CRITICAL-CHAIN IN ACTION

CCPM's solution to reducing project time overruns is to insist on people using the "true 50/50" activity time estimates (rather than estimates which have an 80 to 90 percent chance of being completed before the estimated time); the 50/50 estimates result in a project duration about one-half the low risk of 80 to 90 percent estimates. This requires a corporate culture which values accurate estimates and refrains from blaming people for not meeting deadlines. According to CCPM, using 50/50 estimates will discourage Parkinson's law, the student syndrome, and self-protection from coming into play because there is less "free time" available. Productivity will be increased as individuals try to meet tighter deadlines. Similarly, the compressed time schedule reduces the likelihood of the dropped baton effect.

CCPM recommends inserting time buffers into the schedule to act as "shock absorbers" to protect the project completion date against task durations taking longer than the 50/50 estimate. The rationale is that by using 50/50 estimates you are in essence taking out all of the "safety" in individual tasks. CCPM also recommends using portions of this collective safety strategically by inserting time buffers where potential problems are likely to occur. There are three kinds of buffers in CCPM:

- *Project buffer:* First, since all activities along the critical chain have inherent *uncertainty* that is difficult to predict, project duration is uncertain. Therefore, a project time buffer is adde to the expected *project duration*. CCPM recommends using roughly 50 percent of th aggregate safety. For example, if the modified schedule reduces the project duration by 2 days from 50 to 30, then a 10-day project buffer would be used.
- *Feeder buffers:* Buffers are added to the network where noncritical paths merge with t critical chain. These buffers protect the critical chain from being delayed.
- *Resource buffers:* Time buffers are inserted where scarce resources are needed for an activi Resource time buffers come in at least two forms. One form is a time buffer attached t critical resource to ensure that the resource is on call and available when needed. This prese

SNAPSHOT FROM PRACTICE
Critical Chain Applied to Airplane Part Arrivals*

In the past Spirit Aero Systems, manufacturer of airplane parts, were forced to delay product development projects as a result of missing parts for assemblies. Spirit management cycled through several approaches, such as lean, value chain, cycle time reduction, knowledge based engineering, to reduce the problem. Although each yielded minor improvements, the impacts were not substantial. Rework, overtime, delay costs, and vendor expediting costs continued to have significant impact on costs, meeting commitments, and reputation. Spirit turned to critical chain management methodology in a pilot project.

Joseph Zenisek, the critical chain manager, said the choice of critical chain was "a game changer for us." Spirit applied the critical chain approach to assembly of newly designed pylons (brackets) used for failure destruction testing of casings for a jet engine project. Zenisek credited success to three key factors:

- Creating a rule to never start a work package until all parts and staff are available.
- Ensuring part buffers to cover work packages by vigilantly monitoring assembly parts that use a large number of parts or where rate or number used is high.
- Developing a small engineering team to manage vendors and buffers to ensure that delivery of over 300 parts arrived on time.

The critical chain program led to impressive results. The parts and staffing rule cut down on late deliveries and rework on partially completed work packages caused by missing parts. The result was a reduction of 50 percent in overtime. Reducing delays reduced assembly cycle time by 18 percent. Work in process and work packages were also reduced since availability of buffer parts avoided delays. The critical chain method led to better resource management and reduced stress.

Given the success of the critical chain program, Spirit intends to expand the application of the critical chain method to new product development projects for their clients.

*Peter Fretty, "E Is in the Air," *PMNetwork*, February 2012, Vol. 26, No. 2, pp. 50–56.

the relay race. The second form of time buffer is added to activities preceding the work of a scarce resource. This kind of buffer protects against resource bottlenecks by increasing the likelihood that the preceding activity will be completed when the resource is available.

All buffers reduce the risk of the project duration being late and increase the chance of early project completion.[2] See Snapshot from Practice: Critical Chain Applied to Airplane Part Arrivals.

CRITICAL-CHAIN VERSUS TRADITIONAL SCHEDULING APPROACH

To illustrate how CCPM affects scheduling let's compare it with the traditional approach to project scheduling. We will first resolve resource problems the way described in Chapter 8 and then the CCPM method. Figure A8.1A shows the *planned* Air Control project network without any concern for resources. That is, activities are assumed to be independent and resources will be made available and/or are interchangeable.

[2] For more information on buffers see: L. P. Leach, "Critical Chain Project Management Improves Project Performance," *Project Management Journal* 30 (2) 1999, pp. 39–51.

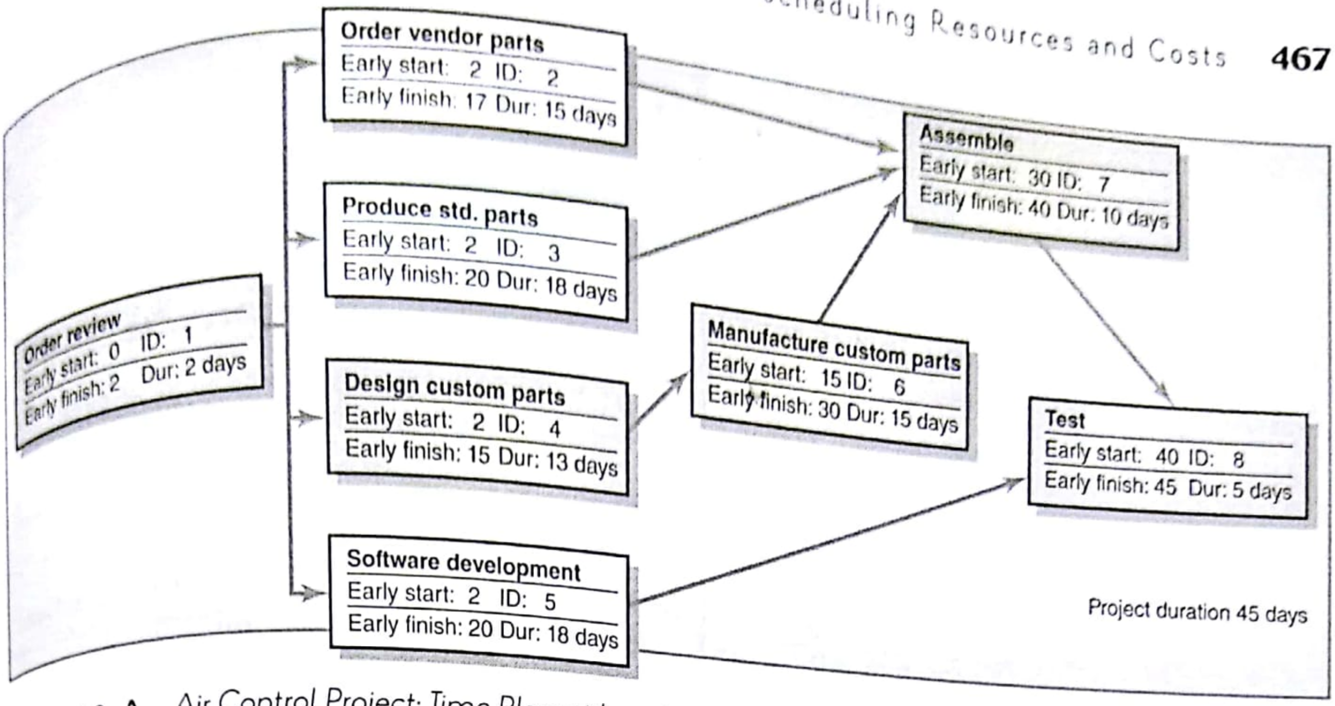


FIGURE A8.1A *Air Control Project: Time Plan without Resources*

Figure A8.1B depicts the bar chart for the project. The dark blue bars represent the durations of critical activities; the light blue bars represent the durations of noncritical activities; the gray bars represent slack. Note that the duration is 45 days and the critical path is represented by activities 1, 4, 6, 7, and 8.

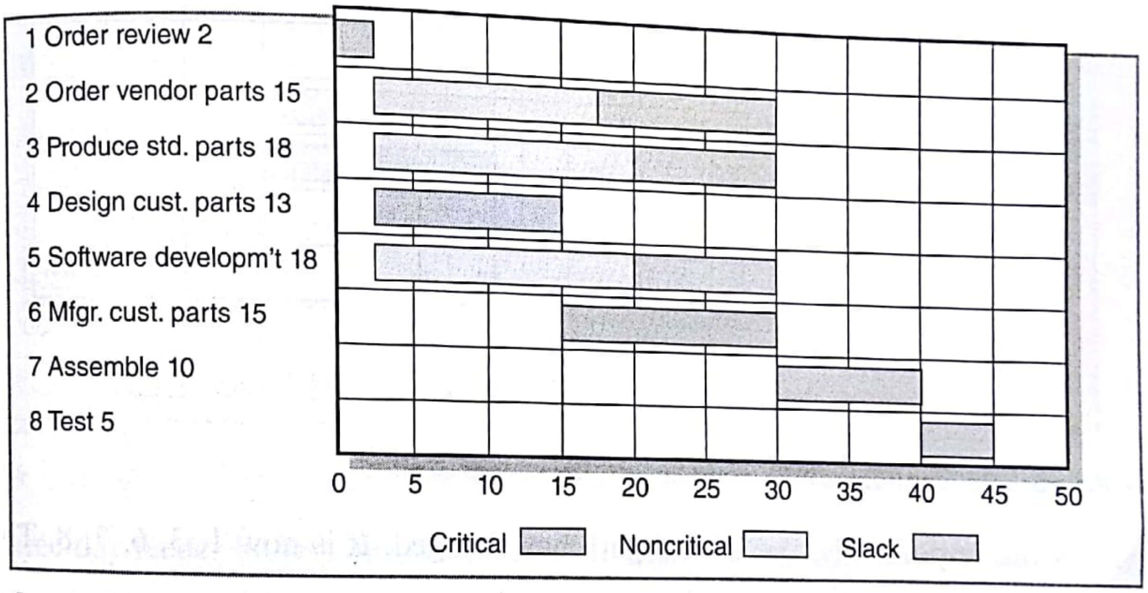


FIGURE A8.1B *Air Control Project: Time Plan without Resources*

Parallel activities hold potential for resource conflicts. This is the case in this project. Ryan is the resource for activities 3 and 6. If you insert Ryan in the bar chart in Figure A8.1B for activities 3 and 6, you can see activity 3 overlaps activity 6 by five days—an impossible situation. Because Ryan cannot work two activities simultaneously and no other person can take his place, a resource dependency exists. The result is that two activities (3 and 6) that were assumed to be independent now become dependent. Something has to give! Figure A8.2A shows the Air Control project network with the resources included. A pseudo-dashed arrow has been added to the network to indicate the resource dependency. The bar chart in Figure A8.2B reflects the revised schedule resolving the overallocation of Ryan. Given the new schedule, slack for some activities has

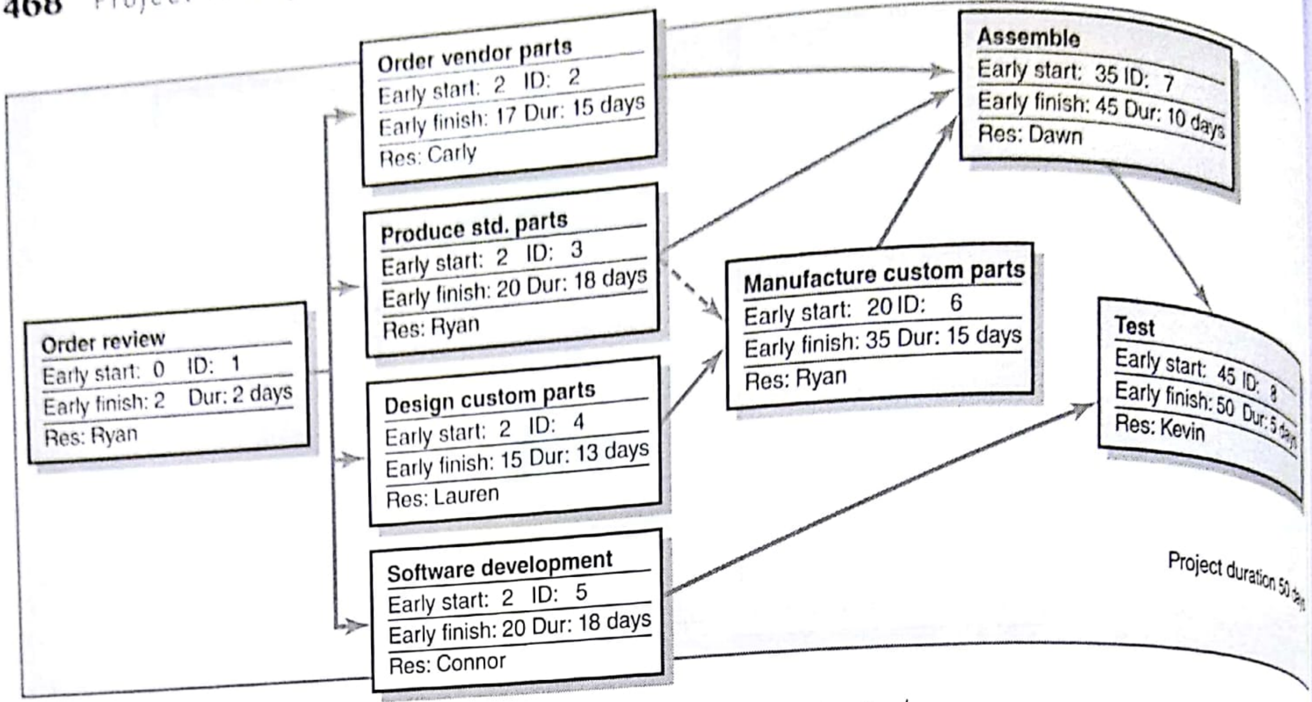


FIGURE A8.2A *Air Control Project: Schedule with Resources Limited*

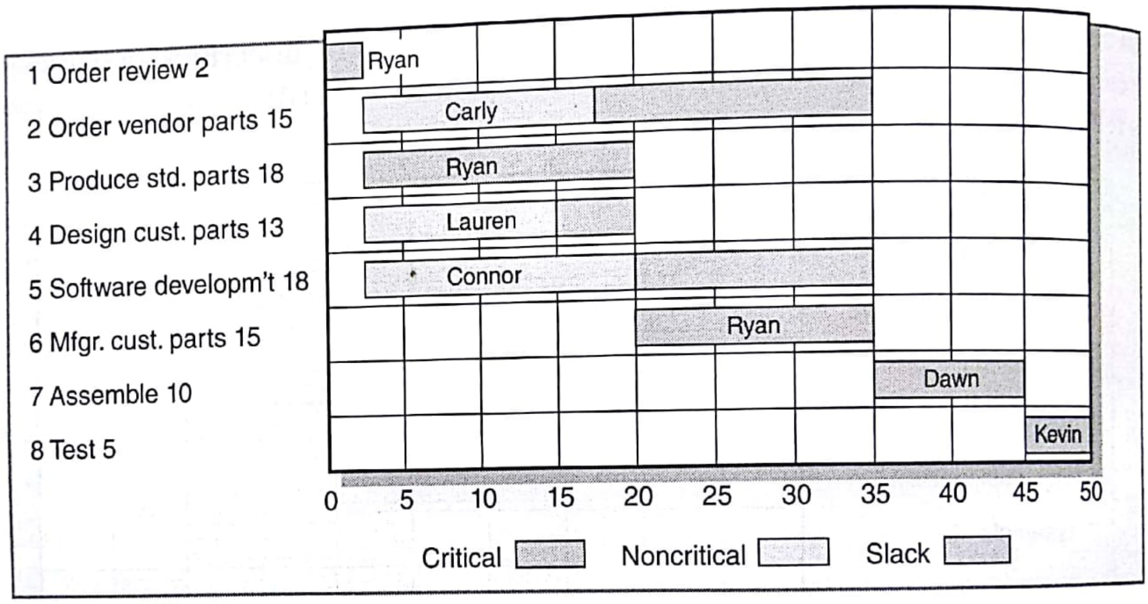


FIGURE A8.2B *Air Control Project: Schedule with Resources Limited*

changed. More importantly, the critical path has changed. It is now 1, 3, 6, 7, 8. The resource schedule shows the new project duration to be 50 days rather than 45 days.

Now let's apply the CCPM approach to the Air Control project. Figure A8.3 details many of the changes. First, notice that task estimates now represent approximations of the 50/50 rule. Second, observe that not all of the activities on the critical chain are technically linked: Manufacture custom parts is included because of previously defined resource dependency. Third, a project time buffer is added at the end of schedule. Finally, feeder buffers are inserted at each point where a noncritical activity merges with the critical chain.

The impact the CCPM approach has on the project schedule can best be seen in the Gantt chart presented in Figure A8.4. Notice first the late start times for each of the three noncritical activities. For example, under the critical path method, order vendor parts and software development would be scheduled to begin immediately after the order review. Instead they are scheduled later in the

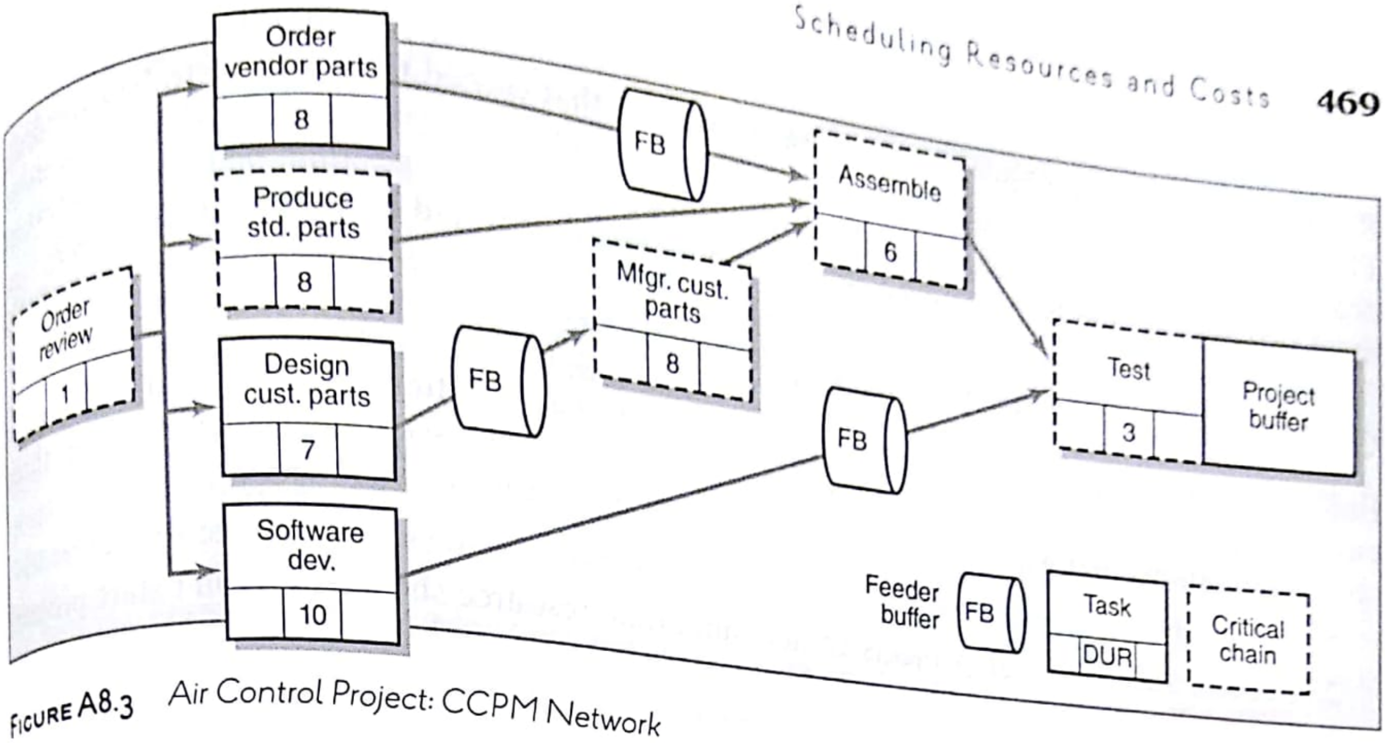
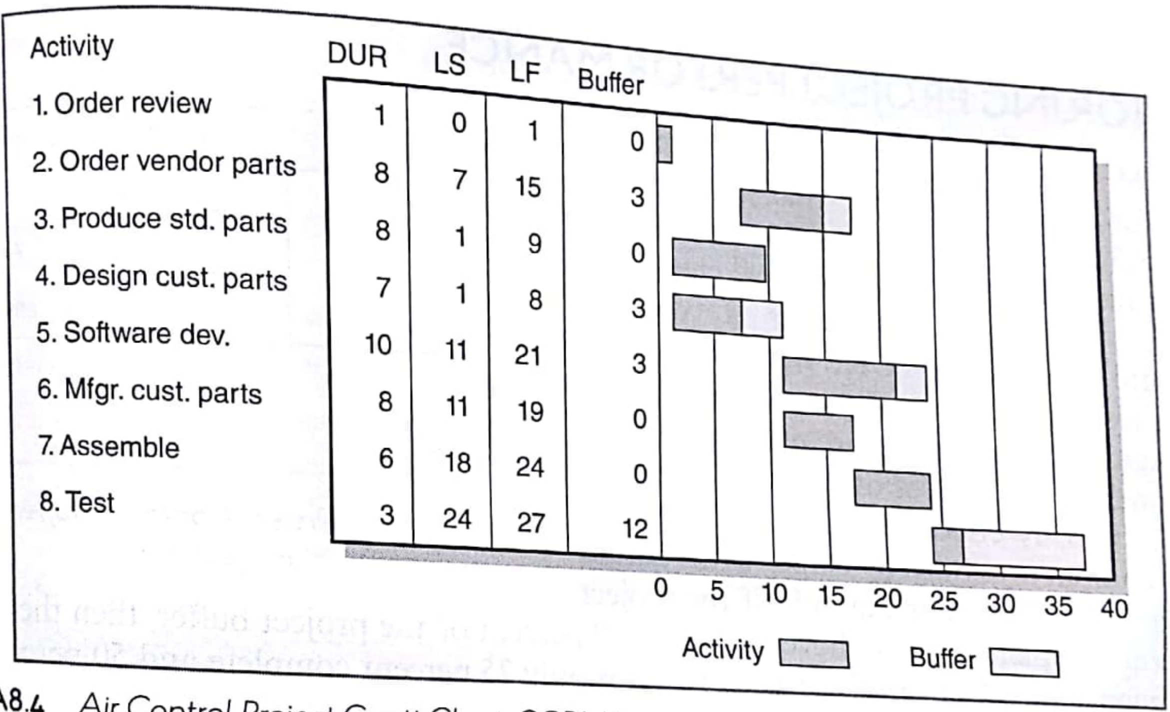


FIGURE A8.3 Air Control Project: CCPM Network



Activity	DUR	LS	LF	Buffer
1. Order review	1	0	1	0
2. Order vendor parts	8	7	15	3
3. Produce std. parts	8	1	9	0
4. Design cust. parts	7	1	8	3
5. Software dev.	10	11	21	3
6. Mfgr. cust. parts	8	11	19	0
7. Assemble	6	18	24	0
8. Test	3	24	27	12

FIGURE A8.4 Air Control Project Gantt Chart: CCPM Network

project. Three-day feeder buffers have been added to each of these activities to absorb any delays that might occur in these activities. Finally, instead of taking 50 days the project is now estimated to take only 27 days with a 10-day project buffer!

This example provides an opportunity for explaining the differences between buffers and slack. Slack is spare time inherent in the schedule of noncritical activities and can be determined by differences between the early start and late start of a specific activity. Buffers, on the other hand, are dedicated time blocks reserved to cover most likely contingencies and are monitored closely so, if they are not needed, subsequent activities can proceed on schedule. Buffers are needed in part because the estimates are based on 50/50 approximations, and therefore roughly half of the activities will take longer than planned. To protect against these extended activity durations, buffers are inserted to minimize the impact on the schedule. Buffers are not part of the project schedule and are used only when sound management dictates it.

While not depicted in the figures, an example of a resource buffer would be to add six days to Ryan's schedule (remember he is the critical resource that caused the schedule to be extended). This would ensure that he could continue to work on the project beyond the 18th day in case the task to produce standard parts and/or manufacture custom parts takes longer than planned. Progress on these two tasks would be monitored closely, and his schedule would be adjusted accordingly.

CCPM AND SPLITTING TASKS

Buffers do not address the insidious effects of pervasive task splitting, especially in a multiproject environment where workers are juggling different project assignments. CCPM has three recommendations that will help to reduce the impact of splitting activities:

1. Reduce the number of projects so people are not assigned to as many projects concurrently.
2. Control start dates of projects to accommodate resource shortages. Don't start projects until sufficient resources are available to work full time on the project.
3. Contract (lock in) for resources *before* the project begins.

MONITORING PROJECT PERFORMANCE

The CCPM method uses buffers to monitor project time performance. Remember that as shown in Figure A8.3 a project buffer is used to insulate the project against delays along the critical chain. For monitoring purposes, this buffer is typically divided into three zones—OK, Watch and Plan, and Act, respectively (see Figure A8.5). As the buffer begins to decrease and moves into the second zone, alarms are set off to seek corrective action. To be truly effective, buffer management requires comparing buffer usage with actual progress on the project. For example, if the project is 75 percent complete and you have only used 50 percent of the project buffer, then the project is in pretty good shape. Conversely, if the project is only 25 percent complete and 50 percent of the buffer has already been used, you are in trouble and corrective action is needed. A method for estimating percentage complete is described in Chapter 13.

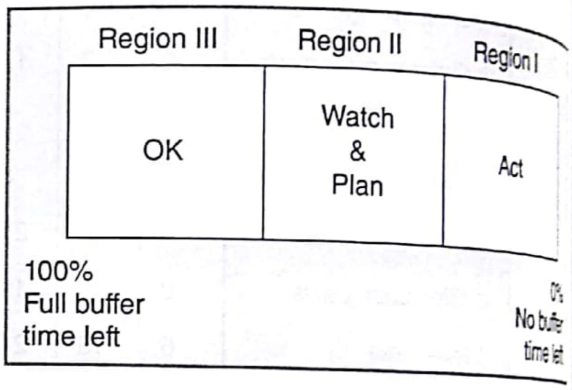


FIGURE A8.5 *Project Control—Buffer Management*

THE CCPM METHOD TODAY

CCPM has generated considerable debate within the project management community. While sound in theory, support at this time is limited but growing. For example, Harris Semiconductor was able to build a new automated wafer fabrication facility within 13 months using CCPM methods when the industry standard for such a facility is 26–36 months. The Israeli aircraft industry has used CCPM techniques to reduce average maintenance work on aircraft from two months to two weeks. The U.S. Air Force and Navy as well as Boeing, Lucent Technologies, Intel, GM, and 3M are applying critical-chain principles to their multi-project environments.[3]

[3] Cited in materials developed by the Eliyahu Goldratt Institute (New Haven, CT) for a workshop attended by one of the authors entitled, "Project Management the TOC Way," 1998.

CCPM is not without critics. First, CCPM does not address the biggest cause of project delays, which is an ill-defined and unstable project scope. Second, some critics challenge Goldratt's assumptions about human behavior. They question the tendency of experts to pad estimates and that employees act deliberately against the organization for their own interest and benefit. Critics also object to the insinuation that trained professionals would exhibit the student syndrome habits (Zalmanson, 2001). Third, evidence of success is almost exclusively anecdotal and based on single case studies or on computer modeling.[4] The lack of systematic evidence raises questions about generalizability of application. CCPM may prove to work best for only certain kinds of projects.

One of the keys to implementing CCPM is the culture of the organization. If the organization honors noble efforts that fail to meet estimates as it does efforts that do meet estimates, then greater acceptance will occur. Conversely, if management treats honest failure differently from success, then resistance will be high. Organizations adopting the CCPM approach have to invest significant energy to obtaining "buy-in" on the part of all participants to its core principles and allaying the fears that this system may generate.

APPENDIX SUMMARY

Regardless of where one stands in the debate, the CCPM approach deserves credit for bringing resource dependency to the forefront, highlighting the modern ills of multitasking, and forcing us to rethink conventional methods of project scheduling.

APPENDIX REVIEW QUESTIONS

1. Explain how time is wasted in management of projects.
2. Distinguish between project and feeder buffers.
3. Buffers are not the same as slack. Explain.

APPENDIX EXERCISES

1. Check out the Goldratt Institute's homepage at *http://www.goldratt.com* for current information on the application of critical-chain techniques to project management.
2. Apply critical-chain scheduling principles to the Print Software, Inc., project presented in Chapter 6 on pages 191–192. Revise the estimated time durations by 50 percent except round up the odd time durations (i.e., 3 becomes 4). Draw a CCPM network diagram similar to the one contained in Figure A8.3 for the Print Software project as well as a Gantt chart similar to Figure A8.4. How would these diagrams differ from the ones generated using the traditional scheduling technique?

APPENDIX REFERENCES

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