A Project Control Milestone Approach to Schedule Control

by Walt Majerowicz

One of the principal benefits of logic network scheduling is that it provides a mechanism for the project manager to focus on potential schedule problems in order to apply the resources necessary to reduce, mitigate or avoid them. However, logic network diagrams can be cumbersome for the project manager to personally manage from, especially on major projects which consist of hundreds of activities, milestones and interrelationships. Likewise, the various Gantt charts, tabular listings, histograms and other products which today's automated project management systems are capable of generating can be overwhelming. And while a detailed schedule is important, the control process can be augmented through the technique of monitoring Project Control Milestones (PCMs). PCMs enable the project manager to understand the schedule "big picture" and focus on urgent schedule issues with the confidence that the PCMs are supported by the underlying detail contained in an integrated project logic network.

The first step in using the PCM approach to schedule control is identifying a suitable set of PCMs. A milestone is an event which represents the start or completion of an activity and is based on a fixed point in time. In general, milestones fall into three categories: major, contract and detail. A major milestone is as its name implies: a key event or one of extremely high visibility such as a Critical Design Reviews (CDR) or launch date. Contract milestones are those in which a supplier is legally obligated to deliver a product or service on a specified date. While major milestones can also be contract milestones, other examples of contract milestones are delivery of a hardware component, completion of a first article qualification test, delivery of a technical data package or completion of a facility's construction. Finally, detail milestones represent the accomplishment of work at lower levels of the project schedule. Examples of detail milestones include release of engineering drawings, placement of a purchase orders for materials or sign-off of test procedures.

PCMs are key events within the project schedule which are considered critical. As such, they can be identified from any part of the logic network and can include major, contract or detail milestones. In addition to the example milestones listed above, PCMs might also include deliveries of flight hardware from industry suppliers, release of major builds of ground system software, successful completion of a prototype test, the release of a Request For Proposal (RFP) to industry, etc. They can also represent the completion of interim stages of work within a major activity. The major criterion for PCMs is simple but important: would missing the milestone threaten project cost, schedule or technical health? If the answer is yes, then it is a candidate for the PCM list.

PCM Illustrated

By way of illustration, Table 1 is the first page of the Project Control Milestone & Total Float Report for the hypothetical Meteoroid Identification & Space Tracking (MIST) Project under development by the TriStar Aerospace Corporation, which is the prime contractor for this NASA mission. The PCMs were identified from MIST's integrated project logic network. For example, the first PCM in Table 1 is MIST255 "Pre-Environmental Test Review" (PER). MIST255 is the activity identifier within the MIST schedule database which corresponds to the completion of the PER. Table 1 also contains the Baseline Delivery and Baseline Total Float columns, which refer to the delivery or completion dates and total float of the PCMs that were planned when the project schedule was baselined. Also included in Table 1 are the current (April) and prior (March) months' forecast delivery dates and total float. An actual PCM completion is identified with the letter "A" next to

METEROID IDENTIFICATION & SPACE TRACKING (MIST) PROJECT
PROJECT CONTROL MILESTONE & TOTAL FLOAT REPORT

DATA DATE: 30APR96

ACTIVITY IDENTIFIER	ACTIVITY DESCRIPTION	BASELINE DELIVERY	BASELINE TOTAL FLOAT	MARCH DELIVERY	MARCH TOTAL FLOAT	APRIL DELIVERY	APRIL TOTAL FLOAT	TF CHANGE MAR / APR
MIST MILESTONES								
MIST255	Pre-Environmental Test Review (PER)	17MAY96	19	17MAY96	23	17MAY96	23	0
OBS242	Pre-Shipment Review (PSR)	17MAR97	15	26MAR97	9	02APR97	3	-6
OBS240	Observatory Ready for Shipment	27MAR97	11	05APR97	3	12APR97	-5	-8
OBS0248	Observatory Arrival at Launch Site	22APR97	11	01MAY97	1	08MAY97	-5	-6
OBS500	MIST Launch Readiness	01APR98	0	01APR98	0	06APR98	-5	-5
MIST250	MIST Mission Operations Review (MOR)	28MAR96	87	28MAR96	87	29MAR96(A)	0	0
POWER SUBSYSTEM								
POSA670	+Z Solar Array Panels Delivery	06MAR96	84	19APR96	52	10MAY96	44	-8
POSA695	+Z Solar Array Panels Ready for SADDS I&T	20MAR96	84	03MAY96	52	24MAY96	44	-8
POSA671	-Z Solar Array Panels Delivery	03MAY96	49	31MAY96	26	31MAY96	33	7
POSA696	-Z Solar Array Panels Ready for SADDS I&T	17MAY96	49	14JUN96	26	14JUN96	33	7
POBAT960	Super NiCd Battery Delivery	15APR96	152	30APR96	142	30APR96(A)	0	0
POBAT980	Super NiCd Battery Delivery (spare set)	13MAY96	152	29MAY96	142	29MAY96	144	2
C&DH SUBSYSTEM								
CDH6012	RTT A Ready for OBS I&T	22MAR96	49	12APR96	5	23APR96(A)	0	0
CDH6022	RTT B Ready for OBS I&T	28MAY96	5	28MAY96	5	04JUN96	8	3
ATTITUDE CONTROL SUBSYSTEM								
ACS402A	ACS B5.2 Ready for Formal S/W IV&V	15MAR96	35	14MAR96	0	14MAR96(A)	0	0
DEPLOYABLES SUBSYSTEM								
DES08021	+Z SADDS Flight Wing Ready for OBS I&T	04SEP96	12	12SEP96	2	03SEP96	14	12
DES08022	-Z SADDS Flight Wing Ready for OBS I&T	06SEP96	14	12SEP96	6	02OCT96	-3	-9
DES2016	SADA Ready for OBS I&T	15MAR96	10	18MAR96	0	18MAR96(A)	0	0

Table 1. Project Control Milestone and Total Float Report.

the date in the April delivery column. These ingredients comprise the fundamental elements of schedule reporting: baseline schedule, actual performance, current forecast and variance.

To describe this concept further, located under the subheading Power Subsystem, is the seventh milestone in Table 1: POSA670 "+Z Solar Array Panels Delivery." Again, POSA670 is the activity identifier which corresponds to the delivery to TriStar of the +Z Solar Array Panels from the Nova Corporation, the industry supplier. Upon delivery to TriStar the panels will be inspected and tested prior to turnover to the next higher assembly. As indicated in Table 1, the baseline delivery for the +Z Solar Array Panels was March 6, 1996 (early finish) with a total float of +84 days. In other words, if the +Z panel delivery is delayed beyond March 6, there are 84 days of float, or slack, available before this delay would impact the target completion date of the hypothetical MIST Project which is its launch date of April 1, 1998. Similar delivery and float status for the current month of April and the prior month of March are contained in the Project Control Milestone & Total Float Report in order to highlight variances against the baseline as well as the prior month's forecast. Float will be described in more detail under the section Control Milestone Analysis.

Lets examine why the POSA670 "+Z Solar Array Flight Panels Delivery" has been identified as a PCM in terms of the schedule, technical and cost health criteria described earlier. First, in terms of schedule health, a delay in the +Z Solar Array Panels could mean a later than planned completion of the + Z Solar Array Flight Wing: the deployable subsystem of which the +Z Arrays are the critical component. Delays in Flight Wing build-up and test could further delay the MIST observatory integration and test program. Ultimately, the launch readiness could be in jeopardy.

Next, the technical health of the project could be threatened by a delay in this PCM. For example, further serious schedule delays with the +Z Solar Array Panels could result in a decision to eliminate or reduce the scope of downstream testing in order to meet the launch date. If the delay of this or any PCM resulted in a slip in the planned launch date, it could mean losing valuable science mission life and possibly lead to a significant cost overrun. In terms of cost, TriStar has a firm fixed price (FFP) contract with the Nova Corporation for the Solar Array Panels. With the exception of change orders, delays in delivery would not necessarily impact MIST's cost for the solar array panels themselves in terms of their development budget. While this direct cost may not be at risk in the case of further delays for this FFP delivery, there is almost certainly the additional indirect cost associated with: 1) the technical team's investigation into the problem 2) further project and procurement management attention, 3) additional travel funds to coordinate with Nova, 4) delay to the start of the next higher assembly, and 5) possible delay to the observatory integration and test program.

Therefore, delivery of the +Z Solar Array Panels from the Nova Corporation to TriStar is a critical milestone on the PCM list primarily for schedule reasons, although cost and technical elements are also considerations. As a first step, identifying the proper PCMs is an important part of providing the project manager with a concise set of the milestones that summarize the entire project schedule and provide a focal point for management control.

Establishing the Project Control Milestone Plan

Once the PCMs have been identified, their corresponding planned completion dates (early finishes) can be easily depicted as a cumulative plan over time. MIST's cumulative PCM plan from its February 1996 rebaseline through December 1996 is summarized in Figure 1. Figure 1 was constructed simply by adding together each month's PCMs and plotting a cumulative curve. The cumulative curve is a logical format for depicting the PCM plan because its realism will be readily apparent in the conservative build-up, rapid acceleration and slow reduction in PCMs typical of the standard "S" curve. The same summary can be done for any period of time, depending on the needs of the project. For a project just getting underway, a summary of the PCMs leading up to the Critical Design Review (CDR) is a good starting point. Additional PCMs could be added in a "rolling wave" fashion as time elapses. The scale could be by week, month or quarter. This approach is similar to cumulative cost plans, drawing releases, etc.

It is important to emphasize that since the PCMs are drawn directly from the project logic network, the PCM plan is traceable to all levels of the project schedule: master, intermediate and detail. The PCM plan is not separate from, but part of, the overall project schedule. A PCM plan similar to Figure 1 conveniently summarizes what is expected to be accomplished over a fixed period of time.

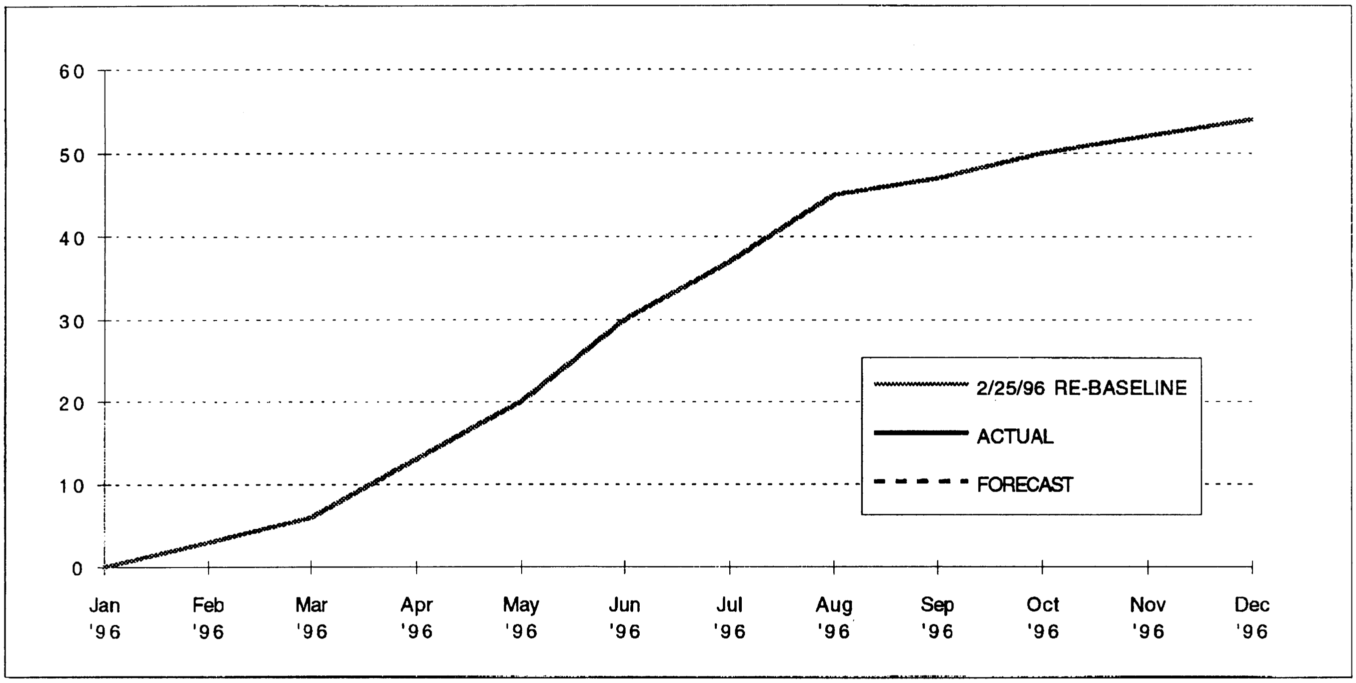
With the PCM plan, the project manager now has a summary metric or way of measuring the schedule in terms of plan, performance and forecast-to-complete. This high level view of the schedule allows him or her to see the big picture, further enhancing schedule control.

Control Milestone Performance & Forecast

On a hypothetical major project such as MIST, the logic network is updated with the current status and forecast once each month to coincide with workforce and financial reporting. Since the PCMs are an integral part of the logic network, they are automatically updated each month when the network is statused. For example, in Table 1 the PCM ACS402A "ACS Build 5.2 Ready For Formal S/W IV&V"was actually completed on March 14, 1996. This actual completion date is identified by the "A" in the April delivery column. This means the build testing of atti-

MIST 1996 PROJECT CONTROL MILESTONE PLAN

(PLAN = 2/25/96 RE-BASELINE)



	Jan '96	Feb '96	Mar '96	Apr '96	May '96	Jun '96	Jul '96	Aug '96	Sep '96	Oct '96	Nov '96	Dec '96
2/25/96 Rebaseline	0	3	6	13	20	30	37	45	47	50	52	54
ACTUAL												
FORECAST (4/30/96)												

STATUS AS OF: 4/30/96

Figure 1. PCM plan.

tude control subsystem software Build 5.2 was actually accomplished on March 14 and delivered to the IV&V laboratory for testing. The delivery of ACS402A allows credit to be taken for completing this PCM.

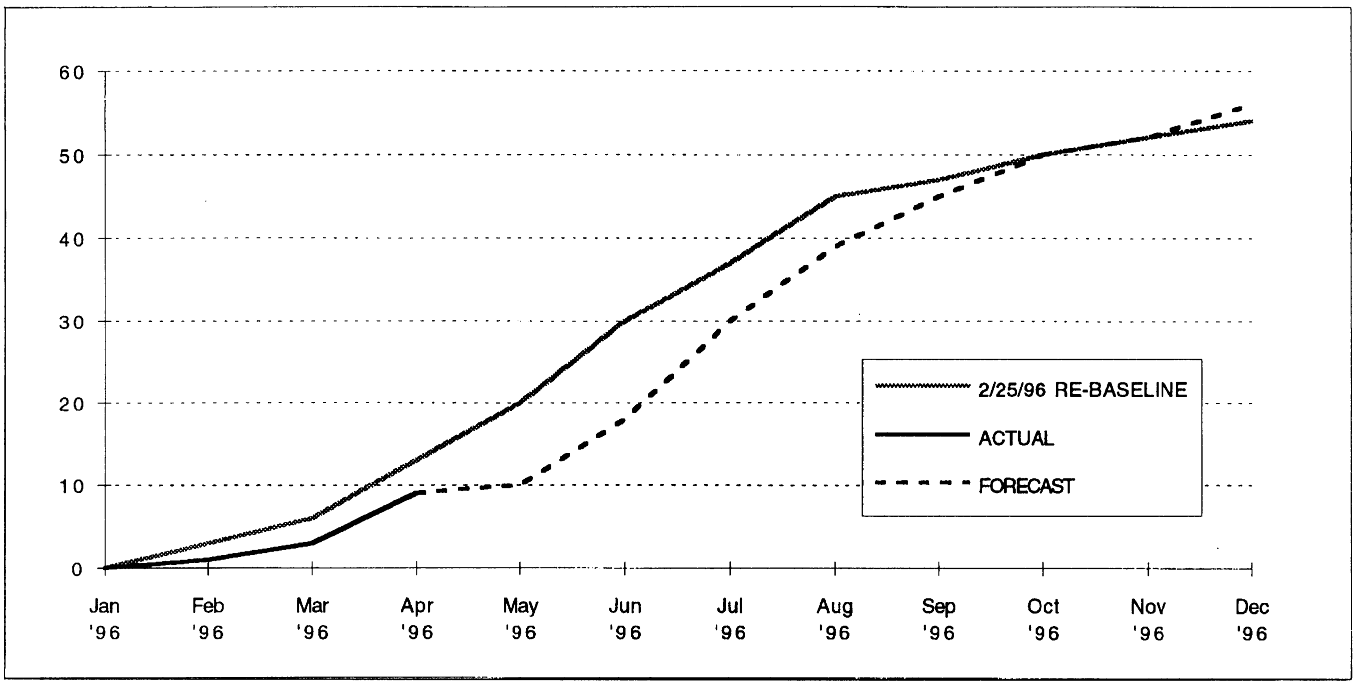
In addition to actual PCMs completed, the status cycle also provides the current forecast, or projection, of when remaining PCMs will be completed. Again, referring to Table 1, PCM CDH6022 "RTT B Ready For Obs I&T" has a baseline scheduled delivery of May 28, 1996, which was also last month's (March) forecast delivery. The current month's (April) forecast completion is June 4, 1996. This means that the Realtime Telemetry Tracker (RTT) B-side flight unit will be finished testing and delivered for integration with the MIST observatory on June 4, based on the forecast for completing the work remaining on it.

Once the schedule status accounting cycle is completed and the actual and forecast dates for the PCMs are obtained, PCM schedule performance is summarized by plotting the actual milestones completed and current forecast against the plan. Figure 2 illustrates the comparison of MIST's cumulative PCM actuals and current forecast to the PCM plan which was introduced in Figure 1.

Again, with a list of PCMs, the project manager can see at a glance what his or her project's major events are, when they are scheduled for completion and how much margin or float exists to accommodate possible delays. At the same time, the project man-

MIST 1996 PROJECT CONTROL MILESTONE PERFORMANCE

(PLAN = 2/25/96 RE-BASELINE)



	Jan '96	Feb '96	Mar '96	Apr '96	May '96	Jun '96	Jul '96	Aug '96	Sep '96	Oct '96	Nov '96	Dec '96
2/25/96 Rebaseline	0	3	6	13	20	30	37	45	47	50	52	54
ACTUAL	0	1	3	9								
FORECAST (4/30/96)					10	18	30	39	45	50	52	56

STATUS AS OF: 4/30/96

Figure 2. PCM performance metric.

ager has confidence in the realism underlying the plan and status because the PCMs are contained directly in the detailed project logic network.

Control Milestone Analysis

So far a basic approach to identifying PCMs and portraying their plan and corresponding performance has been described. This process should be taken a step further by analyzing what the performance data means and making an assessment of what to expect in the future for the project schedule. In the hypothetical MIST example illustrated in Figure 2, some important information can be obtained from the PCM performance metric. For the period ending April 30, 1996 (data or status date), 69% or 9 of the 13 planned PCMs were actually accomplished. The project manager can quickly gauge the overall schedule performance for the month as well as the cumulative performance to date and immediately focus on those major milestones that have not been accomplished. Variances to the plan are readily apparent, and specific PCM problems can now be investigated for cause and corrective action. Additionally, those PCMs that have not been completed in accordance with the baseline schedule indicate not only the amount of work still remaining, but suggest that performance efficiency may have to improve in order to get back on track.

For example, milestone POSA670 "+Z Solar Array Panels Delivery" was described earlier as one of the four PCMs not accomplished as of the reporting period ending April 30th. In Table 1 the project manager can see that its delivery has been delayed from the forecast April 19th delivery at +52 days total float reported last month to the current forecast delivery of May 10th at +44 days total float reported in the current month, a reduction in float of eight days. In addition to a comparison of the current month's forecast delivery to last month's forecast, a comparison against the original baseline delivery of March 6th at +84 days float shows that the +Z Solar Array Panels are almost three months behind the baseline scheduled delivery and forty days of float have been consumed. Recall that total float is the amount of time an activity or event can be delayed before it impacts the project's completion point: the April 1, 1998, launch date in the case of MIST.

While it is a concern that this PCM has been delayed resulting in a loss of eight days of slack from the prior month, it is not yet a major problem. In this hypothetical example, a test equipment problem (cause) has been resolved by the technical team and a software patch (corrective action) has been incorporated by the Nova Corporation. Additionally, the remaining +44 days of schedule slack is still a sufficient margin should other unforeseen problems emerge. The value of the PCM reporting is that it alerts the project manager of significant schedule changes to critical project elements in order to facilitate investigation and implement corrective actions.

For a project that has implemented a performance measurement system (PMS), the PCM data provides a way to augment the variance analysis and schedule efficiency calculations. For example, the Budgeted Cost of Work Performed (BCWP or earned value) minus the Budget Cost of Work Scheduled (BCWS or the budget) indicates the Schedule Variance (SV), or difference between the dollar value of the work actually accomplished versus the work that should have been accomplished in the reporting period: SV = BCWP - BCWS. Similarly, the difference between the PCMs accomplished vs. planned could be compared to the formal SV. On a percentage basis the SV and PCM variance should correlate within a +/- 10% range. If not, then further investigation into the difference may be required.

Similarly, the Schedule Performance Index (SPI) = BCWP/BCWS. This ratio of work performed vs. work scheduled can be easily compared to the ratio of the number of PCMs accomplished vs. planned in order to gauge the relative efficiency of the schedule performance. The formal SPI and PCM ratio should also correlate within a +/- 10% range. If the SPI indicates 92% and the ratio of PCM actuals to plan is only 75%, it might suggest that the project schedule is not fully integrated with the PMS, earned value is being taken for work performed out of sequence, etc.

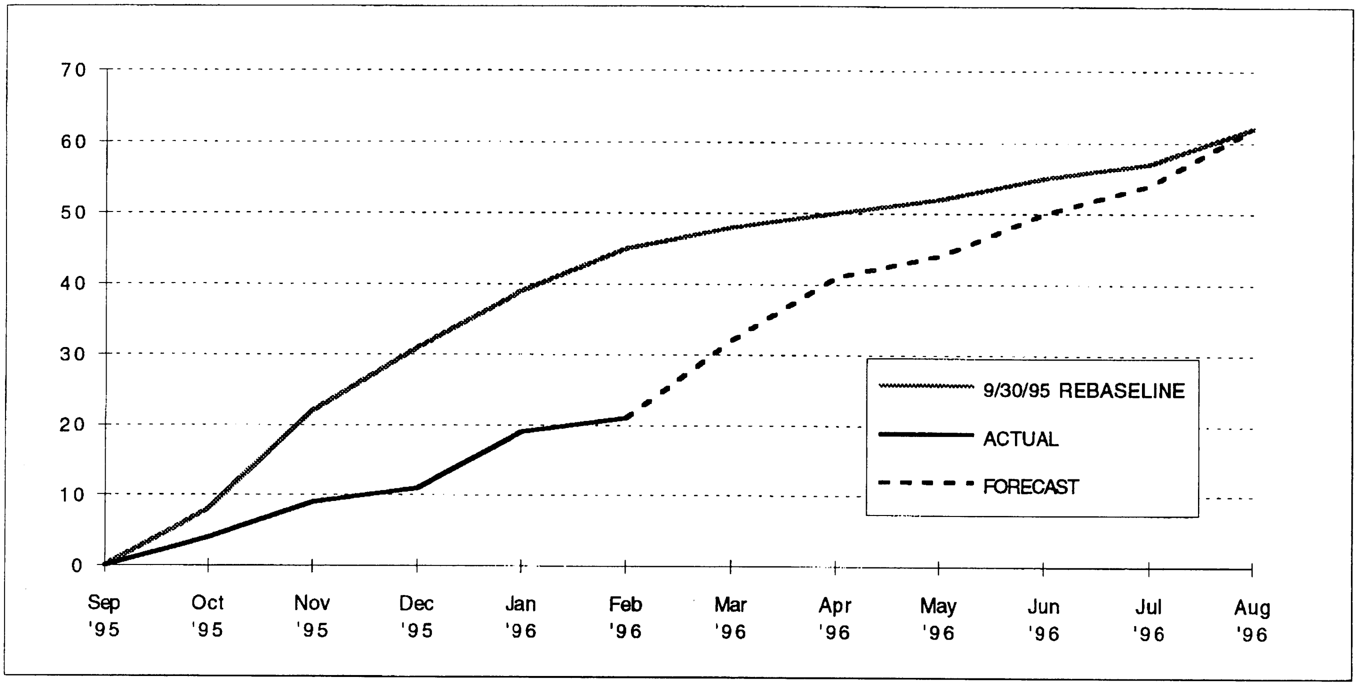
While the PCMs provide a measure of schedule performance, they also provide a good tool for trend analysis and insight into the realism of schedule forecasts, particularly when applied to the surveillance of contractor and supplier schedules. Consider Figure 3 which depicts the PCM plan, performance and forecast for the hypothetical Advanced Spectrum Analyzer (ASA). The ASA is a key scientific instrument for MIST being developed by the Browning Aircraft Company under a Cost Plus Award Fee (CPAF) contract from NASA. NASA, in turn, will provide the ASA as Government Furnished Equipment (GFE) to TriStar for integration into the MIST spacecraft. Figure 3 summarizes the PCM status for the ASA contract identified in Browning's logic network as of February 24, 1996. The NASA logic network is a Contract Data Requirement List (CDRL) item delivered each month to the MIST NASA Project Office.

Clearly, Figure 3 triggers a number of danger signals. First, note that the Browning is 53% behind the cumulative PCM plan through February 1996. Moreover, an alarming trend has emerged in that each month the actual number of milestones has fallen short of the plan. In fact, the Browning is averaging only 4.2 PCM completions each month. Also, another concern illustrated in Figure 3 is the classic case of the overly optimistic forecast. Note how the forecast, or estimate-to-complete, for the PCMs ultimately "catches up" in August 1996, while the performance trend suggests this is unlikely.

Although Figure 3 does not explain why Browning is not performing to plan or what the basis is for its optimistic schedule forecast, it does give the project manager a starting point for investigating the poor performance. Moreover, if caught early enough, proper management and technical attention can be

MIST ASA PROJECT CONTROL MILESTONE PERFORMANCE

(PLAN = 9/30/95 Nova Corp. Rebaseline/Estimate-To-Complete)



	Sep '95	Oct '95	Nov '95	Dec '95	Jan '96	Feb '96	Mar '96	Apr '96	May '96	Jun '96	Jul '96	Aug '96
ETC / REBASELINE	0	8	22	31	39	45	48	50	52	55	57	62
ACTUAL	0	4	9	11	19	21						
FORECAST (2/24/95)							32	41	44	50	54	62

SOURCE: ASA CDRL 005 3/20/96 STATUS AS OF: 2/24/96

Figure 3. PCM plan, performance and forecast.

applied to the underlying problems associated with such contracts. Otherwise, if left unchecked or without an improvement in efficiency, Browning's performance could continue to deteriorate, supported only by the claim that "things will get better next month." In fact, as described earlier, the ASA contract has been averaging 4.2 PCM completions per month since October 1995. A simple extrapolation of this rate suggests that the ASA will not complete all 62 of its PCMs until December 1996 if the present trend continues. This is four months after the planned delivery date of August 1996 (see Figure 3). This could result in potential technical and schedule problems for the MIST spacecraft integration program which needs the ASA instrument to continue into the test program. Moreover, severe cost overruns at the contractor could emerge if this condition continues. As a CPAF contract, the MIST NASA Project Office will have to allocate management reserve to cover the Browning overrun in order to complete the ASA instrument.

However, with careful surveillance of the supplier's schedule performance through PCM monitoring, the MIST Project would understand far in advance that the ASA instrument would probably be delivered much later than the Browning's estimate-to-complete indicated. In anticipation of the late ASA delivery, a workaround plan could be formulated to mitigate this problem. For example, the observatory integration and test sequence could be modified, resulting in a workaround plan that integrates the ASA before the start of the first observatory comprehensive performance test.

Whether for a total project or a key element of it—such as a major hardware item under contract with a supplier—a PCM approach to schedule control provides a framework for the project manager to understand the schedule status against the original baseline and the most recent replan. At the same time it affords a simple, graphical way of not only capturing trend data, but quantifying the amount of effort remaining to be done and the urgent issues which need attention.

A Project Control Milestone approach to monitoring schedule performance, forecasts and margins does not replace a conventional logic network schedule or other scheduling techniques. PCM metrics are simply a way to summarize a vast amount of schedule information for the project manager so he or she can understand the big picture and quickly assess potential schedule threats in order to take the appropriate corrective action. With the enormous number of technical, cost, procurement and administrative matters that demand the typical project manager's time, the PCM approach affords a way to quickly focus on the urgent needs of the project schedule and identify the elements that require immediate attention.