

Building Information Modeling

BIM in Current and Future Practice

Karen M. Kensek,
LEED BD+C, Assoc. AIA

Douglas Noble, FAIA, PhD

WILEY

Contents

	Foreword	xvii
	Acknowledgments	xxi
	Introduction	xxiii
	Software Mentioned	xxxii
PART 1	Design Thinking and BIM	1
CHAPTER 1	Smart Buildings/Smart(er) Designers: BIM and the Creative Design Process	
	<i>Glenn Goldman</i>	
	<i>Andrzej Zarzycki</i>	
	1.1 Introduction	3
	1.2 Evaluation of Visual Information: Form	5
	1.3 Generative Abilities of Parametric Models	6
	1.4 How Lighting, Thermal, and Structural Considerations Can Drive the Design	6
	1.5 Limitations of Current Parametric Models	8
	1.6 Physics and Materiality	9
	1.6.1 Solving for Multiple Criteria	10
	1.6.2 Other Data Types	10
	1.6.3 Soft Constraints	11
	1.7 Design and Construction 2.0	12
	1.7.1 Context-Aware Data	12
	1.7.2 Beyond a Single Lifespan of the Project	13
	1.8 Conclusion	15
	Discussion Questions	15
	Bibliography	16
CHAPTER 2	Necessity of Cognitive Modeling in BIM's Future	17
	<i>Omer Akin</i>	
	2.1 Introduction: Some Useful Concepts	17
	2.2 Building Information Modeling: The Brand New World of Design Computing	20
	2.3 Cognitive Strategies for BIM: Challenges and Opportunities	21
	2.4 Conclusions	26
	Discussion Questions	26
	References	27

Contents

CHAPTER 3	Modeling Architectural Meaning	29
	<i>Mark J. Clayton</i>	
	3.1 Introduction	29
	3.2 Architectural Ontology	30
	3.3 Regulating Lines	30
	3.4 Diagrams and Semantics	36
	3.5 Types	38
	3.6 Conclusion	40
	Discussion Questions	40
	References	41
CHAPTER 4	Knowledge-Based Building Information Modeling	43
	<i>Hugo Sheward</i>	
	<i>Charles Eastman</i>	
	4.1 The Potential of Building Information Modeling (BIM) to Capture Design Expertise	43
	4.2 "Vanilla BIM" versus Knowledge-Based BIM	44
	4.3 What Is Design Expertise?	44
	4.3.1 Heuristics Applied to Design Processes	45
	4.3.2 Design Workflows and Knowledge-Based BIM	46
	4.4 Capturing and Deploying Design Expertise	47
	4.4.1 Capturing Design Expertise	47
	4.4.2 Embedding Knowledge in BIM	47
	4.4.3 Example 1: Building Service Core	49
	4.4.4 Example 2: Ventilation in Laboratories	50
	4.5 Examples of Deployment	53
	4.5.1 Deployment in Manufacturing	53
	4.5.2 Uses in Architecture, Engineering, and Construction	53
	4.6 Summary	54
	Discussion Questions	54
	References	55
PART 2	BIM Analytics	57
CHAPTER 5	Parametric BIM SIM: Integrating Parametric Modeling, BIM, and Simulation for Architectural Design	59
	<i>Wei Yan</i>	
	5.1 Executive Summary	59
	5.2 Introduction	59
	5.2.1 Parametric Modeling	60
	5.2.2 BIM and Parametric BIM	60
	5.2.3 Building Energy Simulation	61
	5.2.4 A Streamlined Modeling Process	63
	5.3 Complexity and Interfaces	65

5.3.1 Complexity and Computability	65
5.3.2 User Interfaces and System Interfaces	66
5.4 Case Studies	69
5.4.1 Physical BIM for Thermal and Daylighting Simulations	69
5.4.2 Parametric BIM-Based Energy Optimization	72
5.5 Conclusion	74
Acknowledgments	74
Discussion Questions	74
References	75

CHAPTER 6	Models and Measurement: Changing Design Value with Simulation, Analysis, and Outcomes	79
	<i>Phillip G. Bernstein</i>	
	<i>Matt Jezyk</i>	
6.1	Introduction	79
6.2	BIM 1.0	80
6.3	Analysis and Simulation through BIM 1.0	80
6.4	BIM 2.0	83
6.5	Geometry, Behavioral Properties, Parameters, and Analysis	85
6.6	Ideation and Design Production under BIM 2.0	89
6.7	Design Empowerment	91
6.8	Conclusion: Avenues to Alternative Value Generation	91
	Discussion Questions	92
	References	93

CHAPTER 7	Energy Modeling in Conceptual Design	95
	<i>Timothy Hemsath</i>	
7.1	Introduction	95
7.2	Building Performance Simulation (BPS)	95
7.3	BIM's Role in the Process	97
7.4	Conceptual Design Decisions	98
7.5	Sensitivity Analysis and Optimization	101
7.5.1	Sensitivity Analysis	101
7.5.2	Conceptual Design Optimization	102
7.6	BIM Affordances	105
7.7	Conclusion	107
	Acknowledgments	107
	Discussion Questions	107
	References	108

CHAPTER 8	Performance Art: Analytics and the New Theater of Design Practice	109
	<i>Daniel Davis</i>	
	<i>Nathan Miller</i>	
8.1	Introduction	109

	8.2 Instruments	1 10
	8.3 Analytics	112
	8.4 Interactions	1 15
	8.5 Conclusion: Algorithms Are Thoughts	1 16
	Discussion Questions	117
	References	1 17
CHAPTER 9	Automated Energy Performance Visualization for BIM	1 19
	<i>Paola Sanguinetti</i>	
	<i>Past Paasiala</i>	
	<i>Charles Eastman</i>	
	9.1 Introduction	1 19
	9.2 Case Study: Automated Analysis of U.S. Courthouse Models for GSA	1 20
	9.2.1 Preliminary Concept Design (PCD)	120
	9.2.2 Post-Processing for Energy Analysis	1 20
	9.2.3 Building Model Property Definition	1 23
	9.3 Performance Visualization	123
	9.3.1 Aggregation of Simulation Output Variables	1 24
	9.3.2 Visualization of Thermal Flows	1 24
	9.4 Discussion	125
	9.5 Conclusion	1 27
	Acknowledgments	127
	Discussion Questions	1 27
	References	127
CHAPTER 10	Urban Energy Information Modeling: High Fidelity Aggregated Building Simulation for District Energy Systems	1 29
	<i>Nina Baird</i>	
	<i>Shalini Ramesh</i>	
	<i>Henry Johnstone</i>	
	<i>Khee Poh Lam</i>	
	10.1 Introduction	1 29
	10.2 Understanding District Energy Systems	1 29
	10.3 Community Energy Planning	130
	10.4 Dynamic Energy Mapping	1 32
	10.4.1 An Initial Example: Pittsburgh's Lower Hill District	1 32
	10.4.2 Urban Energy Simulation of the Lower Hill District	1 33
	10.4.3 Future Improvements Using Cloud Services	1 34
	10.4.4 First Order District System Analysis	1 35
	10.4.5 Data Visualization for Time-of-Use Aggregate Load Profiles	1 36
	10.4.6 Interpreting Lower Hill District Results	1 37
	10.5 The Future: BIM in Urban Energy Information Modeling	1 39
	Discussion Questions	140
	References	140

CHAPTER 11	BIM and the Predesign Process: Modeling the Unknown	143
	<i>Michael Donn</i>	
11.1	Introduction	143
11.1.1	Current BIM Concepts Limit Performance Analysis	144
11.1.2	Performance Analysis in Early Design	144
11.2	Limits of Traditional Early Design Analysis	145
11.2.1	The Promise of BIM in Early Design	145
11.2.2	Performative (Generative) Design as a Solution	145
11.2.3	Daylight Design Example of Limits of Traditional Analysis	147
11.2.4	Modern Performance Metrics in Daylight Design	147
11.3	BIM-Based Detailed Performance Analysis	149
11.3.1	A BIM Is More than a Representation of a Building	149
11.3.2	The Role of the Analyst in Performance Simulation	150
11.3.3	Tools for Rapid Evaluation of Design Scenarios	152
11.4	Conclusion: Inventing a New BIM for Early Design Analysis	153
	Discussion Questions	154
	References	154
CHAPTER 12	Analytical BIM: BIM Fragments, Domain Gaps, and Other Impediments	157
	<i>Karen M. Kensek</i>	
12.1	Introduction	157
12.2	Analytical Modeling	157
12.3	Building Information Modeling	158
12.4	Levels of BIM	159
12.4.1	Pre-BIM: Planning Stages	161
12.4.2	BIM Light: A Component-Based 3D Model	161
12.4.3	BIM + Information	161
12.4.4	BIM + Knowledge	162
12.4.5	BIM + Decisions	163
12.5	FDEIC Knowledge	164
12.6	Feedback Loop	165
12.7	Fragment BIMs and Three Gaps	166
12.7.1	Architect to Energy Consultant	167
12.7.2	Architect to Contractor	167
12.7.3	Architect and Contractor to Facilities Manager and Owner	169
12.8	Conclusion	170
	Acknowledgments	170
	Discussion Questions	170
	References	171
PART 3	Comprehensive BIM	173
CHAPTER 13	One BIM to Rule Them All: Future Reality or Myth?	175
	<i>Brian R. Johnson</i>	
13.1	Introduction	175

1 3.2 A Brief History of the Single Model	175
1 3.3 The 2D Interregnum	176
13.3.1 Drawings versus Models	176
1 3.4 What's Wrong with This Picture?	177
13.4.1 Task Complexity	177
13.4.2 Software Complexity	179
13.4.3 When a Model Isn't Enough: Data versus Process	1 80
13.4.4 Limitations on Data as an Expression of Intent	1 81
13.4.5 People and Cognition	1 82
1 3.5 One BIM to Rule Them All?	183
Discussion Questions	1 84
References	184
 CHAPTER 14 Component-Based BIM: A Comprehensive, Detailed, Single-Model Strategy	 187
<i>Anton C. Harfmann</i>	
14.1 Executive Summary	1 87
14.2 The Wicked Problem of Making Architecture	1 88
14.2.1 Design Complexity and Uniqueness	188
14.2.2 Fragmentation and Multiple Representations	1 89
14.2.3 Redesign and Discovery	1 89
14.3 Implementing Component-Based Design	190
14.3.1 The Component-Based Paradigm: Overview	190
14.3.2 Product/Manufacturer Links	191
14.3.3 External Reasoning	191
14.3.4 BIM-Driven Component Modeling	192
14.3.5 Component-Based Model Example	192
14.3.6 Component Model as Authority	195
14.4 Conclusion	195
Discussion Questions	196
References	196
 CHAPTER 15 BIM Ecosystem: The Coevolution of Products, Processes, and People	 197
<i>Ning Gu</i>	
<i>Vishal Singh</i>	
<i>Kerry London</i>	
15.1 Introduction	197
15.2 Coevolution of Products, Processes, and People	198
15.3 Understanding the Industry Context of BIM	199
15.3.1 Fundamental Characteristics of BIM and Their Evolution	199
15.3.2 Industry Perception of BIM-Related Products, Processes, and People	201
15.4 Establishing a BIM Ecosystem: Operational and Support	
Technical Requirements in BIM	202
15.5 Establishing a BIM Ecosystem: Collaborative Platform BIM	
Decision Framework	203
15.5.1 Current Scope and Development of the Decision Framework	203

15.5.2	Sections of the Decision Framework for BIM Implementation	204
15.5.3	Applying the Decision Framework in Collaborative Practice	204
15.6	Discussion and Future BIM Ecosystem	207
15.6.1	Key Issues and Implication of Future BIM Ecosystem	207
15.6.2	Preparing for Future BIM Ecosystem	208
	Discussion Questions	209
	References	209
PART 4	Reasoning with BIM	21 1
CHAPTER 16	BIM, Materials, and Fabrication	213
	<i>Christopher Beorkrem</i>	
16.1	The Uber-Detail	21 3
16.2	Materials	214
16.3	The Logic of Materiality	215
16.4	Soft Data	21 8
16.5	Backward BIM	220
16.6	BIM, Materials, and Fabrication	222
16.7	Going Forward	222
16.8	Conclusion	223
	Discussion Questions	224
	References	224
CHAPTER 17	Communicating Semantics through Model Restructuring and Representation	225
	<i>Ramesh Krishnamurti</i>	
	<i>Varvara Toulkeridou</i>	
	<i>Tajin Biswas</i>	
17.1	Introduction	225
17.2	Spatial Reasoning and Querying	227
17.2.1	BIM as an Infrastructure for Spatial Reasoning	227
17.2.2	Extraction, Restructuring, Representation	227
17.2.3	Spatial Topology Data Extraction from IFC	228
17.2.4	Prototype for Spatial Topology Queries	229
17.3	Reasoning for Green Certification	230
17.3.1	Aggregation, Augmentation, Representation	231
17.3.2	Prototype for Green Certification	232
17.4	Conclusion	233
	Discussion Questions	233
	References	234
CHAPTER 18	BIM as a Catalyst to Foster Creativity through Collaboration	237
	<i>Murali Paranandi</i>	
18.1	Introduction	237
18.2	The Role of Collaboration in Design	238

18.3 Social Framework	238
18.3.1 The Human Side	239
18.3.2 Define and Manage Roles	240
18.3.3 Co-locating to Facilitate Dialog	241
18.4 Computational Workflows	242
18.4.1 Tools for Designing and Collaborating	242
18.4.2 Collaborative Prototyping	243
18.4.3 Crowdsourcing	244
18.4.4 Knowledge Capture and Sharing in the Cloud	245
18.5 Conclusion	247
18.5.1 Feedback to Academia	247
18.5.2 Feedback to the Profession	247
Acknowledgments	248
Discussion Questions	248
References	248
CHAPTER 19 BIM and Virtual Reconstruction: A Long-Term View of (Re-)Modeling	251
<i>Bob Martens</i>	
<i>Herbert Peter</i>	
19.1 Executive Summary	251
19.2 Introduction	252
19.3 BIM and Virtual Reconstruction	253
19.4 Information Basis: Model Tree Structures	257
19.5 Model Porting and Data Exchange	261
19.5.1 Model Porting	262
19.5.2 Data Exchange	262
19.6 Outlook: Where Do We Go from Here?	263
19.7 Conclusion	264
Discussion Questions	264
References	264
PART 5 Professional BIM	267
CHAPTER 20 Managing BIM Projects, Organizations, and Policies: Turning Aspirations into Quantitative Measures of Success	269
<i>Calvin Kam</i>	
20.1 Introduction	269
20.2 Scorecard Methodology	270
20.3 Project Evaluation	272
20.4 Continuous Evaluation	275
20.5 Performance Indicators	276
20.6 Portfolio Evaluation	277
20.7 Country-Level BIM Evaluations	278
20.8 Conclusion	279

Acknowledgments	280
Discussion Questions	280
References	280

CHAPTER 21	Space: The First (and Final) Frontier of BIM	281
	<i>Stephen R. Hagan</i>	
21.1	Introduction	281
21.2	Historical Perspectives of Space and the Facility Life Cycle	282
21.3	Space, Measurement, and BIM	282
21.4	BIM Spatial Pioneers: Coast Guard and GSA	283
21.5	Project Spatial BIM: Connecting Program to Design, Construction, and Facility Management	288
21.6	Geospatial, Campus-Wide, and Services-Oriented Spatial BIM	289
21.7	Standardizing Spatial BIM: IFMA-BOMA, BISDM, CityGML, and Indoor Navigation	290
21.8	Conclusion	290
	Discussion Questions	292
	References	292
CHAPTER 22	Translating Designs for Construction + Operations: The Future of BIM in a World of Material and Energy Scarcity	295
	<i>Franca Trubiano</i>	
22.1	Buildings, Information, and Modeling	295
22.1.1	The Promise	295
22.1.2	The Critique	296
22.2	The Changing Character of Architectural Representations	297
22.3	Facilitating the Translation from Design to Construction—with Matter	299
22.4	Facilitating the Translation from Design to Operations—with Energy	308
22.5	Conclusion	310
	Discussion Questions	311
	References	311
CHAPTER 23	Marx, BIM, and Contemporary Labor	313
	<i>Peggy Deamer</i>	
23.1	BIM and Work	313
23.2	BIM Managers: What They Are Doing	314
23.2.1	Design versus Technology	314
23.2.2	Networked Tasks	315
23.2.3	Political/Organizational Change	316
23.3	The Enactment of Enlightened Management Theory	317
23.4	Conclusion: Post-Capitalist Architecture	319
	Discussion Questions	319
	References	319

BIM Speculation	321
Beyond BIM: Next-Generation Building Information Modeling to Support Form, Function, and Use of Buildings	323
<i>Yehuda E. Kalay</i>	
<i>Davide Schaumann</i>	
<i>Seung Wan Hong</i>	
<i>Davide Simeone</i>	
24.1 Rationale	323
24.2 The Shortcomings of BIM	325
24.3 Form, Function, Use	327
24.3.1 Form	327
24.3.2 Function	327
24.3.3 Use	328
24.4 Dependencies	329
24.4.1 Form versus Function	329
24.4.2 Form versus Use	330
24.4.3 Function versus Use	330
24.5 Objectives	330
24.6 Methodology	330
24.7 Implementation	331
24.8 Conclusion	334
Acknowledgments	334
Discussion Questions	334
References	334
Engines of Information: Big Data from Small Buildings	337
<i>Chandler Ahrens</i>	
<i>Aaron Sprecher</i>	
25.1 Introduction	337
25.2 Data to Information	338
25.3 Looking through the Lens of Data	340
25.4 Building an Information Model	342
25.5 The Present Future	343
25.6 IM: Drop the (B)	344
25.7 Information to Knowledge	347
25.8 Conclusion	347
Discussion Questions	347
References	348
BIM and MetaBIM: Design Narrative and Modeling Building Information	349
<i>Mark Burry</i>	
26.1 Background to a Series of Dilemmas	349
26.2 A Case in Point: The Sagrada Familia Basilica <i>Sala Creuer</i>	351

26.2.1 <i>Sala Creuer</i> Documentation	351
26.2.2 Project Phases	352
26.3 Creative Digital Workflow as BIM	357
26.4 Watch This Space . . .	360
Acknowledgments	362
Discussion Questions	362
Glossary	363
Author Biographies	373
Index	385