

Invisible Earned Value

The Magic Table, Tracking Small Projects, Schedule Projection, and Error Analysis

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The Magic Table tracks the progress of small projects. It's intended for minimal, five-to-ten task projects, but may, with some care, be extended to 30-40 task projects. The "Magic" of the title comes from Arthur C. Clarke's observation that "Any sufficiently advanced technology is indistinguishable from magic." Using the table can raise questions about alternative ways to forecast a project's scheduled completion date. When additional schedule forecasts are included in the Magic Table, a careful user will want to understand how and where forecasting errors can occur. Part I of this white paper will introduce the Magic Table and explain its use. Part II will review what's behind the "magic" (earned-value forecasts using the CPI and SPI), illustrate three alternative ways to forecast project schedules, and conclude with an error analysis of all five project projections.

Part I: The Basic Magic Table

The Magic Table's "magic" is that it transforms small-project information from the Magic Data into the Magic Chart. (See Figure 1.) The Magic Data lists the project tasks. The Magic Chart plots these tasks by schedule and cost. The Chart initially shows the plan of the project. As tasks are completed, the Chart displays the actual results of the project and the latest estimates of the project's cost and schedule. The calculations behind these transformations come from the large-project ideas of "earned value" analysis.

When to Use the Magic Table

Small projects are often characterized by loose relationships between the date a task is due and the amount of work a task requires. It is not unusual for a task to need as little as 10 hours of work at some time during a two-week timeframe. As projects grow in size, the hours of work become large enough to affect the due date.

When staff is dedicated to a project full-time, the relationship between the staffing intensity, the total hours of work and the calendar period becomes more calculated. For example, the task's full-time-equivalent (FTE) staff intensity, say 1.5 FTEs, multiplied by the task's duration, say 8 days, equals the task's total number of labor hours, say 96 staff-hours.

Because the Magic Table treats a task’s labor hours and due date independently, it works well on small projects with a loose relationship between the hours worked and the due date. But as projects get bigger, if you are careful about the relationship between the hours worked and the due date, the Magic Table will continue to produce information that will help you manage your project.

Using the Magic Table with a Small Project

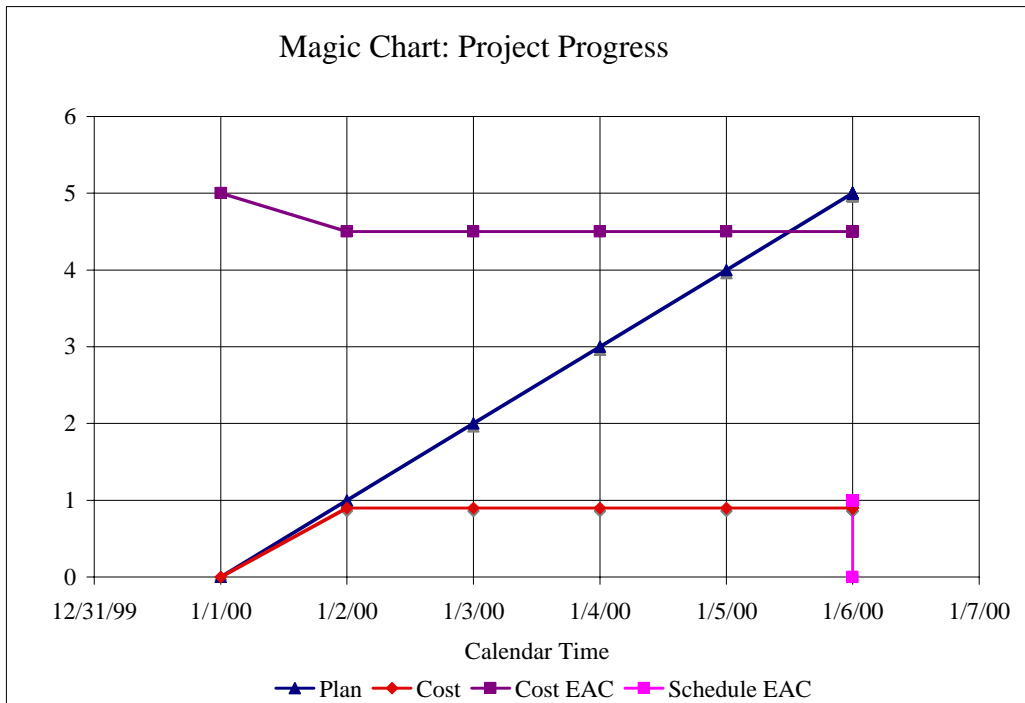
In the Magic Data area of the spreadsheet, enter the start date and the current date. (See Figure 1 for an example.) List the tasks by name. Call all tasks “critical” by entering a “C”. Assume one hour for each task and write down its due date. Pretend the first task has been completed on schedule and enter values for the completed task (you may change these values when you actually complete the task). Change the current date to the date of the first completed task.

Be sure to enter the tasks in your Magic Data list *in order of the planned due date*. If they get out of order, sort them with the “Sort” command in Excel. (If you are unfamiliar with the “Sort” command, learn how to use it with the “Help” command. You will also need to “unprotect” the first sheet of the spreadsheet. After you have sorted, remember to reprotect the spreadsheet.)

At this point the Magic Table will present the project as planned, when the project will be finished, and how much it will cost. The Magic Data will show you the numbers you entered and the Magic Chart will illustrate the picture they make.

Figure 1. Magic Data and Magic Chart of a 5-task project after 1 task is completed.

| Magic Data | | 1/1/00 | Start date | 1/6/00 | End date |
|-------------------|----------------------|----------------------------|-------------------------|---------------------------|------------------------------|
| | | 1/2/00 | Current date | | |
| <u>Task name</u> | <u>Critical Path</u> | <u>Planned Staff-Hours</u> | <u>Planned Due Date</u> | <u>Actual Staff-Hours</u> | <u>Actual Completed Date</u> |
| 1 Task A | C | 1 | 1/2/00 | 0.9 | 1/2/00 |
| 2 Task B | C | 1 | 1/3/00 | | |
| 3 Task C | C | 1 | 1/4/00 | | |
| 4 Task D | C | 1 | 1/5/00 | | |
| 5 Task E | C | 1 | 1/6/00 | | |



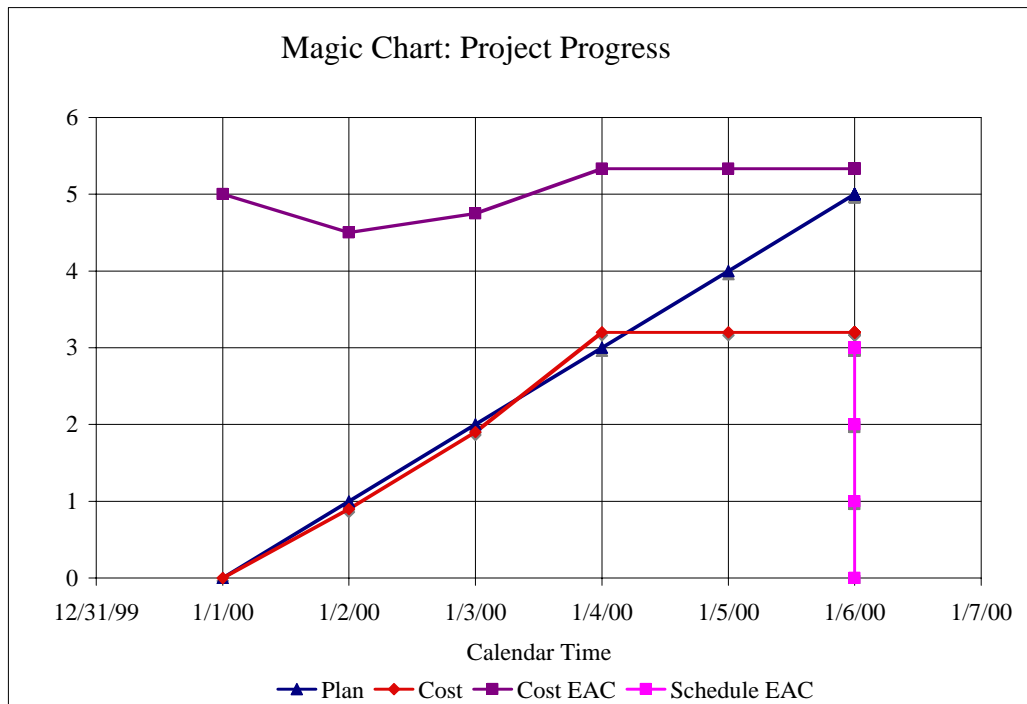
The blue diagonal line is the planned path of the project on the Magic Chart. Notice that the horizontal scale is in units of calendar time (days) while the vertical scale is in hours of work (or other units of work, such as staff-days or dollars). The red Actual Cost line and the purple Cost EAC (estimate at completion) line end at the first task and then “flatline” to the end of the project.

The chart shows how much the project will cost at the right end of the Cost EAC (estimate at completion) line. Because the first task only took 0.9 hours, the Cost EAC is now 4.5 hours, a little less than the original plan of 5 hours. The date the project will finish is the top end of the pink Schedule EAC line. This line still estimates the project to finish on time, on January 6.

As you complete each task on your project, you may enter the actual number of hours it took to complete it and the date you actually finished.

Figure 2. Magic Data and Magic Chart of a 5-task project after 3 tasks are completed.

| Magic Data | | 1/1/00 | Start date | 1/6/00 | End date |
|-------------------|----------------------|----------------------------|-------------------------|---------------------------|------------------------------|
| | | 1/4/00 | Current date | | |
| <u>Task name</u> | <u>Critical Path</u> | <u>Planned Staff-Hours</u> | <u>Planned Due Date</u> | <u>Actual Staff-Hours</u> | <u>Actual Completed Date</u> |
| 1 Task A | C | 1 | 1/2/00 | 0.9 | 1/2/00 |
| 2 Task B | C | 1 | 1/3/00 | 1 | 1/3/00 |
| 3 Task C | C | 1 | 1/4/00 | 1.3 | 1/4/00 |
| 4 Task D | C | 1 | 1/5/00 | | |
| 5 Task E | C | 1 | 1/6/00 | | |

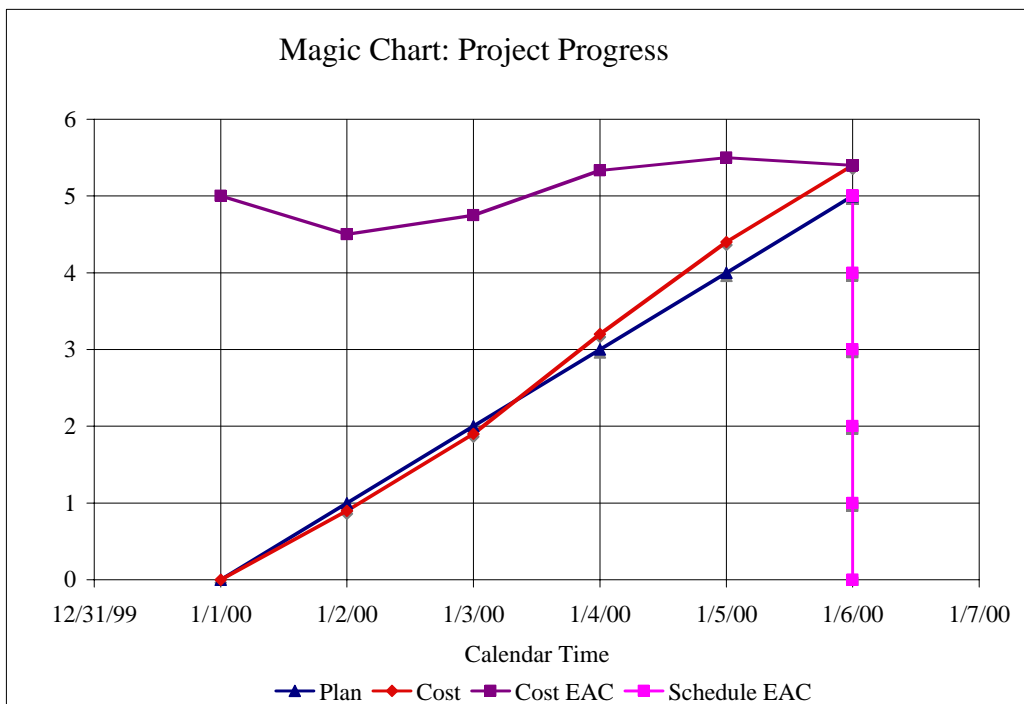


The chart now displays the red line of the actual cost a little above the blue line of the plan. The right end of the purple Cost EAC line estimates the project's cost at a little over the original plan of 5 hours. The date the project will finish is still estimated to be January 6.

When the project concludes, the Magic Table shows the results.

Figure 3. Magic Data and Magic Chart of a 5-task project after 5 tasks are completed.

| Magic Data | | 1/1/00 | Start date | 1/6/00 | End date |
|-------------------|----------------------|----------------------------|-------------------------|---------------------------|------------------------------|
| | | 1/6/00 | Current date | | |
| <u>Task name</u> | <u>Critical Path</u> | <u>Planned Staff-Hours</u> | <u>Planned Due Date</u> | <u>Actual Staff-Hours</u> | <u>Actual Completed Date</u> |
| 1 Task A | C | 1 | 1/2/00 | 0.9 | 1/2/00 |
| 2 Task B | C | 1 | 1/3/00 | 1 | 1/3/00 |
| 3 Task C | C | 1 | 1/4/00 | 1.3 | 1/4/00 |
| 4 Task D | C | 1 | 1/5/00 | 1.2 | 1/5/00 |
| 5 Task E | C | 1 | 1/6/00 | 1 | 1/6/00 |



Compared to the blue original plan, the project finished on time, but ran a little high on cost.

Printing Your Results

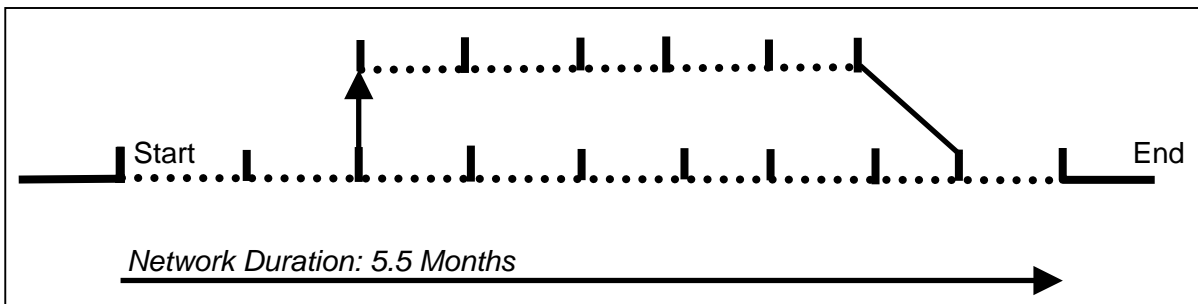
The first sheet of the Magic Table spreadsheet is protected so that you will not erase a formula by accident. The Magic Data Area is unlocked to allow data entry. However, in order to *sort the data* or to *print out a Magic Chart*, you must first *unprotect* the spreadsheet. After you have sorted or printed what you wished, remember to *re-protect* the sheet to guard against accidentally erasing a formula.

Bigger Projects With Parallel Tasks

For projects where two or more tasks are being worked on at the same time, be sure to draw a precedence network of the tasks and calculate which of the parallel tasks is on the critical path. You may indicate a critical-path task with the letter “C” in the Magic Table. (If you are unsure whether a task is critical, label it with a “C.”)

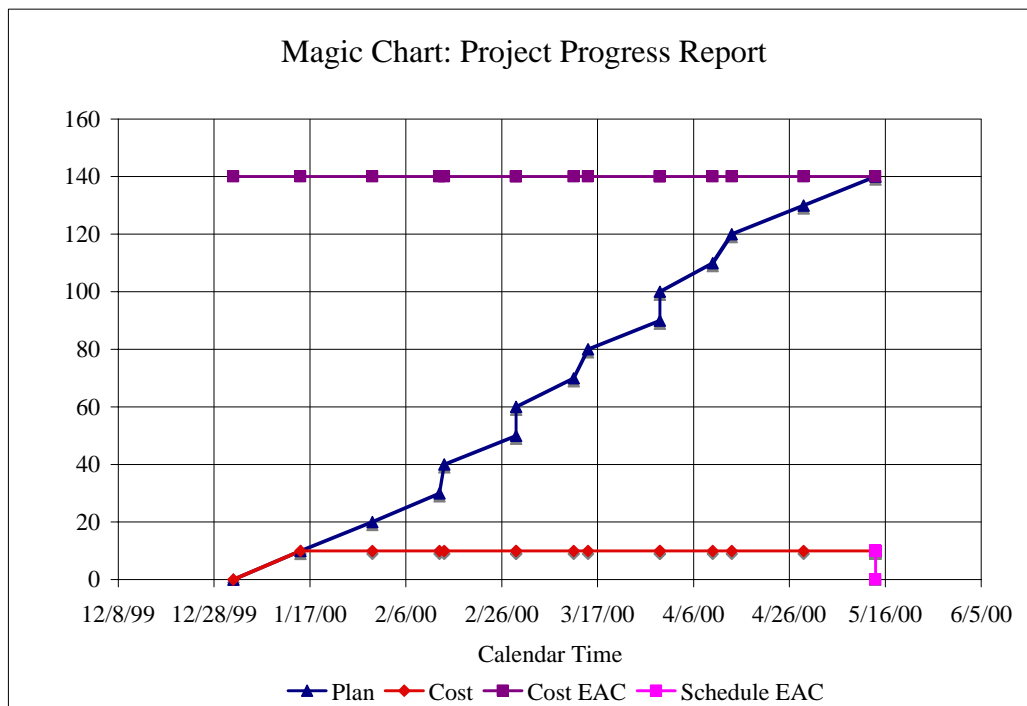
Below is a precedence network diagram (Nevison Timeline Diagram [NTD[®]]) for a 14-task project. Notice that 9 tasks are on the critical path and 5 are not.

Figure 4. Precedence network diagram of a 14-task project



When this project is entered into the Magic Table, The Magic Chart looks like Figure 5.

Figure 5. The Magic Chart of the 9 + 5 task project at the beginning.



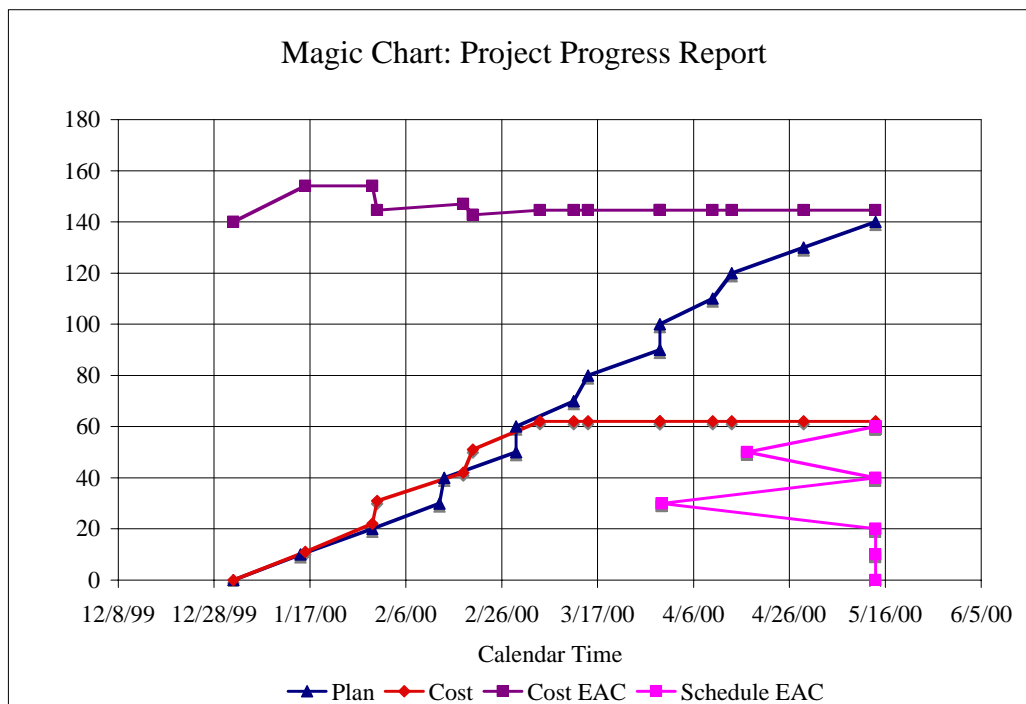
This project is bigger than our first project and has several new features. The project takes longer and costs more. Not all tasks are on the critical path. Some tasks are scheduled to

finish at the same time. In the Magic Chart, vertical line segments connect tasks that finish at the same time in the plan.

As the project advances, the Magic Data grows and the Magic Chart revises its estimate of how much the project will cost and when it will be completed.

Figure 6. The Magic Table of the 9+5 task project after 6 tasks are completed.

| Magic Data | | 1/1/00 | Start date | 5/14/00 | End date |
|----------------------|---------------|---------------------|------------------|--------------------|-----------------------|
| | | 3/5/00 | Current date | | |
| <u>Task name</u> | Critical Path | Planned Staff-Hours | Planned Due Date | Actual Staff-Hours | Actual Completed Date |
| 1 Plan red | C | 10 | 1/15/00 | 11 | 1/16/00 |
| 2 Build red | C | 10 | 1/30/00 | 11 | 1/30/00 |
| 3 Write green | | 10 | 2/13/00 | 9 | 1/31/00 |
| 4 Review red | C | 10 | 2/14/00 | 11 | 2/18/00 |
| 5 Review green | | 10 | 2/29/00 | 9 | 2/20/00 |
| 6 Develop pink | C | 10 | 2/29/00 | 11 | 3/5/00 |
| 7 Test green | | 10 | 3/12/00 | | |
| 8 Test pink | C | 10 | 3/15/00 | | |
| 9 Write blue | | 10 | 3/30/00 | | |
| 10 Verify pink | C | 10 | 3/30/00 | | |
| 11 Review blue | | 10 | 4/10/00 | | |
| 12 Assemble crimson | C | 10 | 4/14/00 | | |
| 13 Integrate crimson | C | 10 | 4/29/00 | | |
| 14 Deliver crimson | C | 10 | 5/14/00 | | |



The zigzag of the Schedule EAC line on the Magic Chart is especially dramatic. When the third task was completed ahead of schedule, the Magic Chart predicted that the entire project would finish ahead of schedule. The fourth task was a little late and the Magic Table revised its prediction to the original date. The fifth project was early and the Table again predicted an early date. And so on.

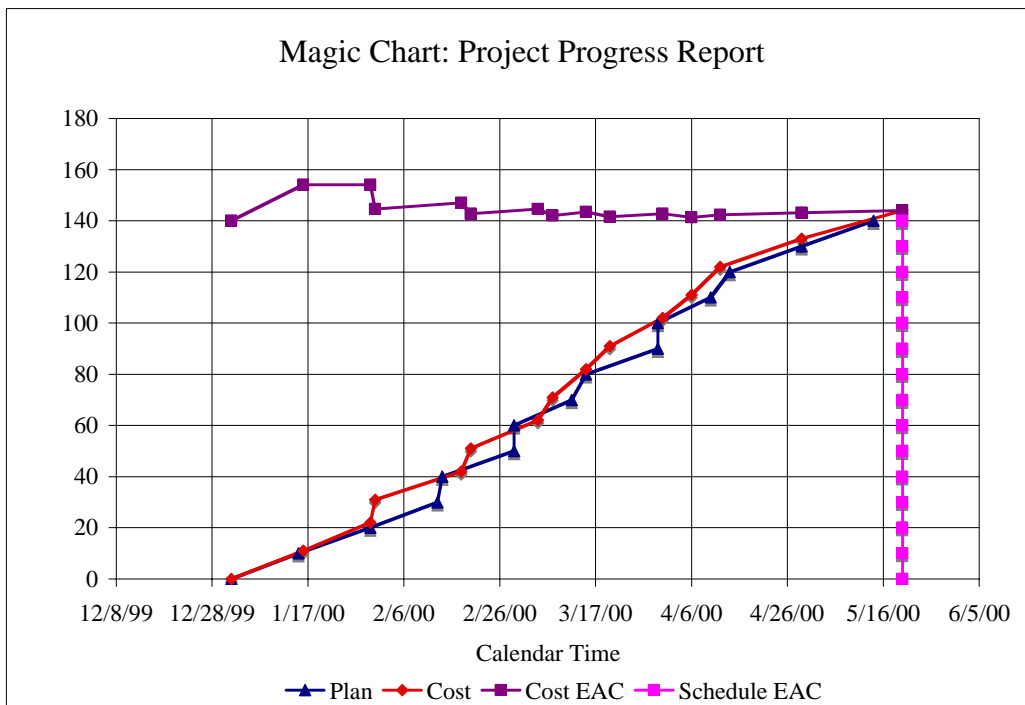
The schedule prediction works the other way as well. If a task falls behind schedule and misses its due date the Magic Chart will predict a later date for the whole project.

The Cost EAC also bounces around as task efforts vary from the original plan. After the 6th task, the Magic Table estimates the total project will cost just a little more than planned.

As the project continues, the Magic Table's Magic Data and Magic Chart continue to track its progress. At the end, you can see how the project concluded close to the original plan.

Figure 7. *The Magic Table of the 9+5 task project at the end.*

| Magic Data | | 1/1/00 | Start date | 5/20/00 | End date |
|-----------------------------|----------------------|----------------------------|-------------------------|---------------------------|------------------------------|
| | | 5/20/00 | Current date | | |
| <u>Task name</u> | <u>Critical Path</u> | <u>Planned Staff-Hours</u> | <u>Planned Due Date</u> | <u>Actual Staff-Hours</u> | <u>Actual Completed Date</u> |
| 1 Plan red | C | 10 | 1/15/00 | 11 | 1/16/00 |
| 2 Build red | C | 10 | 1/30/00 | 11 | 1/30/00 |
| 3 Write green | | 10 | 2/13/00 | 9 | 1/31/00 |
| 4 Review red | C | 10 | 2/14/00 | 11 | 2/18/00 |
| 5 Review green | | 10 | 2/29/00 | 9 | 2/20/00 |
| 6 Develop pink | C | 10 | 2/29/00 | 11 | 3/5/00 |
| 7 Test green | | 10 | 3/12/00 | 9 | 3/8/00 |
| 8 Test pink | C | 10 | 3/15/00 | 11 | 3/15/00 |
| 9 Write blue | | 10 | 3/30/00 | 9 | 3/20/00 |
| 10 Verify pink | C | 10 | 3/30/00 | 11 | 3/31/00 |
| 11 Review blue | | 10 | 4/10/00 | 9 | 4/6/00 |
| 12 Assemble crimson | C | 10 | 4/14/00 | 11 | 4/12/00 |
| 13 Integrate crimson | C | 10 | 4/29/00 | 11 | 4/29/00 |
| 14 Deliver crimson | C | 10 | 5/14/00 | 11 | 5/20/00 |



At the end, the Schedule EAC line snaps perfectly vertical on the final actual date (which is a little late). The Cost EAC remains steady in its prediction of a little more than the original 140 hours. The history of the project’s actual behavior is in red and the original plan remains in blue.

Working with the Magic Table

If you have not yet used the Magic Table, now would be a good time to test it by using one of the examples in Figures 1-7. Be sure your dates are typed correctly and that the current date is in line with the actual dates.

Some things to try:

1. Try out different patterns of tasks for your plan. (Remember to type in the first “actual” task data as well.)
2. Pretend to do the project by typing in actual task hours and dates—and adjusting the current date as you go.
3. Let all the actual tasks take more (or fewer) hours than planned.
4. Let the actual tasks take a steadily increasing (or decreasing) number of hours more (or less) than planned.
5. Experiment with early and late dates for task completion.
6. Let the actual tasks take on progressively later (or earlier) dates than planned.
7. Experiment with hours worked on tasks that are not yet complete.

As you experiment, you will see how the different project behaviors are reflected in the Magic Chart. You should also develop a good idea of how to make best use the Magic Table on your project.

Conclusion to Part I

With its Magic Data and Magic Chart, the Magic Table lets you track the progress of a small project. The “magic” produces not only a picture of your “planned” and “actual” project, it makes a running prediction of how much the final project will cost and when it will finish. For small projects, the Magic Table is a simple, convenient way to report progress quickly.

Part II: The Full Magic Table

Some users of the Magic Table may want to understand how the predictions of cost and schedule are calculated. Others may want to see alternative predictions for schedules. A few may wish to understand what kind of errors these predictions can generate. The following discussions should address these questions and allow these curious users to better understand the Magic Table and to use the Full Magic Table with increased confidence.

The earned-value formulas behind the Magic Table

Both the cost EAC (estimate at complete) and the schedule EAC are calculated using the sum-to-date of the planned cost of tasks that have been completed. This sum is called the “earned value.” Earned-value analysis compares the project’s earned value (to date) to the project’s actual cost (to date) and calls the ratio the Cost Performance Index (CPI). The CPI is used to estimate the Cost Estimate at Completion (EAC).

The formulas are:

$$\langle \text{Cost Performance Index (CPI)} \rangle = \langle \text{Earned Value} \rangle / \langle \text{Actual Cost} \rangle$$

and

$$\langle \text{Cost Estimate At Complete (EAC)} \rangle = \langle \text{Original Budget} \rangle / \langle \text{CPI} \rangle$$

Earned-value analysis also compares the project’s earned value (to date) to the project’s planned cost (to date) and calls the ratio the Schedule Performance Index (SPI). The SPI is used to estimate what the Magic Table calls the Schedule EAC.

The formulas are:

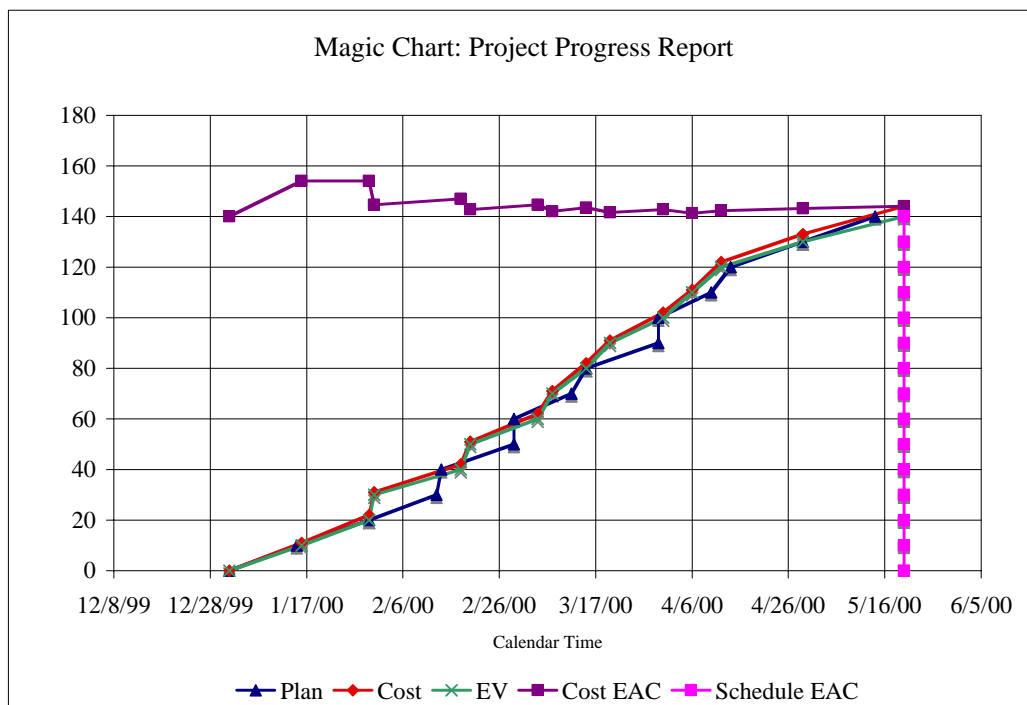
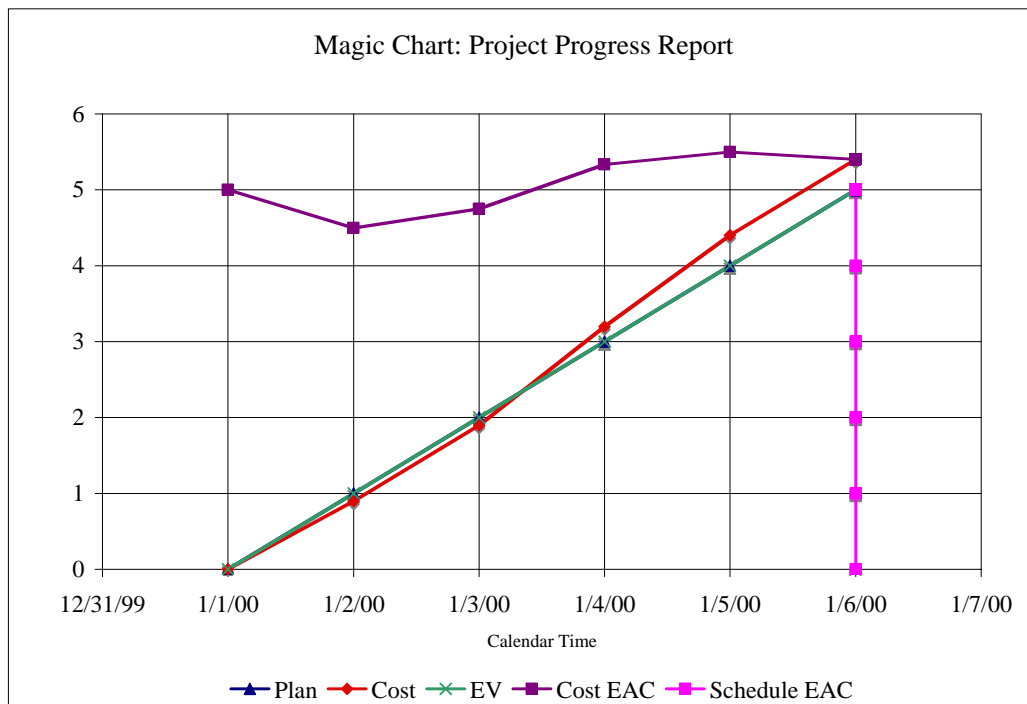
$$\langle \text{Schedule Performance Index (SPI)} \rangle = \langle \text{Earned Value} \rangle / \langle \text{Planned Cost} \rangle$$

and

$$\langle \text{Schedule Estimate at Complete (EAC)} \rangle = \langle \text{Original Shedule} \rangle / \langle \text{SPI} \rangle$$

Here are the two earlier examples of estimates at completion with the earned value line included.

Figure 8. Two Magic Charts with earned value lines included.



In the first example in Figure 8, the green earned-value line is exactly the same as the blue plan line. In the second example, the green earned-value line differs from the red actual cost line and the blue plan line. In both examples, the end of the earned-value line is at the actual final project date and as high as the end of the blue line.

Experience shows that the CPI produces a reliable measure of cost performance. The Schedule Performance Index (SPI) is less reliable, but also useful, to estimate a revised completion date.

Alternative Schedule Projections

Beginning with the full SPI, a project manager could employ additional methods to project a final scheduled date. Here are four methods:

1. Full SPI
2. Critical-Path SPI
3. Calendar Date + Offset
4. Calendar Date Ratio

Methods using the Schedule Performance Index (SPI) are based on planned value and earned value. If the earned value is larger (or less) than the planned value of the tasks, the estimated final date (the new schedule) will be earlier (or later) than the original, or old, final date (the planned schedule).

The full SPI calculation includes off-critical tasks. If off-critical path tasks differ in performance (earlier or later) from on-critical path tasks, the SPI will be biased by the extent of that difference. A biased SPI will lead to a biased expected final date. (See the articles and references at the end of this white paper for a more complete description of the traditional CPI and SPI earned-value ratios.)

The second, third, and fourth methods focus on the project's critical path tasks. The critical path calendar line is a helpful diagram that highlights some interesting aspects of these three predictions.

Figure 9. *An example of a simple critical path calendar line.*

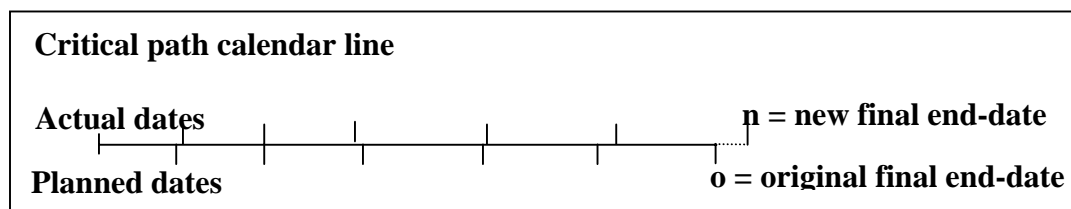


Figure 9 shows the critical-path calendar line for a completed project. The critical-path tasks line up from the beginning to the end of the project. The planned completion date of each task is indicated below the line. The actual completion dates are marked above the line. The original, “o,” and the new, “n,” final end-dates are indicated. In the project depicted, the schedule ran longer than planned.

The Critical Path's SPI

The second method, the Critical-Path SPI, forecasts a new final date based on the ratio of the earned value to the planned value for tasks on the critical path. Both of these values are from the plan whose dates are indicated beneath the critical-path calendar line. As the tasks are actually completed earlier (or later) than their planned dates, the estimated new final

date, “n,” (the new schedule) will be set earlier (or later) than the original final date, “o,” (the planned schedule).

The Critical-Path SPI excludes any bias due to a discrepancy between on-critical and off-critical task performance and generates a better prediction of the final date.

100% Completed Progress Makes Forecasts Jump

Because, in many SPI calculation methods, credit is taken only after the task is 100% completed, when a task’s completion is delayed past its due date, the planned value goes up, the earned value falls behind, the SPI drops below 1.0, and the expected schedule pushes out. When the task is completed, the earned value again equals (or gets closer to) the planned value, the SPI jumps up to (or towards) 1.0 and the forecast falls back to (or closer to) the original planned final date.

Calendar Date Methods of Projecting Schedules

The third and fourth methods are based on comparing the calendar date of the last completed task and the current calendar date.

Figure 10. A critical path calendar line of a partially completed project

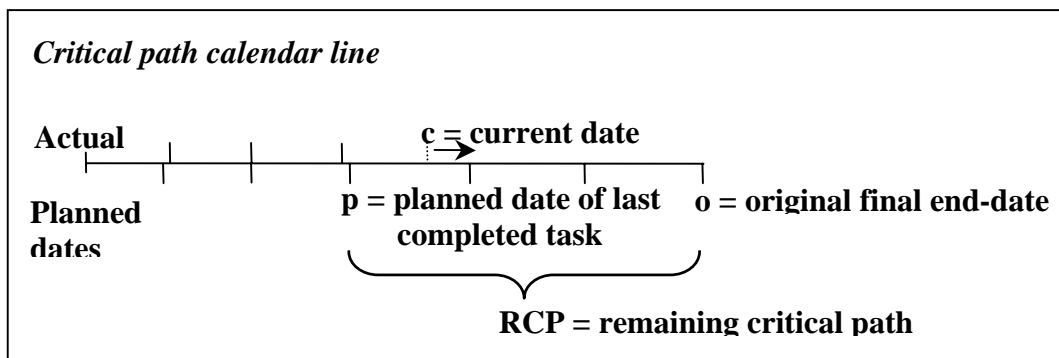


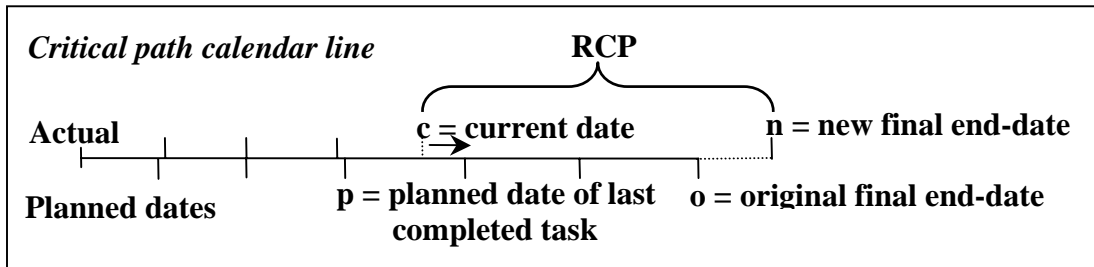
Figure 10 shows a partially completed project. In addition to planned and actual task dates, the current date, “c,” and the planned date of the last completed task, “p,” are marked. Also marked on this calendar line are the original final end-date, “o,” and the remaining critical path, “RCP.” The remaining critical path is $(o - p)$, or, $RCP = o - p$.

The two calendar-date methods both make the conservative assumption that **nothing has been done since the planned date of the last completed task, “p,”** and work forward from the current date, “c,” to the new final end-date, “n,” as either a simple offset or as a ratio multiple.

Calendar Date + Offset Method

The Calendar Date + Offset method is diagrammed in Figure 11.

Figure 11. A critical path calendar line illustrating the calendar date + offset method.



The formula that goes with Figure 11 is:

$$\langle \text{new final date} \rangle = \langle \text{current date} \rangle + \langle \text{remaining critical path offset} \rangle$$

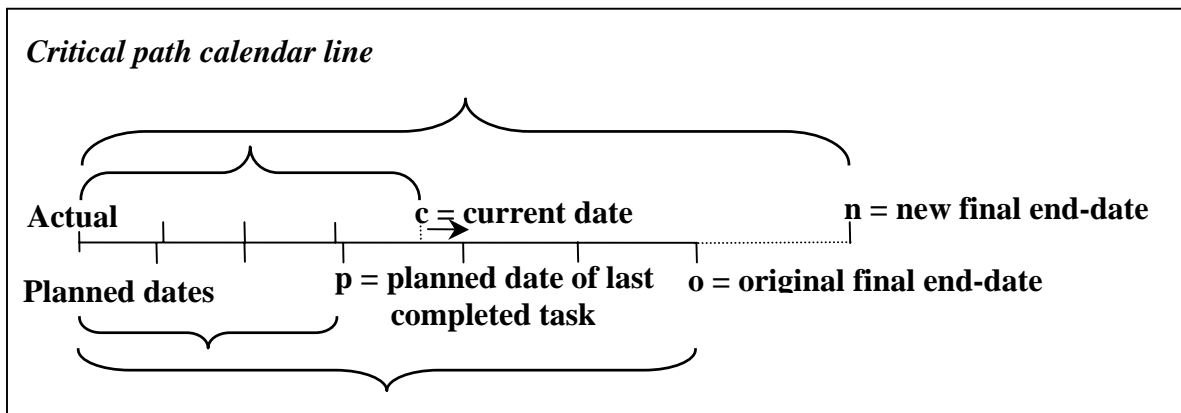
or,

$$n = c + RCP.$$

The Calendar Date Ratio Method

The Calendar Date Ratio method is diagrammed in Figure 12.

Figure 12. A critical path calendar line illustrating the calendar date ratio method.



The formula that goes with Figure 12 is:

$$\langle \text{new final date} \rangle = \langle \text{original final date} \rangle \times (\langle \text{current date} \rangle / \langle \text{planned date of last completed task} \rangle),$$

or,

$$n = o \times (c / p).$$

This formula assumes that the current ratio will persist to the end of the project or,

$$\langle \text{current date} \rangle / \langle \text{planned date of last completed task} \rangle = \langle \text{new final date} \rangle / \langle \text{original final date} \rangle$$

or,

$$(c / p) = (n / o)$$

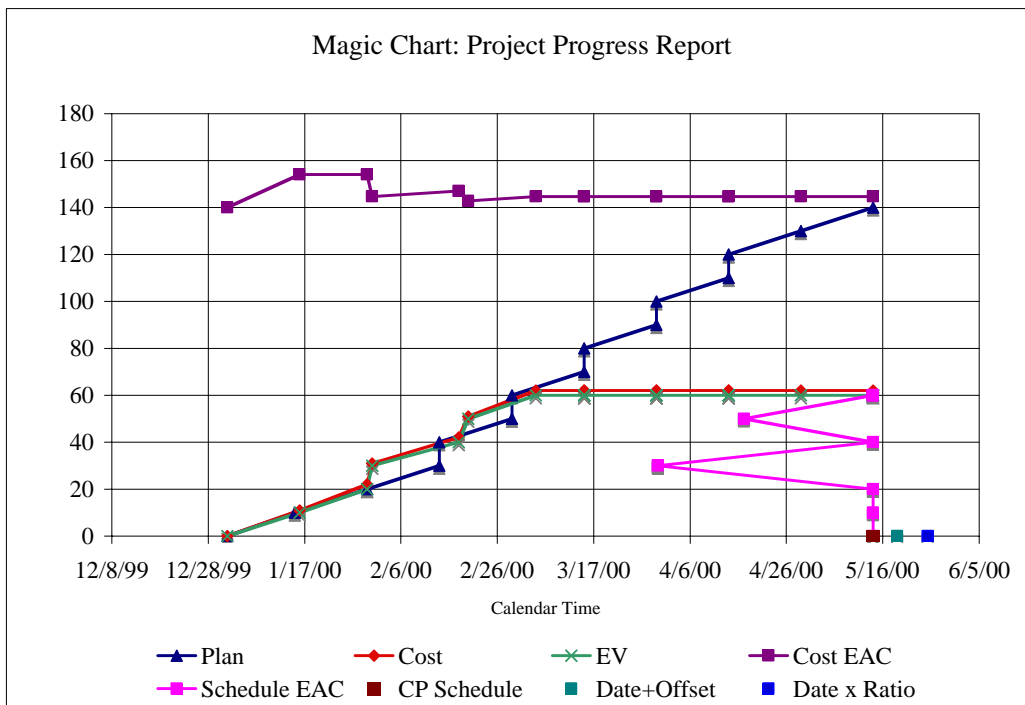
The Full Magic Table

The Full Magic Table includes the alternate methods of predicting the final schedule date. With the inclusion of these additional methods comes the Magic Report, with details on all the probable figures for the project. The Magic Chart now includes points for the alternative schedule forecasts. The full Magic Table is comprised of the Magic Data, the Magic Report, and the Magic Chart.

Figure 13. An example of a full Magic Table with Magic Data, Magic Report, and Magic Chart.

| Magic Data | | 1/1/00 | Start date | 5/14/00 | End date |
|-----------------------------|----------------------|----------------------------|-------------------------|---------------------------|------------------------------|
| | | 3/5/00 | Current date | | |
| <u>Task name</u> | <u>Critical Path</u> | <u>Planned Staff-Hours</u> | <u>Planned Due Date</u> | <u>Actual Staff-Hours</u> | <u>Actual Completed Date</u> |
| 1 Plan red | C | 10 | 1/15/00 | 11 | 1/16/00 |
| 2 Build red | C | 10 | 1/30/00 | 11 | 1/30/00 |
| 3 Write green | | 10 | 2/14/00 | 9 | 1/31/00 |
| 4 Review red | C | 10 | 2/14/00 | 11 | 2/18/00 |
| 5 Review green | | 10 | 2/29/00 | 9 | 2/20/00 |
| 6 Develop pink | C | 10 | 2/29/00 | 11 | 3/5/00 |
| 7 Test green | | 10 | 3/15/00 | | |
| 8 Test pink | C | 10 | 3/15/00 | | |
| 9 Write blue | | 10 | 3/30/00 | | |
| 10 Verify pink | C | 10 | 3/30/00 | | |
| 11 Review blue | | 10 | 4/14/00 | | |
| 12 Assemble crimson | C | 10 | 4/14/00 | | |
| 13 Integrate crimson | C | 10 | 4/29/00 | | |
| 14 Deliver crimson | C | 10 | 5/14/00 | | |

| Magic Report: Estimates at Complete | |
|--|--|
| 140 | What was the original project cost? |
| 14-May-00 | When was the original project scheduled to be completed? |
| 5-Mar-00 | What is the current date? |
| 145 | What will the whole project cost based on the CPI? |
| 14-May-00 | When will the project be done based on the SPI? |
| 14-May-00 | When will the project be done based on the critical path's SPI? |
| | If nothing has been done since the last completed date on the critical path: |
| 19-May-00 | When will the project be done based on the current date plus offset? |
| 25-May-00 | When will the project be done based on the ratio of the last completed date to the current date? |



The full table shows how different estimates for the schedule look, both as dates in a report and as points on a chart. In this example, the full SPI (that drives the Schedule EAC) and the Critical-Path SPI (that drives the CP Schedule) agree. The two calendar-date projections differ both from the SPI calculations and from each other. Taken together, the calendar-date projections estimate that the project will take a little longer than planned.

Using the Full Magic Table

You can use the example in Figure 13 to illustrate how the various ratios behave when you change the plan or the actual results.

Here are some things to try:

1. Make all the off-critical actual tasks finish late and the on-critical actual tasks finish on time to see how the two SPIs can differ.
2. Make all the actual tasks finish early (or late).
3. Experiment by entering hours for tasks that are not yet completed.

Estimation Errors

As you make repeated use of the Magic Table, you will notice that early estimates of costs and schedules can move around a lot. Bouncing cost projections and zig-zagging schedule projections are especially pronounced early on. If you enter cost data on tasks that are not yet complete, these variations may be especially noticeable.

Because the current date, “c,” moves smoothly along the calendar date line, while the value of the planned date of the last completed task, “p,” jumps from one task date to next, the project’s schedule estimates move steadily further into the future, then jump back to their best value as each task finishes.

Both the traditional CPI and SPI are ratios and their estimation error (in between task completions) is large at the beginning of the project and decreases as the project goes forward and the ratio encompasses more of the total project.

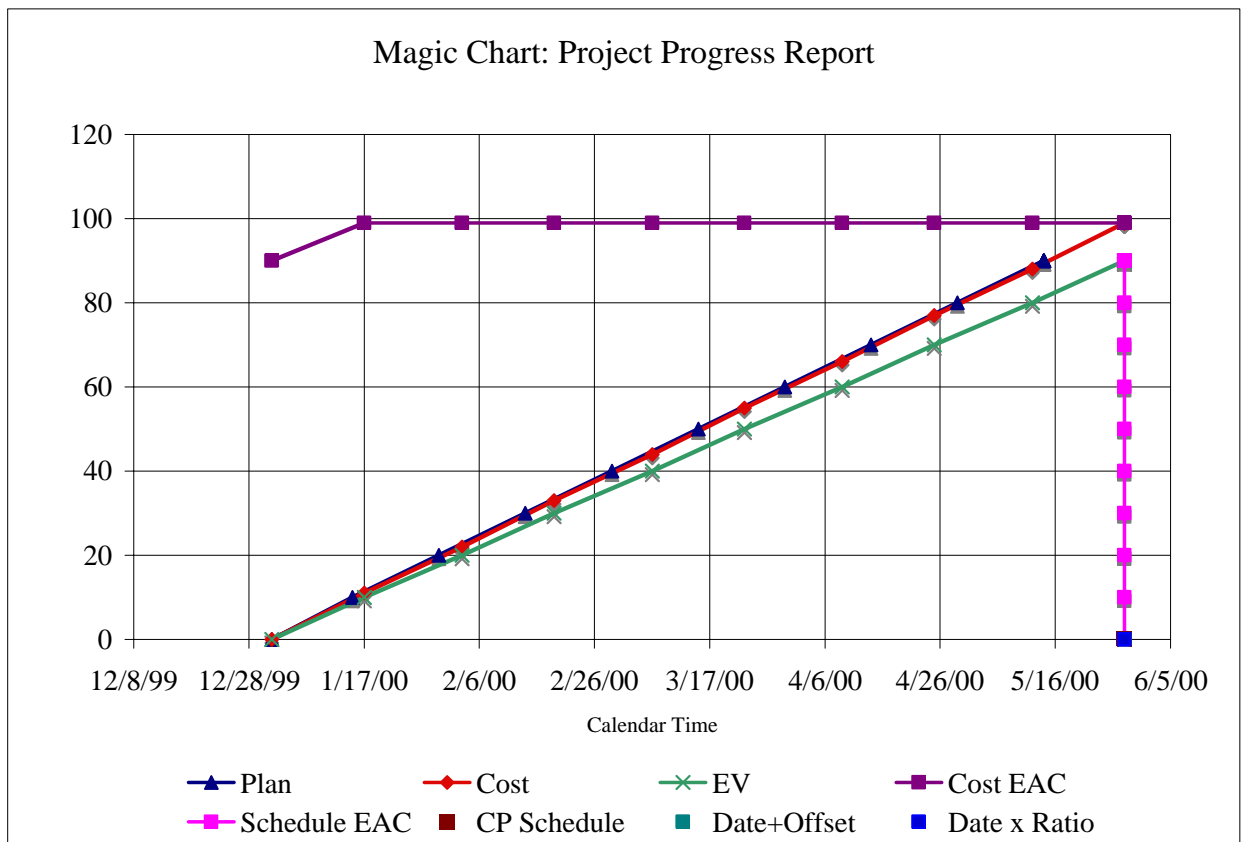
The Critical-Path SPI is also a ratio and the ratio's error (again, in between task completions) is large at the beginning of the project and decreases as the project goes forward and the ratio encompasses more of the total project.

The Calendar Date + Offset calculation assumes that no work has been performed since the last completed task. This method's error is never larger than the duration of the current task throughout the project.

The Calendar Date Ratio calculation also assumes that no work has been performed since the last completed task. Because the projection is based on a ratio, the percentage of error in projection is very large at the beginning of the project but decreases as the project approaches completion.

Figure 14 shows a project that consists of nine tasks in a row. The planned cost was 90 staff-hours of work and the planned schedule was January 1 through May 14. However, the actual project was 10% more expensive and 10% longer. The actual project cost 99 staff-hours and lasted until May 28.

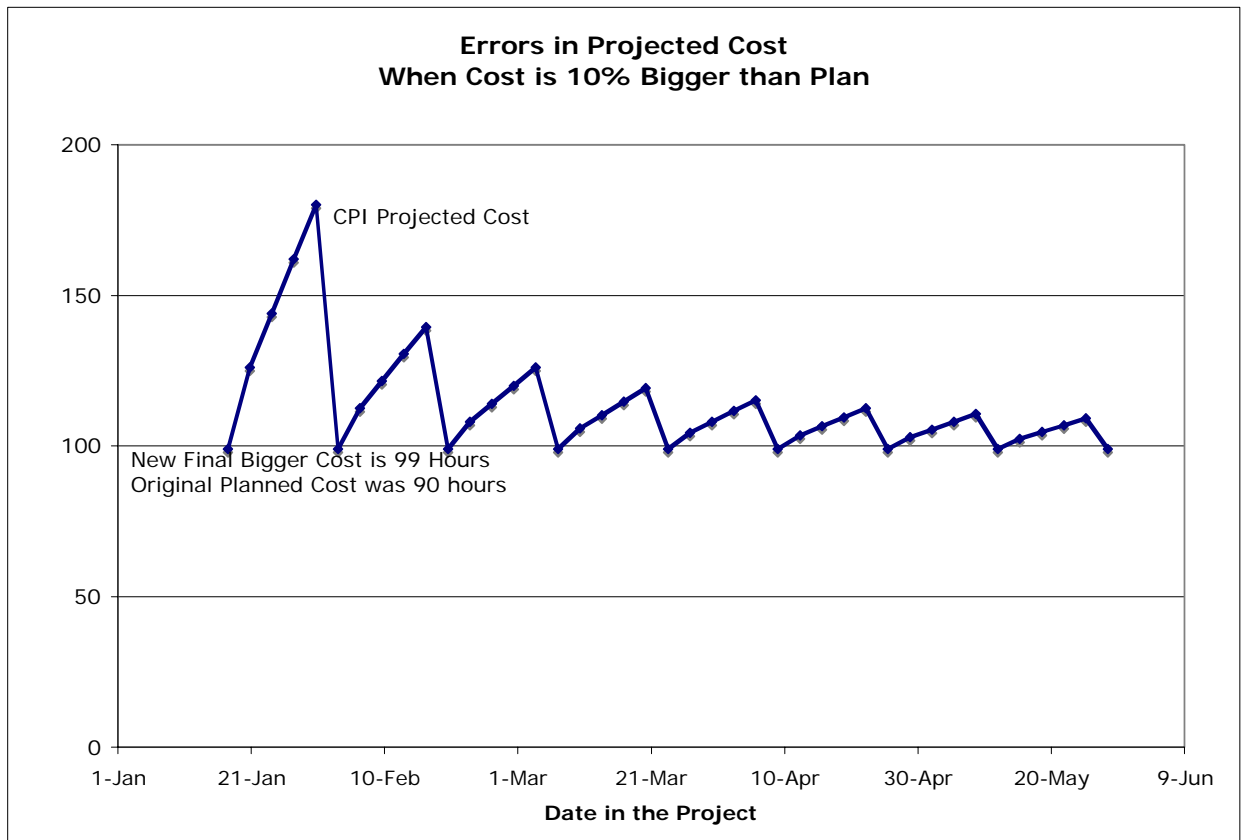
Figure 14. A project that went 10% over in cost and schedule



Progress in Figure 14 looks smooth, but, when progress is measured five times during each task, the intra-task measurements made before the task was completed lead to significant errors in estimated cost and schedule.

Figure 15 shows how the CPI estimated the final cost for the project.

Figure 15. *Errors in estimated final cost*

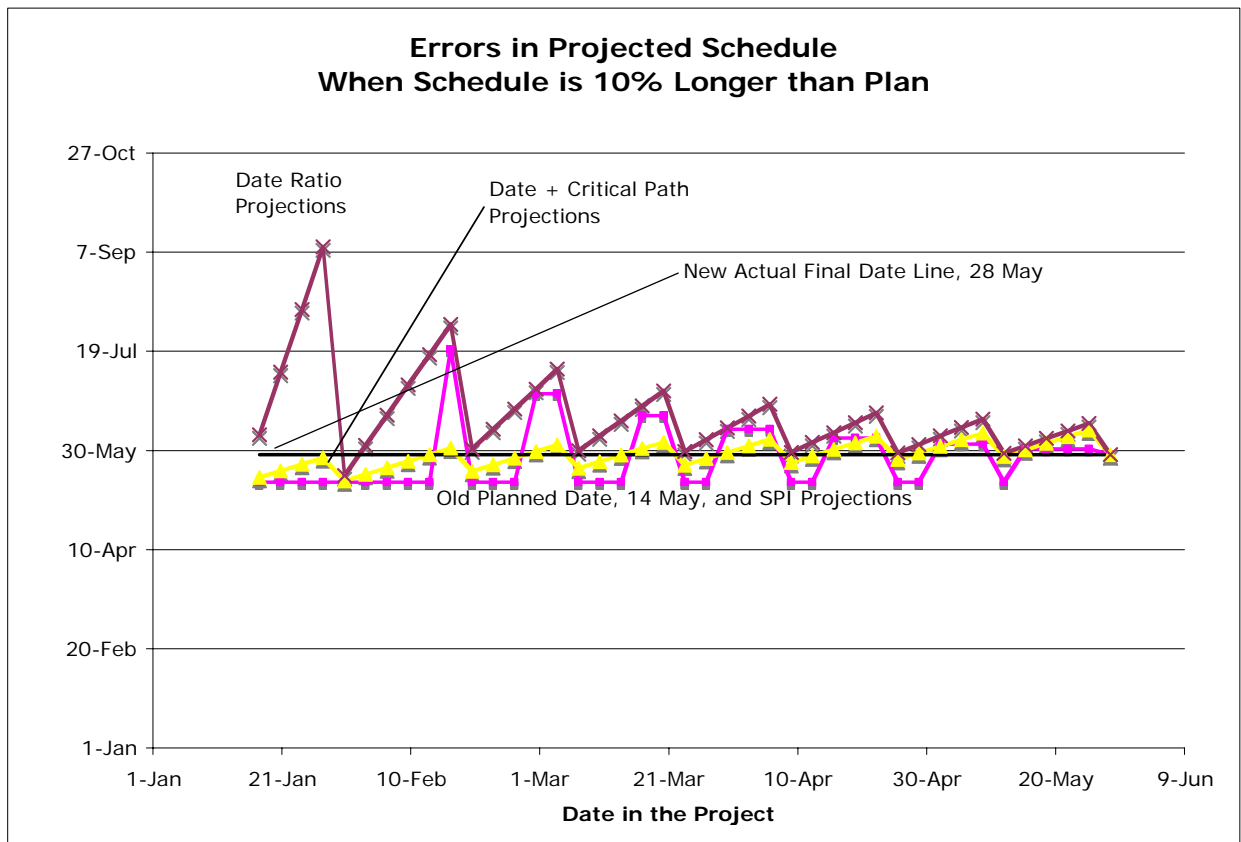


Notice that the projections can only begin after the first task is complete and the earned value is greater than zero. On the second task, the estimates are the most erroneous because the intra-task measurements of actual cost are a big percentage of the total-to-date earned value. As the project continues, the total gets bigger, the intra-task measurements' percentage shrinks, and the projected values move closer to the final mark.

A similar pattern exists for the errors in anticipated schedules using three of our critical-path techniques.

Figure 16 shows how the Critical-Path SPI and the two Calendar Date methods predicted the final schedule.

Figure 16. Errors in predicted final schedule



Again, the estimates can only begin after the first task is complete and the earned value is greater than zero. (The Date + Offset method could begin at the beginning.) On the second task, the Calendar Date Ratio method is the most flawed because the intra-task measurements are a big percentage of the early, total-to-date, earned value. As the project continues, the total grows, the intra-task measurements' percentage shrinks, and the Calendar Date Ratio estimated values move closer to the final mark.

The Critical-Path SPI estimates stay with the original schedule until an intra-task measurement catches a task delayed beyond its planned date. At this point, the planned value advances, the earned value falls behind, the SPI drops below 1.0, and the estimated final date pops up on the chart. When the task is completed, the earned value again equals the planned value, the SPI returns to 1.0 and the estimate returns to the original planned final date. Because the Critical-Path SPI is also a ratio, it errs the most in the early phases and later converges on the true estimate as the project continues.

The Calendar Date + Offset projection has the smallest variation because it is never more than one task's length off the projected value for the schedule. Notice how, at each down-tick in the line, the value is a little larger than the one before. The down-tick values gradually converge on the true final schedule.

One lesson of these plotted errors is that, when you use the full Magic Table, you can minimize all estimation errors if you *record an activity only after it is completed*. This practice will eliminate intra-task measurements and will ensure the best estimates of the project's final cost and schedule.

Conclusion to Part II

With the additional details on earned value, schedule predictions, and patterns of errors, you can now use the Full Magic Table with confidence and precision. The three views – the Magic Data, the Magic Report, and the Magic Chart – will always show you clearly where your project is and where it is going. With a bit of exercise, you can add a powerful new tool to your project management practice, and track even the smallest project's progress.

Further Reading (available free at www.NewLeafPM.com)

For a simple explanation of earned value and how it can be used in a real project, read Mark Durrenberger's *An Earned Value Tutorial*.

To try your hand at calculating basic earned-value figures and other project metrics (including the StSI), read John Nevison's *Earned Value: Ideas and Exercises*.

For more details on the RWI and the StSI, read John Nevison's *The Remaining Work Index (RWI) and the Staffing-to-Schedule Index (StSI): How to use NewLeaf's new indexes to adjust staffing and make your schedule*.

To see the original use and definition of the Re-baseline Staffing Index (RbSI), read John Nevison's *Earned-Value Benchmarks for Re-baselining Your Project: Handy benchmarks to help you re-baseline the project*.

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About the Author

John M. (Jack) Nevison, PMP is the author of six books and numerous articles on computing and management. During the course of his business career, Nevison has built and sold two businesses, managed projects, managed project managers, and served as both an internal and external consultant to Fortune 100 companies. He is past president of the Mass Bay Chapter of the Project Management Institute (PMI®), a past president of the Greater Boston Chapter of the Association for Computing Machinery (ACM), a certified Project Management Professional (PMP), and a Phi Beta Kappa graduate of Dartmouth.

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PDU Questions: The Magic Table

(\$49.95 for 5 PDUs)

1. The word “Magic” comes from a comment by:
 - a. Arthur C. Clarke
 - b. Robert Heinlein
 - c. Mark Twain
 - d. Will Rogers

2. The Magic Table is *primarily* intended for use on what size projects?
 - a. Small
 - b. Medium
 - c. Large
 - d. All of the above

3. The Magic Table is primarily intended to be used by projects whose tasks are staffed:
 - a. Part-time
 - b. Full-time
 - c. Neither
 - d. Both

4. Which of the following is NOT required input to the Magic Data?
 - a. Start date
 - b. Current date
 - c. Finish date
 - d. First task actual completion date

5. Task data in the plan should be entered in order of:
 - a. Size of effort
 - b. Planned due date
 - c. Whether or not task is critical
 - d. Random occurrence

6. Which item is not displayed in the Figure 1 Magic Chart?
 - a. Current planned project path
 - b. Current actual project path
 - c. Current cost estimate at complete
 - d. Current earned value

7. The Figure 1 Magic Chart estimates?
 - a. The project cost at completion
 - b. The project schedule at completion
 - c. Both
 - d. Neither

8. The project in Figure 3 finishes:
 - a. On time and on budget
 - b. Over time and over budget
 - c. Over time and on budget
 - d. On time and over budget

9. On the Magic Chart plot of the project path, two tasks that end on exactly the same date are plotted:
 - a. With a horizontal line between them
 - b. With a vertical line between them
 - c. With a near-horizontal line between them
 - d. With a near-vertical line between them
10. The project in Figure 7 finishes:
 - a. On time and on budget
 - b. Over time and over budget
 - c. Over time and on budget
 - d. On time and over budget
11. If the actual cost to date is higher than the plan, the CPI will lead to an estimate of the cost at completion that is:
 - a. Somewhat higher
 - b. Proportionately higher
 - c. Somewhat lower
 - d. Proportionately lower
12. If the actual progress to date is ahead of the plan, the SPI will lead to an estimate of the schedule at completion that is:
 - a. Somewhat earlier
 - b. Proportionately earlier
 - c. Somewhat later
 - d. Proportionately later
13. Which of the following methods is NOT an *additional* method for estimating a final schedule:
 - a. Full SPI
 - b. Critical-Path SPI
 - c. Calendar Date + Offset
 - d. Calendar Date Ratio
14. Which diagram best illustrates different kinds of schedule estimates?
 - a. Critical path calendar line
 - b. Precedence diagram
 - c. Work breakdown structure
 - d. All of the above
15. Which of the following indexes leads to a ratio-based estimate of schedule?
 - a. Full SPI
 - b. Critical-Path SPI
 - c. Calendar Date Ratio
 - d. All of the above
16. In Figure 16, which of the following methods introduces the *least* estimating error in schedule over the whole project?
 - a. Full SPI
 - b. Critical-Path SPI
 - c. Calendar Date + Offset
 - d. Calendar Date Ratio
17. In Figure 15, in the first plotted task, what is the biggest error in CPI projected cost?
 - a. 180%
 - b. 160%
 - c. 140%
 - d. 120%

The Magic Table

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