration, support
 decisions, 450–452
 3D BIM systems, compatibility, 466f
 web-based virtual participation, 459f
 workflow (process map), 448f
- Sweeps, 33f
 Systems integrator, 259
- T**
 Target value design (TVD), 462, 464
 Teaming, challenges, 26–27
 Teamwork, enhancement, 326
 Technological drivers, 380–382
 Technology
 risks, 188–189
 trends, 352
 Tekla Structures, 51, 88–91, 102
 automated reinforcing layout/
 connections, 51f
 format support, 90t
 interface support, 89
 Lite-wall precast pieces, stack, 225f
 model/field data, 232f
 input, 485f
 Revit model, interoperability
 (absence), 457
 strengths, 89, 91
 structural steel connection, 329f
 weaknesses, 91
 Tekla Structures for Construction
 Management software, 484
 Texture maps, preapplication, 244
 Thickness, definition, 42
 3D-based Internet technologies,
 availability (increase), 362
 3D/BIM
 building model, merge/update, 290
 usage, 303
 3D BIM systems, compatibility, 466f
 3D catalogs, building product
 manufacturer provision, 359
 3D details, automatic development
 (smarter routines), 375–376
 3D sketching tools, 206–222
 Three-dimensional (3D) CAD, 2
 tools, implementation, 2
 Three-dimensional (3D) modeled
 objects, usage, 32
 Three-dimensional (3D) modeling, 33–39
 development, 38
 Three-dimensional (3D) solid modeling,
 36–37
 Tilt-up concrete construction panels,
 designers, 310
 Time to market, 165–167
 reduction, parametric models
 (usage), 165
 Tool-level capabilities, 74
 Top-level drawing functionality,
 support, 63
 Topology, 57
 Toyota Production System (TPS), lean
 production, 297–298
 Toyota Way, 387
 Trade contractors, detail design
 (prevention), 436–437
 Trained personnel, absence, 371
 Training costs, elevation, 186–187
 Transaction
 definition, 136–138, 589
 usage, ease, 138
 Transformation-Flow-Value (TFV)
 concept, 298
 Trelligence, 212–213
 Affinity, 373
 Two-dimensional (2D) CAD, 2
 drawings, 12
 reference files, combination, 19
 technology, platform, 321
 Two-dimensional (2D) drawings,
 generation, 21–22
- U**
 Undefined, 117
 Unevaluated shape, 36
 Uniformat, 130, 236, 253
 United States Coast Guard (USCG)
 BIM-based assessment system,
 small-scale implementation
 (lessons), 577
 BIM-based scenario planning system,
 implementation (lessons),
 580–581

- United States Coast Guard (USCG)
(*Continued*)
- BIM implementation, 566
 - Roadmap, 567f
 - building information model, levels, 572f
 - building model data, views
(OCCSU Planner system usage), 579f
 - case study, 566
 - export utilities, 579
 - facility assessment/planning, BIM
(usage), 569–577
 - facility assessment Roadmap, 570f
 - facility assessment system
 - description, 571–574
 - requirements, 569–571
 - facility condition index, 569
 - hazardous material data, viewing
schedule, 575f
 - interoperability goals,
 - implementation, 567f
 - ISC PROject, planning system
(usage), 574–576
 - lessons, 583–584
 - Level 2/3 building model, team
creation, 572–573
 - manual/BIM-based assessment
processes, comparison, 576f
 - medium-scale implementation, OPS
involvement, 574
 - mission dependency index, 569
 - OCCSU Planner system,
 - workflow, 578f
 - OCCSU system, 581–583
 - projects, partner service providers,
 - overview, 568t
 - reporting tools, 579
 - rooms
 - assessment values, plan view, 575f
 - information, OPS interfaces, 573f
 - sample, template layout
(display), 578f
 - SCCP benefits, personnel
discussion, 581
 - scenario planning, BIM usage,
 - 577–581
 - scenario planning system
 - description, 577–579
 - implementation, 579–580
 - sector command centers design,
 - BIM-based scenario planning
implementation (metrics), 580t
 - space utilization index, 569
 - 3D room layout, 579
 - 2D room layout, 579
- Unit systems, 338
- U.S. Coast Guard, internal knowledge
construction, 177
- U.S. Courts Design Guide*, 214, 216
- U.S. Green Building Council, 415–416
- Userdefined, 117
- User-defined parametric objects,
 54–57
- V**
- Value engineering, usage, 2
- Vancouver Convention Center
construction, 4D view, 283f
- Variation (reduction), BIM (usage), 298
- Vectorworks (Nematschek), 40, 68,
 86–88
 - in-memory system, 87
 - interfaces, 87
- Vendors, BIM scope expansion, 359
- Vertical logic, 246f
- Veterans Administration BIM
Guide*, 355
- Veterans' hospital, lifetime
capital/operating costs
(components), 255f
- Vico Estimator, 277–278
- Virtual BIM, linking (enabling), 360
- Virtual construction, 306
- concept, 360
- Virtual Design and Construction Survey
(VDC)*, 360
- Virtual Reality Cave environment, 159f
- Vision 2015, 361–380
 - limitations, 379–380
- Visual Basic scripting language, 209
- Visual inspection, technical
possibility, 372
- Visualization formats, 384
- Vizella FACILITY space,
 - screenshot, 171f
- Volume-enclosing criteria, 33
- W**
- Wall-object family, conceptual
structure, 41f
- Walls
construction, assignation, 42
type, 117
uniquity/complexity, 42–43
- Waste, occurrence, 317
- Web-based project management
systems, 136
- Web-based virtual participation,
 GoToMeeting (usage), 459
- Webex, 440, 452
- Welding instructions, output, 334
- Wireless Application Protocol
(WAP), 106
- Within object parametric relations, 64
- Work distribution, increase, 327–328
- Work face, 378–379
- Workflows
definition, 589
improvement, 100
stability (improvement), BIM
(usage), 326
- Work processes, 376–379
- Y**
- Yas Island Formula One, physical
spaces, 368f