Continuing Integrative Class Project

It is now time to construct the project schedule. You may do this by hand or using a software package for project management as mentioned in Chapter 1. Begin with your WBS and determine the precedence relationships among the activities at the most detailed level of your project's WBS. Next, develop the three time estimates for each activity. Based on the precedence relationships and time estimates, create a network diagram for your project. Develop a simulation model for your project and determine the distribution of project completion times for your project. Finally, analyze your project and determine what deadlines will provide you and your team a 75 percent and 90 percent chance of completing the project on time.

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The following case presents a real project (in aggregate form) that allows the student to compare the critical path solution approach for both completion time and cost as well as a simulated solution for time variability and then also for both time and cost variability. The student should better understand the risk of projects running late and overbudget after this exercise.

Case

NutriStar Energy, Inc.[9] S. Shafer

Wesley James had recently arrived in Boston from Manchester, UK for a position as Project Owner at NutriStar Energy, Inc. He was now meeting with Ava Smith, President of NutriStar, to discuss his upcoming duties and responsibilities associated with their latest product, the Nutri-Sports Energy Bar.

As Ava explained: "NutriStar produces a line of vitamins and nutritional supplements. We recently introduced our Nutri-Sports Energy Bar, which is based on new scientific findings about the proper balance of macronutrients in the body. Fortunately, the energy bar has quickly become popular among elite athletes and others who focus on eating an optimal balance of macronutrients. One distinguishing feature of the Nutri-Sports Energy Bar is that each bar contains 50 milligrams of eicosapentaenoic acid (EPA), a substance strongly linked to reducing the risk of cancer but found in only a few foods, such as salmon. We were able to include EPA in our sports bars because we had previously developed and patented a process to refine EPA for our line of fish-oil capsules."

"Because of the success of the Nutri-Sports Energy Bar in the United States, we are considering offering it in Latin America. With our domestic facility currently operating at capacity, we have decided to investigate the option of adding approximately 10,000 square feet of production space to our facility in Latin America, at a cost of $5.1 million."

"This is where you come in, Wesley. The project to expand the Latin American facility involves four major phases: (1) concept development, (2) definition of the plan, (3) design and construction, and (4) start-up and turnover. During the concept development phase, a project owner, that will be you, is chosen to oversee all four phases of the project and given a budget to develop a plan. The outcome of the concept development phase consists of just a rough plan, feasibility estimates for the project, and a rough schedule. Also, a justification for the project and a budget for the next phase will be needed."

"In the plan definition phase, the project owner selects and works with a project manager to oversee the activities associated with this phase. Plan definition consists of four major activities that are completed more or less concurrently: (1) defining the project scope, (2) developing a broad schedule of activities, (3) developing detailed cost estimates, and (4) developing a plan for staffing. The outputs of this phase are combined into a detailed plan and proposal for management specifying how much the project will cost, how long it will take, and what the deliverables are."

"If the project gets management's approval and provides the appropriations, the project progresses to the third phase, design and construction. This phase consists of four major activities: (1) detailed engineering, (2) mobilization of the construction employees, (3) procurement of production equipment, and (4) construction of the facility. Typically, the detailed engineering and the mobilization of the construction employees are done concurrently. Once these activities are completed, construction of the facility and procurement of the production equipment are done concurrently. The outcome of this phase is the physical construction of the facility."

"The final phase, start-up and turnover, consists of four major activities: pre-start-up inspection of the facility, recruiting and training the workforce, solving start-up problems, and determining optimal operating parameters (called *centerlining*). Once the pre-start-up inspection is completed, the workforce is recruited and trained at the same time that start-up problems are solved. Centerlining is initiated upon the completion of these activities. The desired outcome of this phase is a facility operating at design requirements."

"The cost to complete an activity depends on both the amount of time required to complete the task and the cost rate of performing the activity. I have compiled two tables here for you. Table A provides optimistic, most likely, and pessimistic time estimates for the major activities. Table B provides similar estimates for the cost rates to complete the activities. Like time estimates, the cost rate to complete the facility expansion project can vary for a number of reasons such as using more or less expensive resources, price changes in labor and materials, the need to outsource work that was expected to be performed in-house, and so on. According to the data in Tables A and B, Concept Development is expected to cost $24,000, 12 months at $2,000/month."

TABLE A **Three Time Estimates for NutriStar Production Facility Expansion Project**

Activity	Optimistic Time (months)	Most Likely Time (months)	Pessimistic Time (months)
A: Concept Development	3	12	24
Plan Definition			
B: Define project scope	1	2	12
C: Develop broad schedule	0.25	0.5	1
D: Detailed cost estimates	0.2	0.3	0.5
E: Develop staffing plan	0.2	0.3	0.6
Design and Construction			
F: Detailed engineering	2	3	6
G: Facility construction	8	12	24
H: Mobilization of employees	0.5	2	4
I: Procurement of equipment	1	3	12
Start-up and Turnover			
J: Pre-start-up inspection	0.25	0.5	1
K: Recruiting and training	0.25	0.5	1
L: Solving start-up problems	0	1	2
M: Centerlining	0	1	4

TABLE B Three Cost Rate Estimates for NutriStar Production Facility Expansion Project

Activity	Optimistic Cost Rate ($/Month)	Most Likely Cost Rate ($/Month)	Pessimistic Cost Rate ($/Month)
A: Concept Development	1,900	2,000	2,300
Plan Definition			
B: Define project scope	23,750	25,000	28,750
C: Develop broad schedule	15,200	16,000	18,400
D: Detailed cost estimates	28,500	30,000	34,500
E: Develop staffing plan	27,000	30,000	33,000
Design and Construction			
F: Detailed engineering	360,000	400,000	440,000
G: Facility construction	112,500	125,000	156,250
H: Mobilization of employees	270,000	300,000	330,000
I: Procurement of equipment	360,000	400,000	440,000
Start-up and Turnover			
J: Pre-start-up inspection	90,000	100,000	110,000
K: Recruiting and training	540,000	600,000	660,000
L: Solving start-up problems	90,000	100,000	110,000
M: Centerlining	45,000	50,000	55,000

"Well, that's it Wesley! We're glad to have you on board and look forward to working with you. Do you have any questions?"

Questions

1. Draw a network diagram for this project. Identify which path you expect to be the critical path and its expected completion time. Which paths are most likely to threaten this path in terms of becoming critical?
2. Simulate the completion of this project 1,000 times assuming that activity times follow a triangular distribution and that the cost rates are known with certainty and equal to the most likely cost rate. Estimate the mean and standard deviation of the project completion time and the project cost. How does the time compare to your previous answer based solely on the critical path?
3. Develop histograms for both the project completion time and the cost to complete the project. What do these histograms tell you?
4. Using the results of your simulation analysis, calculate the probability that the project can be completed within 30 months. What is the probability that the project will take longer than 40 months? What is the probability that the project will take between 30 and 40 months? What is the probability the project will cost $5.1 million or less to complete? The probability the project will cost between $5 and $6 million to complete?
5. Modify your simulation model to determine the probability that the path you expected to be the critical path actually was the critical path? What are the managerial implications of this?
6. Simulate the completion of this project 1,000 times assuming that the activity times follow a triangular distribution and that the cost rates are also triangularly distributed. Estimate the mean and standard deviation of the project completion time and project cost. How do these results compare to the results you obtained in Question 2?
7. Would you expect there to be a relationship between the duration of an activity and the cost *rate* to complete the activity? If so, how could your simulation model be modified to reflect this relationship?

This brief reading illustrates the kinds of things that can go wrong in a project and delay it, but also the kinds of remedies PMs can come up with to keep the project on schedule. The types of creative remedies available to PMs are then summarized.