Chapter 11
The Mutum-Paraná II Bridge Project (B)

Abstract The case description of this chapter is a follow-up exercise of the case of Chap. 6 and also acts as an integrated exercise to get acquainted with the scheduling principles discussed in Part II of this book. The primary goal of this fictitious case study is to get acquainted with project scheduling software and to construct a feasible resource-constrained project schedule, which is clearly understandable by all project stakeholders. The goal of the student is to go further than submitting software print-outs to the project team. Instead, the purpose is the integration of the resource-constrained scheduling principles of the previous chapters within the features of a project scheduling tool in order to provide an easy and understandable information sheet on the predicted project execution to the various members of a project team.
Similar to the first case study, the topic of this chapter can also be used to teach extended scheduling principles, such as the use of CC/BM scheduling principles, the incorporation of other scheduling objectives in a resource-constrained project setting, and many more. In this chapter, only the case description is given. The solution and the educational approach depend on the wishes and needs of the students who solve the case and the teacher who can act as the moderator during the case teaching session.

11.1 Introduction

The second longest river in South America after the Amazon, the Paraná River joins with the Paraguay and Uruguay Rivers before emptying into the Ro de la Plata estuary on its way to the Atlantic Ocean. The river begins its 3,032-mile (4,879-km) course in east-central Brazil. The Paraná flows mainly among high plateaus through Paraguay and Argentina.

The Brazilian company Curitiba Pontes Ltd. has been awarded for the construction of the Mutum-Paraná II bridge over the river Paraná. The river Paraná in Argentina was the last obstacle in the highway project. This highway was a promise

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from the government to the poor people of the interior to link their region to Buenos Aires. Therefore large investments were made to stimulate the economy.

A team meeting was held last week in which initial estimates about the project activity duration have been reviewed and updated, resource requirements and risk numbers have been analyzed, proposed and evaluated. Exactly 1 week later, the team received a detailed outline of the different activities from Orlando Carvalheiro, in which all activities have been described into detail, with a more precise duration estimate and the nine most important resources. Management has instructed Orlando for a project finish at the earliest possible time. They have requested a complete plan.

11.2 The Project in Detail

José Silva Coelho opened the team meeting with the announcement that the executive committee of Curitiba Pontes Ltd. confirmed the starting date for the project of January 2nd, 2012 and asked Orlando to project a completion date with his submission of the plan. The committee's request implied that whatever date Orlando came up with was acceptable, but Orlando knew that he would be expected to keep the project lead-time under control.

Orlando noticed that the final project deadline proposed last week (February 25th, 2013) would be an unfair and unrealistic estimate. He was proud about the detailed analysis of the project and presented the detailed information in a long and monotone monologue about the various project activities and their need for resources. The major parts of this overwhelming monologue of Orlando were accompanied by a detailed description and tables with the technological precedence relations between the activities and the resource requirements (see Tables 11.2 and 11.3). Maria Mota Pereira was proud to tell the team that the resource problem at the beginning of the project was solved, and presented a detailed outline of the availability of all resources necessary to complete the project with success (Table 11.1).

During the previous meeting held last week, Carlos Garez expressed his concern regarding the possible unstable underground of the river banks. Today, he was proud

Table 11.1 The resource availability and cost for the highway bridge construction project

Description	Availability	Cost/h
Crane	1	150
Pile driver man	4; 2 (June, July and August)	60
Carpenter	7	60
Labourer	12	40
Iron worker	4; 2 (July and August)	60
Equipment operator	2	60
Oiler	1	60
Cement mason	2	100
Truck driver	2	60

Table 11.2 The resource use for the highway bridge construction project

	Activity description	Time (weeks)	CR	PD	CA	LA	IW	EO	OI	CM	TD	MDC
1	Preparatory work and move in	6			3	5		2			2	
2	Mobilize pile rig 1	1	1	2		1		1	1		1	350
3	Mobilize pile rig 2	1	1	2		2		1	1		2	350
4	Mobilize pile rig 3	1	1	2		1		1	1		2	350
5	Excavate abutment 1	1				5		1				
6	Excavate abutment 2	1				5		1				
7	Excavate abutment 3	1				5		1				
8	Drive piles abutment 1	3		4	1	2		1	1			350
9	Drive piles abutment 2	3		4	1	2		1	1			350
10	Drive piles abutment 3	1		4	1	2		1	1			350
11	Demobolize pile rig 1	1	1	2		2		1	1		1	350
12	Demobolize pile rig 2	4	1	2		2		2	1		2	350
13	Demobolize pile rig 3	4	1	2		2		1	1		1	350
14	Forms, pour and strip footing 1	1			3	5		1	1	1		1,850
15	Forms, pour and strip footing 2	8			4	5		1	1	1		1,850
16	Forms, pour and strip footing 3	1			3	5		1	1	1		350
17	Forms, pour and strip abutment 1	2			6	10		1	1	1		1,850
18	Forms, pour and strip abutment 2	1			7	12		1	1	1		1,850
19	Forms, pour and strip abutment 3	2			6	10		1	1	1		1,850
20	Backfill abutment 1	4				4						
21	Backfill abutment 2	2				4						
22	Backfill abutment 3	3				4						
23	Set girders and forms deck 1–2	2			3	4	4	1	1			2,350
24	Set girders and forms deck 2–3	2			3	4	4	1	1			5,350
25	Pour deck	1			2	5		1	1	2		3,350
26	Saw joints	2				1						
27	Strip deck and rub concrete	1				7						
28	Clean up and final inspection	1				6						350

to present his report consisting of a detailed engineering study concluding that the unstable river banks problem due to the swirling water was no longer a threat for this project.

In addition, Orlando points out that labor costs in Argentina are extremely low due to the economic crisis. The accounting department told Orlando that he could estimate a cost of €40 per hour per employee (laborer) and €60 for other employees. Moreover, it is assumed that a working day contains 8 working hours (between 8.00 and 17.00 with 1 h break between 12.00 and 13.00) from Monday till Friday, resulting in a 40 h workweek. This information would enable him to provide a cash flow forecast along with his plan, which the chief accountant said would be expected. José knew that it was customary at Curitiba Pontes Ltd. to provide the following as parts of a plan to be submitted to the executive committee:

- Work breakdown structure.
- Network diagram.
- A Gantt-chart with the earliest possible project completion time that can be achieved with unlimited resources.
- The critical activities and milestones.
- Resource loading charts and cumulative labor requirements, for every resource separately and in total.
- A feasible project schedule satisfying the existing resource constraints that minimizes the project duration.
- A cash flow requirements graph for the project when leveled.
- A personal opinion on the project and a proposal to the management committee.

In the new detailed information it is stated that the government is willing to pay a bonus of €15,000 per week that the project end date can be moved forward. Knowing this, you are asked to find the ideal number of laborers to employ.

11.2.1 The Resources

The resource use is shown in the Table 11.2. Each resource has been abbreviated as follows: crane (CR), pile driver man (PD), carpenter (CA), laborer (LA), ironworker (IW), equipment operator (EO), oiler (OI), cement mason (CM) and truck driver (TD). The cost for material and other direct charges (MDC) have been indicated in the last column.

11.2.2 The Relations

The precedence relations between all activities are shown in Table 11.3.

Table 11.3 The minimal time-lag precedence relations for the highway bridge construction project (in weeks)

		Minimal time lags		
		SS	FS	FF
1	**2**	2		
	3		5	
	4		5	
	5		0	
	6		8	
	7		8	
2	**8**		0	
3	**9**		0	
4	**10**		0	
5	**8**		3	
6	**9**	6		
7	**10**	3		
8	**11**		0	
	14		0	
9	**12**		0	
	15		0	
10	**13**		0	
	16		0	
11	**17**		0	
12	**18**		0	
13	**19**		0	
14	**17**		0	
15	**18**		0	
16	**19**		0	
17	**20**		0	
	23		0	
18	**21**		0	
	23		0	
	24		0	
19	**22**		0	
	24		0	
20	**28**		0	
21	**28**		0	
22	**28**		0	
23	**25**	1		
24	**25**	1		
25	**26**		1	
	27		2	
26	**28**		0	
27	**28**			2