Example 7.14 Elevator Design Process

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Problem Statement

The Industry Foundation Classes (IFC) project is the world's largest effort to date aimed at standardizing the representation of building product and process knowledge. IFCs are developed by an international nonprofit organization named BuildingSMART and have become widely accepted as the international standard. The process modeling methods used in the IFC development are IDEF0 and Business Process Modeling Notation (BPMN). This study observed two important limitations of the IFC process modeling:

- IDEF0 and BPMN are only able to create well-structured models when the activities include a sufficient level of detail. They represent the dependencies in the process in a limited way, so it is difficult to see the true architecture of the process.
- The tools were employed in merely a top-down fashion, where the modeling begins at a high level and is decomposed as needed. However, it is also useful to go backward (i.e., to use the deliverables as building blocks and integrate the model from the bottom-up). This also helps to verify the accuracy of the interactions in the model.

Thus, this study demonstrated the complementary use of parameter-based DSM models with conventional higher level process models in the construction industry.

Data Collection

We applied the parameter-based DSM modeling in a case study of elevator design. An architectural office, its engineering collaborators, and an elevator provider participated in the study. Sule Tasli Pektas collected the data through inspection of design documents and interviews with designers over five months.

First, higher level IDEF0 process models of the elevator design process were produced in compliance with the IFC process modeling notation. Then a parameter-based DSM model of the process was developed to provide better insights into the processes. The data collection process was highly iterative; the draft models were often revised according to the comments received from the participants.

Model

In the DSM model shown in figure 7.14.1, marks in a row represent inputs to a parameter decision while marks in a column represent the output results of the parameter decision (IR/FAD convention). Colors associate the parameter decisions with higher level activities. Parameters highlighted in red on the diagonal are critical ones that would appear to cause large iteration cycles in the process.

Results

This bottom-up, parameter-based approach provided new insights into the higher level tasks and allowed the improved process to be based on the rational and natural information flows rather than superficial assumptions. To illustrate how the parameter-based DSM helped to improve the higher level models in the case study, a simple example was extracted from the large models.

Figure 7.14.2 shows two coupled activities in the elevator design process. However, the detailed structure within this cycle (i.e., which parameter decisions within the activities depend on each other) is not clear from either the IDEF0 view (a) or from the high-level activity-based DSM (b).

However, the parameter-based DSM decomposes the two-coupled activities to the parameter level. This shows the parameter decisions in a more detailed process map (figure 7.14.3a). When this DSM is resequenced, the appropriate ordering of decisions is obtained, and, in this case, the iteration is removed from the process (figure 7.14.3b). As a result, the parameters in the process can be regrouped into three activities instead of the original two. In this way, the integrated process model can be based on the more detailed information flows rather than just the overview activities.

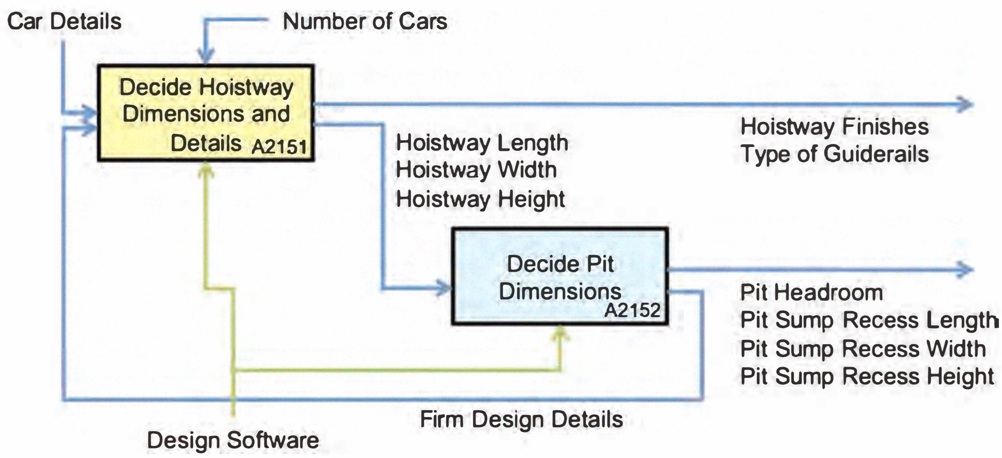
Of course, this example is simple, and in many cases iteration cannot be totally removed from engineering design processes. However, we applied this approach in two case studies in building design, and we believe that the findings of these studies supported the complementary uses of the parameter-based DSM with the conventional IFC process models.

One challenge of the parameter-based DSM observed in this study is the large number of parameters to be determined by the design processes. However, capturing and managing all parameter decisions in a process may not be necessary. In order to increase the efficiency of the models, the parameter-based DSM decomposition can be used only for the problematic activities such as highly coupled activities, activities that involve many actors, or critical activities that tend to cause delays in the process. Thus, this study demonstrated the functionality of the parameter-based DSM. We believe that this procedure can be further explored and exploited in many ways.

		1 Building Type	2 Building Style	3 Tenancy Type	4 Floor Area	5 Building Structure Layout	6 Number of Floors Served above Main Terminal	7 Average Interfloor Distance	9 Passenger Arrival Rate	8 Building Population	10 Uppeak Interval	11 Average Number of Passengers per Trip	12 Contract Capacity	13 Average Highest Call Reversal Floor	14 Average Number of Stops	15 Contract Speed	16 Single Floor Transit Time	17 Car Door Opening Configuration	18 Door Opening/Closing Time	19 Time Consumed when Stopping	20 With Gearing	21 Floor Cycle Time	22 Average Passenger Transfer Time	23 Round Trip Time	24 Uppeak Handling Capacity	25 Number of Elevators	26 Car Door Width	27 Elevator Type	28 Car Width	29 Car Depth	31 Car Grouping	32 Structural Frame LH Side Clearance	33 Structural Frame RH Side Clearance	34 Structural Frame Rear Clearance	35 Structural Frame Front Clearance	36 Landing Clearance	37 Hoistway Width	38 Hoistway Depth
Building Type	1	1																																				
Building Style	2		2																																			
Tenancy Type	3	X		3																																		
Floor Area	4				4																																X	X
Building Structure Layout	5					5																									X						X	X
Number of Floors Served above Main Terminal	6						6																															
Average Interfloor Distance	7							7																														
Passenger Arrival Rate	9	X							9																													
Building Population	8	X	X	X	X					8																												
Uppeak Interval	10	X									10													X		X												
Average Number of Passengers per Trip	11									X	X	11	X																									
Contract Capacity	12	X									X		12																									
Average Highest Call Reversal Floor	13						X					X	X	13																								
Average Number of Stops	14												X		14																							
Contract Speed	15	X					X						X			15					X																	
Single Floor Transit Time	16	X						X								X	16																					
Car Door Opening Configuration	17												X					17																				
Door Opening/Closing Time	18																	X	18																			
Time Consumed when Stopping	19																X			19		X																
With Gearing	20															X					20																	
Floor Cycle Time	21																X		X			21																
Average Passenger Transfer Time	22	X																X					22				X		X	X								
Round Trip Time	23											X		X	X		X			X			X	23														
Uppeak Handling Capacity	24										X	X												X	24	X												
Number of Elevators	25										X		X											X	X	25			X	X							X	X
Car Door Width	26									X			X					X									26											
Elevator Type	27						X											X									X	27										
Car Width	28												X													X	X	X	28								X	
Car Depth	29												X													X		X		29								X
Car Grouping	31				X	X																							X	X	31							
Structural Frame LH Side Clear nce	32																															32						

Figure 7.14.1
A partial view of the partitioned DSM model of the elevator design process.

(a)



(b)

		1	2
Decide Hoistway Dimensions and Details	1		X
Decide Pit Dimensions	2	X	

Figure 7.14.2
Two coupled activities in the elevator design process: IDEF0 view (a) and activity-based DSM view (b).

		1	2	3	4	5	6	7	8	9
Hoistway Width	1									
Hoistway Depth	2									
Hoistway Height	3	X	X				X			
Hoistway Finishes	4	X	X							
Type of Guiderails	5			X						
Pit Headroom	6									
Pit Sump Recess Length	7		X							
Pit Sump Recess Width	8	X								
Pit Sump Recess Depth	9									

(a)

		1	2	4	6	3	5	7	8	9
Hoistway Width	1									
Hoistway Depth	2									
Hoistway Finishes	4	X	X							
Pit Headroom	6									
Hoistway Height	3	X	X		X					
Type of Guiderails	5					X				
Pit Sump Recess Length	7		X							
Pit Sump Recess Width	8	X								
Pit Sump Recess Depth	9									

(b)

Figure 7.14.3
Two coupled activities of the elevator design process: the initial parameter-based DSM (a) and the resequenced DSM (b).

References

Pektas, Sule T. 2010, July. *The Complementary Use of the Parameter-Based Design Structure Matrix and the IFC Process Models for Integration in the Construction Industry*. Proceedings of the 12th International Dependency Structure Modelling (DSM) Conference: Managing Complexity by Modelling Dependencies, Cambridge, UK, pp. 389–402.

Pektas, Sule T., and Mustafa Pultar. 2006. Modelling Detailed Information Flows in Building Design with the Parameter-based Design Structure Matrix. *Design Studies* 27 (1):99–122.