

Contents

	Foreword	xvii
	Foreword to the First Edition by Jerry Laiserin	xxi
	Preface	xxv
	Acknowledgments	xxxix
	About the Companion Website	xxxiii
CHAPTER 1	Introduction	1
	1.0 Executive Summary	1
	1.1 Introduction	2
	1.2 AECO Business Models	2
	1.2.1 Design-Bid-Build	4
	1.2.2 Design-Build	7
	1.2.3 Construction Management at Risk	7
	1.2.4 Integrated Project Delivery and Other Collaborative Procurement Models	9
	1.2.5 What Kind of Building Procurement Is Best When BIM Is Used?	11
	1.3 BIM: State-of-the-Art Technologies and Processes	12
	1.3.1 BIM Models	12
	1.3.2 BIM Platforms and Tools	14
	1.3.3 BIM Processes	14
	1.3.4 Uses of BIM	17
	1.3.5 Collaboration in Design and Construction	19
	1.4 BIM as a Lifecycle Information Source for Built Facilities	20
	1.5 What are the Benefits of BIM? What Problems Does it Address?	22
	1.5.1 Preconstruction Benefits to Owner	22
	1.5.2 Benefits for Architectural and Engineering Design	23
	1.5.3 Construction and Fabrication Benefits	26
	1.5.4 Post Construction Benefits	28

1.6	BIM and Lean Construction	28
1.7	What Challenges can be Expected?	31
1.7.1	Challenges with Collaboration and Teaming	31
1.7.2	Legal Changes to Documentation Ownership and Production	32
1.7.3	Changes in Practice and Use of Information	32
1.7.4	Implementation Issues	32
1.8	Future of Designing, Building, and Operating With BIM	34
1.9	Case Studies	34
	Chapter 1 Discussion Questions	34
CHAPTER 2	Core BIM Enabling Technologies	37
2.0	Executive Summary	37
2.1	Introduction to Core BIM Enabling Technologies	38
2.2	The Evolution of Object-Based Parametric Modeling	39
2.2.1	Birth of 3D Feature-Based Modeling	39
2.2.2	Object-Based Modeling and Properties	42
2.2.3	Parametric Modeling and Object Behavior	45
2.2.4	BIM for Knowledge Embedment and Management	48
2.3	Interoperability and Interfacing Technologies	50
2.3.1	Causes of Interoperability Problems	52
2.3.2	Information Requirements and Data Schemas on Three Levels	53
2.3.3	Different Kinds of Data Exchange Methods	55
2.3.4	Interfacing Technologies	58
2.4	From File-Based Data Exchange to Object-Based Project Management and Collaboration	62
2.4.1	Advent of BIM Servers	62
2.4.2	Project Transactions and Synchronization	63
2.5	BIM Standards	68
2.5.1	Standardization Efforts and Organizations	68
2.5.2	Information Framework Standards	70
2.5.3	Information Management and Requirements Standards	82
	Chapter 2 Discussion Questions	92

CHAPTER 3	BIM Tools, Platforms, and Environments	93
3.0	Executive Summary	93
3.1	BIM Environments, Platforms, and Tools	94
3.2	BIM Platforms	96
3.2.1	Considerations for Selecting BIM Platforms	97
3.2.2	Allplan	100
3.2.3	Archicad	101
3.2.4	Digital Project, CATIA, and 3DExperience	102
3.2.5	OpenBuildings Designer	104
3.2.6	Revit	105
3.2.7	Tekla Structures	107
3.2.8	Vectorworks Design Suite	108
3.2.9	AutoCAD-Based Applications	109
3.3	BIM Servers	110
3.3.1	Functionality of BIM Servers	111
3.3.2	BIM Server Products	114
3.4	Design Review and Collaboration Tools	117
3.4.1	Model Viewers	118
3.4.2	Real-Time Rendering for Extended Reality	119
3.4.3	Project Collaboration	120
3.4.4	Model Checkers	121
3.5	Construction Management Tools	126
	Chapter 3 Discussion Questions	128
CHAPTER 4	BIM for Owners and Facility Managers	129
4.0	Executive Summary	129
4.1	Introduction: Why Owners Should Care About BIM	130
4.2	Owner's Role in a BIM Project	134
4.2.1	Design Assessment	134
4.2.2	Complexity of Building Infrastructure and Building Environment	139
4.2.3	Time to Market: Schedule Management	140
4.2.4	Cost Management and Project Control	144
4.2.5	Sustainability	146
4.2.6	Facility and Information Asset Management	147
4.2.7	BIM and the Public Procurement Process	149

4.3	BIM Tool Guides for Owners	150
4.3.1	BIM Cost Estimating Tools	153
4.3.2	Facility and Asset Management Tools	153
4.3.3	Operation Simulation Tools	155
4.4	An Owner and Facility Manager’s Building Model	155
4.4.1	Information Content of BIM-FM Model	155
4.4.2	Alternative Approaches to Creating a BIM-FM Model	161
4.4.3	Classification of Model Data and Standards	164
4.5	Leading the BIM Implementation on a Project	166
4.5.1	Develop Guidelines for Use of BIM on Projects	167
4.5.2	Build Internal Leadership and Knowledge	170
4.5.3	Service Provider Selection	171
4.5.4	Provide for Use of a “Big Room” for Design and Construction	173
4.5.5	Adopt and Specify a CDE	174
4.6	Challenges for BIM Implementation: Risks and Common Myths	175
4.7	Considerations for Owners When Adopting BIM	179
4.7.1	Perform a Pilot Project with a Short Time Frame, a Small Qualified Team, and a Clear Goal	179
4.7.2	Do a Prototype Dry Run	179
4.7.3	Focus on Clear Business Goals	179
4.7.4	Select a Project Team That Has Demonstrated Prior BIM Experience	180
4.7.5	Establish Metrics to Assess Progress	180
4.7.6	Actively Participate in the BIM Effort	180
4.7.7	Increase Internal BIM Knowledge	181
4.8	BIM for FM Case Study—Korea Airports Corporation	181
4.8.1	A Digital Twin for Space Management	182
4.8.2	Real-time Air Traffic Monitoring	182
4.8.3	Real-time Passenger Monitoring	185
4.8.4	Information Quality Checking	185
4.8.5	Inspection and Repair Management	185
	Chapter 4 Discussion Questions	187

CHAPTER 5	BIM for Architects and Engineers	189
5.0	Executive Summary	189
5.1	Introduction	191
5.2	Impact of BIM on Design Services	194
5.3	BIM Use in Design and Engineering Processes	196
5.3.1	Conceptual Design	197
5.3.2	Design Development	215
5.3.3	Prefabrication	224
5.3.4	Construction Documentation	224
5.3.5	Design Review	230
5.3.6	Drawing Generation and Document Production	234
5.4	Building Object Models and Libraries	237
5.4.1	Embedding Expertise into Building Components	238
5.4.2	Object Libraries	240
5.4.3	BIM Object Portals	243
5.5	Considerations in Adoption for Design Practice	243
5.5.1	Justification for Information Modeling Cost	244
5.5.2	From Conceptual Design to Construction	246
5.6	Generative Design: The Yeosu–Namhae Underwater Tunnel	248
5.7	Advanced Delivery of Structural Design Information: Nine The Esplanade, Elizabeth Quay Project	251
5.7.1	Conventional Delivery of Construction Information	253
5.7.2	Advanced Delivery of Construction Information	253
5.7.3	BIM Process	254
5.7.4	The Impact	257
	Chapter 5 Discussion Questions	258
CHAPTER 6	BIM for Contractors	261
6.0	Executive Summary	261
6.1	Introduction	264
6.2	Types of Construction Firms	264
6.3	Information Contractors Want From BIM	266

6.4	BIM-Enabled Process Change	268
6.4.1	Virtual Construction	268
6.4.2	Leaner Construction	269
6.4.3	Paperless Construction	271
6.4.4	Increased Distribution of Work	271
6.4.5	Digital Twin Construction	273
6.5	Developing a Construction Building Information Model	273
6.5.1	BIM for Tendering	276
6.5.2	Product and Process Detailing	276
6.5.3	Big Room Colocation	280
6.5.4	Using a Contractor Building Information Model	282
6.6	3D: Visualization and Coordination	283
6.7	4D: Construction Analysis and Planning	287
6.7.1	4D Models to Support Construction Planning	288
6.7.2	Benefits of 4D Models	289
6.7.3	BIM Tools with 4D Capability	292
6.7.4	BIM-Supported Planning and Scheduling Issues and Guidelines	296
6.8	5D: Quantity Takeoff and Cost Estimating	297
6.8.1	Extracting Quantities from BIM Models for Estimating	298
6.8.2	Guidelines and BIM Implementation Issues to Support Quantity Takeoff and Estimating	300
6.9	Production Planning and Control	302
6.10	Off-Site Fabrication and Modular Construction	304
6.11	BIM in the Field	306
6.11.1	Delivering Design Information to the Field	306
6.11.2	Coordinating Production	310
6.11.3	Surveying Site Conditions	311
6.11.4	Monitoring Construction Progress	316
6.12	Cost and Schedule Control and Other Management Functions	318
6.13	Commissioning and Turnover	321
	Chapter 6 Discussion Questions	322
CHAPTER 7	BIM for Subcontractors and Fabricators	325
7.0	Executive Summary	325
7.1	Introduction	326

7.2	Types of Subcontractors and Fabricators	328
7.2.1	Subcontractor Trades	329
7.2.2	Made-to-Stock and Made-to-Order Component Suppliers	331
7.2.3	Engineered-to-Order Component Fabricators	332
7.2.4	Design Service Providers and Specialist Coordinators	333
7.2.5	Full-Service Design-Build Prefabricated and Modular Construction	334
7.2.6	Design for Manufacture	334
7.3	The Benefits of a BIM Process for Subcontractor Fabricators	335
7.3.1	Marketing and Tendering	337
7.3.2	Reduced Production Cycle Times	338
7.3.3	Fewer Design Coordination Errors	339
7.3.4	Lower Engineering and Detailing Costs	343
7.3.5	Increased Use of Automated Manufacturing Technologies	344
7.3.6	Increased Preassembly, Prefabrication, and Modular Construction	346
7.3.7	Quality Control, Supply Chain Management, and Lifecycle Maintenance	347
7.4	Generic BIM System Requirements for Fabricators	349
7.4.1	Parametric and Customizable Parts and Relationships	350
7.4.2	Reporting Components for Fabrication	353
7.4.3	Interface to Management Information Systems	354
7.4.4	Interoperability	355
7.4.5	Information Visualization	355
7.4.6	Automation of Fabrication Tasks	357
7.5	Specific BIM Requirements for Fabrication	357
7.5.1	Traditional ETO Component Fabricators	357
7.5.2	Modular Construction	365
7.5.3	3D Printing and Robotic Construction	367
7.6	Adopting BIM in a Fabrication Operation	368
7.6.1	Setting Appropriate Goals	369
7.6.2	Adoption Activities	370
7.6.3	Planning the Pace of Change	371
7.6.4	Human Resource Considerations	373

7.7	Focchi Group's Use of BIM for High-End Curtain Wall Design, Fabrication, and Installation	373
7.7.1	The Company and Its Services	373
7.7.2	BIM Adoption	376
7.7.3	Information System Architecture	377
7.7.4	Façade Layout Design and Coordination	378
7.7.5	Detailed Design for Production of Parts	381
7.7.6	Smart Construction Site	382
7.7.7	Future Development	383
	Chapter 7 Discussion Questions	385
CHAPTER 8	Facilitators of BIM Adoption and Implementation	387
8.0	Executive Summary	387
8.1	Introduction	388
8.2	BIM Mandates	389
8.2.1	Significance of Government BIM Mandates	390
8.2.2	The Status of Government BIM Mandates Around the World	394
8.2.3	Motivations	395
8.2.4	BIM Requirements	395
8.2.5	Challenges and Considerations	396
8.3	BIM Roadmaps, Maturity Models, and Measures	397
8.3.1	BIM Roadmaps	397
8.3.2	BIM Maturity Models	403
8.3.3	BIM Measures	406
8.4	BIM Guides	407
8.4.1	BIM Guides by Region and Organization	408
8.4.2	BIM Guides by Topic	410
8.5	BIM Education and Training	411
8.5.1	Transition of Senior Staff	412
8.5.2	BIM Roles and Responsibilities	413
8.5.3	Industry Training and Certificate Programs	416
8.5.4	University Education Programs	420
8.6	Considerations for Adoption and Deployment	421
8.7	Legal, Security, and Best Practice Issues	423
8.7.1	Legal and Intellectual Property Issues	423
8.7.2	Cyber Security for BIM	426
8.7.3	Best Practices and Other Social Issues	427
	Chapter 8 Discussion Questions	428

CHAPTER 9	The Future: Building with BIM	431
9.0	Executive Summary	431
9.1	Introduction	433
9.2	BIM Before 2000: Predicting Trends	434
9.3	Development and Impact of BIM from 2000 to 2020	439
9.3.1	Impact on Owners: Better Options, Better Reliability	439
9.3.2	Impact on the Design Professions	443
9.3.3	Impact on Construction Companies	444
9.3.4	Impact on Building Material and Component Suppliers	446
9.3.5	Impact on Construction Education: Integrated Education	446
9.3.6	Impact on Statutory Authorities: Model Access and Review	446
9.3.7	Impact on Project Documentation: On-Demand Drawings	447
9.3.8	Impact on BIM Tools: More Integration, More Specialization, More Information	448
9.4	Current Trends	449
9.4.1	Process Trends	449
9.4.2	Technology Trends	453
9.4.3	Commercial Trends	455
9.4.4	Innovation Trends	456
9.4.5	Obstacles to Change	458
9.5	Vision 2030	459
9.5.1	Thoroughly Digital Design	459
9.5.2	Artificial Intelligence in Design	461
9.5.3	Automated Code Checking	462
9.5.4	Support for Sustainable Construction	463
9.5.5	Off-site Construction	465
9.5.6	Globalization	466
9.5.7	AI and Robotics in Construction	466
9.5.8	Digital Twin Construction	468
9.5.9	Semantically Connected Information	470
9.6	BIM Beyond 2030	474
	Chapter 9 Discussion Questions	477
	Glossary	479
	References	489
	Index	509

