The "One-Pager": Methodology and Application

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Today's NASA program/project managers must operate within an environment of increasing volatility, uncertainty and seemingly contradictory goals. With Congress intent upon cutting federal discretionary spending, programs may be slipped, reduced in content or scope and/or redesigned, perhaps within the space of a single fiscal year. The litany of faster, better, cheaper implies a willingness to accept greater technical risk, yet NASA may not be allowed to fail, thereby making it extremely difficult to achieve the cost, schedule and technical goals set for programs. Certainly, the magnitude of cost and schedule overruns experienced by past NASA programs will not be tolerated in the future.

NASA program and project managers need a system that will facilitate timely, accurate top-down program/project assessments required to establish and/or assess the program's baseline plan, determine progress against the plan and assess planning alternatives. It must operate effectively and efficiently under constantly changing conditions. Existing NASA systems often fail to satisfy these requirements. Scheduling and performance measurement systems are very detailed and extensive and generate vast amounts of data, but rarely in a form or format that is conducive to providing timely visibility into today's programs. This, coupled with the NASA project management community's great appetite for detail, tends to choke the system and prohibit quick action. In addition, contractual arrangements between NASA and its contractors often discourage the contractor from providing accurate long range budget planning, as there is no incentive offered to provide the occasional bad news.

The One-Pager is a single chart that presents an integrated cost, schedule and content (metrics) display for a selected end item. It was designed to help management focus on key cost, schedule and technical drivers and serve as a common basis for communications. It is simple in concept and appearance, is produced using a consistent methodology, focuses at the subsystem or key ORU level, is done in the context of a hardware /integration/test "backbone," captures only the important "nuggets," and places its emphasis on "programmatics," which are defined here as the interplay and relationship between the cost, schedule and technical aspects of a program.

Figure 1 is an example of a one-pager which reflects the baseline plan for a new development nickel hydrogen battery as of December 1992. While it is not as complete (in terms of cost and metrics) as might be desired, it nonetheless provides an excellent example of the type and amount of information contained within a properly constructed one-pager.

A little background is in order before discussing Figure 1. The nickel-hydrogen battery comprises four basic components: the cells, the battery signal conditioning and control module (BSCCM), an enclosure, and some

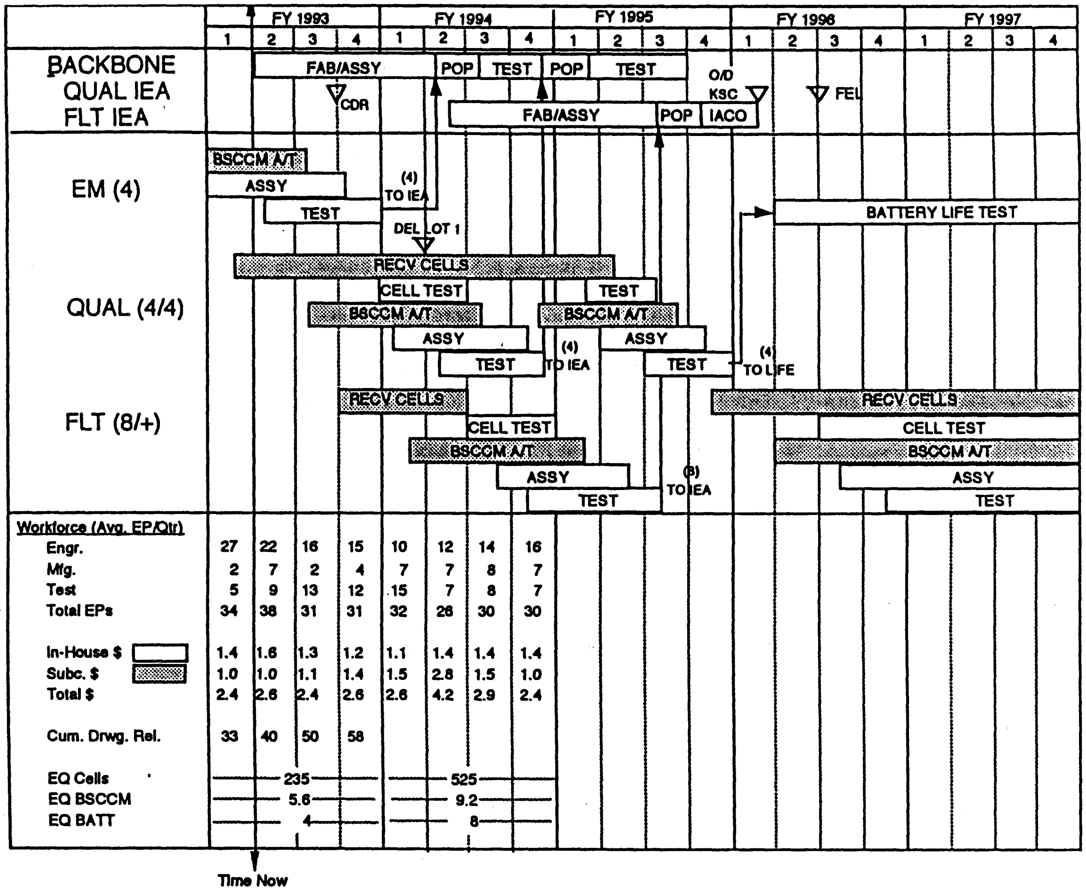


Figure 1. Battery One-Pager 12/92

parts. The one-pager in Figure 1 focuses on the cells and the BSCCM (the most complex and costly components), and tracks the engineering models, the qualification units and the flight hardware for each. Engineering models (EM) are often referred to as form-fit-and-function articles, and with the exception of certain environmental and space-rated parts requirements, conform to actual flight specifications (volume, shape and weight constraints, power utilization limitations, etc.). The results of engineering model testing feed into the critical design review (CDR) process. The qualification or "qual" unit (sometimes referred to as the prototype unit) is the first unit built to all flight specification requirements; it also undergoes extensive testing. In crewed programs, this unit is not usually flown. Flight hardware is the actual unit flown. The unit not only meets form, fit and function criteria, but also is constructed of space-rated parts. In uncrewed programs, a protoflighting approach is often used, whereby the qualification unit is refurbished and flown, thus avoiding the production of another flight unit.

The "backbone" or multi-system hardware/integration/test program, which provides a context for the battery hardware, is shown at the top of the one-pager in Figure 1. This program dictates that, after individual testing, engineering model hardware from several different systems will be used to populate half of the Integrated Equipment Assembly (IEA) qual unit. The IEA then undergoes a series of tests designed to determine whether the integrated hardware from different systems will play together properly.

At the completion of these tests, qual hardware from the different systems will populate the other half of the qual IEA and a series of integrated tests are again conducted. The final piece of the "backbone" shows flight hardware populating the flight IEA unit in preparation for Integration, Assembly & Checkout (IACO). These multi-system hardware/integration/test programs govern, to a considerable degree, both the fidelity (engineering model, qual unit, or flight unit) and delivery dates of hardware and, as we shall see, play an important role in the overall risk profile of the program.

Finally, shaded schedule activity bars refer to subcontractors, while unshaded activity bars refer to in-house.

Now examine Figure 1, starting at the top left. As of T_{Now}, the cell EM tests have been completed, the BSCCM EM tests are underway (with four months remaining until completion), but the battery EM tests have not yet commenced. Note that CDR is scheduled to occur three months before the completion of battery engineering model testing. Since the results of engineering model testing feed into the CDR process, we should be aware that the CDR may not be as complete as it could be, thereby introducing technical risk and/or the possibility that a delta CDR might have to be conducted.

Battery EM tests are completed prior to beginning the assembly of battery qual units, and although there is a bit of overlap between the completion of the first battery qual tests and the assembly of the flight units, the overlap is acceptable and the risk is deemed low. The time between the completion of the EM tests and the first flight article delivery (to the flight IEA) is a bit over eighteen months. Historically, this time period has been closer to twenty-four months, so the intent to accomplish delivery much earlier should be viewed with moderate concern.

The IEA EM testing is scheduled to be completed at the same time as the first battery set qual tests are to be completed and midway through the assembly of the battery flight unit. This means that if the battery EM contains some error such that it does not play properly with other system hardware in an integrated test mode, that error is also present in the qual and flight hardware. Errors that occur at this stage of the design/production cycle may cost as much as ten times more to correct than errors detected much earlier.

The first battery flight article is scheduled to be delivered two months prior to completion of the IEA qual tests, and the fully integrated IEA flight article is due on-dock at KSC only five months after completion of the IEA qual tests. There is clearly no schedule slack available to correct any errors in the battery that might be detected through integrated testing of the IEA. This schedule should be viewed overall with a high level of concern. However, given that the multi-system integrated testing schedule seems somewhat out of phase with the battery's development schedule, the importance of the integrated testing with respect to the battery should be investigated.

Turning our attention to the cost and metrics section of the battery one-pager in Figure 1, note that the engineering work force peaked at 27 EPs in the quarter prior to T_{Now}, and is scheduled to continue decreasing to 60 percent of peak at CDR and 37 percent of peak at the start of battery qual assembly. This decrease in the engineering work force at a time when engineering should be at or near its peak should be viewed with a high level of concern. The risk is one of additional costs to sustain engineering at higher levels and/or of additional schedule to complete the engineering job. The manufacturing work force is at 25 percent of its peak during the last quarter of the EM assembly, while the test work force is at 50 percent of its peak during the last quarter of qual testing. This is counter to what one might expect, and should be viewed with a high level of concern, as the reconciliation of this risk is liable to be either increased cost and/or additional schedule.

Finally, notice the equivalent units of subcontracted work and the dollars associated with them in FY93 and FY94. The plan shows that more than twice as many equivalent units of cells and twice as many equivalent batteries are to be produced in FY94 as in FY93, but for much less than twice the cost. Coupled with the probability that more engineering effort than anticipated will occur during FY93, there should be a moderate level of concern that the project will be unable to achieve the levels of production as planned.

One-pagers contain an impressive amount of information in a simple, comprehensible format. They also confer a number of benefits on users. They force a very disciplined analytical approach by both the people who construct them and those who use them. They promote a greater in-depth understanding as to how a program fits together, force everyone to focus at the same level, and communicate extremely well. If used to facilitate a replanning, the turnaround time is extremely low. If used to assess a baseline plan or determine progress against a plan, it yields an informed opinion, finding or observation, sets agenda items for management forums and focuses management's attention on the target area. Perhaps one of the most beneficial yields from the use of one-pagers is that engineers, analysts and management become attuned to programmatic issues and develop a "feel" for the program. (A "feel" for the program is defined as a personal knowledge base as to how various cost, schedule and technical aspects of a program play together such that one develops an intuitive understanding of how a change in one will affect the others.)

Perhaps the best way to further describe the discipline of the one-pager is to discuss how you would use the one-pager concept to build a baseline plan for a selected end-item. You will notice that at almost every step, you will be encouraged to "test" the data, to question whether what you see makes sense or meets your expectations. This promotes the kind of in-depth understanding of the program that is required by the analyst and, ultimately, by the users of the one-pager.

Putting together a one-pager is not an easy job. It is assumed that anyone attempting to build one has a familiarity with work breakdown structures, is able to understand and use schedules, understands program logic and can lay out conceptual hardware flows, is well-versed in "programmatics" and program analysis and has experience with elements of cost.

The first thing you ought to do is become familiar with the project. Review the program/project plans to get a feel for end-items or deliverables, systems, subsystems and components, key project milestones, key risk areas, number of procurements and summary cost data. You will need assistance from project and engineering personnel in selecting critical items to include in one-pagers, so you ought to develop contacts and data sources that will facilitate an understanding of the top level technical issues and the overall risk profile. You must understand how the program/project schedules were developed and what the underlying assumptions were with respect to barlength, shifting, lead times, learning, analogies, smoothness/continuity, etc. Once you have determined these things, you should calibrate the overall risk inherent in the baseline schedule. This provides information that will be useful later on as you assess progress against the plan or contemplate a replanning activity.

Prior to selecting candidates for one-pagers, you should develop a hardware hierarchy tree for each system and identify the most critical components. The selection of candidates for one-pagers is based on the principle that management attention should be focused on major drivers, i.e., those definitive end items which exhibit one or more of the following characteristics: 1) high cost, 2) high technical risk, 3) high schedule risk and 4) key integration intersection.

There is generally a high correlation between risk (technical and schedule) and cost. A good rule of thumb to observe is that one-pagers should include content worth at least 65 percent or more of the total cost. Please note that ***who*** performs the work has no bearing on whether a system or subsystem is selected for a one-pager. In major development projects, 50 percent or more of the work may be subcontracted. Do ***not*** accept the premise that it is the prime contractor's job to worry about the subs, and that one-pagers are therefore unnecessary for subcontracted items. There may be pressure to convince you otherwise, but one of the most common problems experienced by project managers is an unforeseen growth in subcontractor estimates.

Deciding what ***not*** to include is perhaps the most difficult process. Since we are focusing management's attention on major drivers, minor products and processes should be reviewed on an exception basis only, and should not be included in a one-pager. The prime contractor's schedule book for a major space development contract ($100M to several billion dollars) may contain 500 to 1,000 pages. For a project of this size, no more than 20 one-pagers should be selected for project-level management. Lower levels should have one-pagers for their respective areas of responsibility that tier into the 20.

After selecting an item for a one-pager, lay out a conceptual logic flow, focusing on the "backbone" concept, critical items and fidelity-to-fidelity relationships. The goal is to identify the major pieces of each item and how they flow together.

The next step in the preparation of a one-pager is selecting the schedule items. Your selection should emphasize the hardware development process, the hardware hierarchy and the fidelity of the hardware. It is critically important to use a schedule template which possesses the following characteristics:

1. Conciseness—As discussed earlier, the one-pager concept requires that you reduce the 500 to 1,000 pages of a major space systems project schedule book to 20 or fewer one-pagers. An additional target is to represent schedule, cost and metric data for each one-pager in 20 lines. Figure 2 shows an example of how 20 lines of data might be allocated.

2. Standardization—Select a common set of activities and milestones that can be applied to all systems, subsystems and components.

3. "Relatability"—Select activities and milestones that can be related to cost, work force levels and metrics.

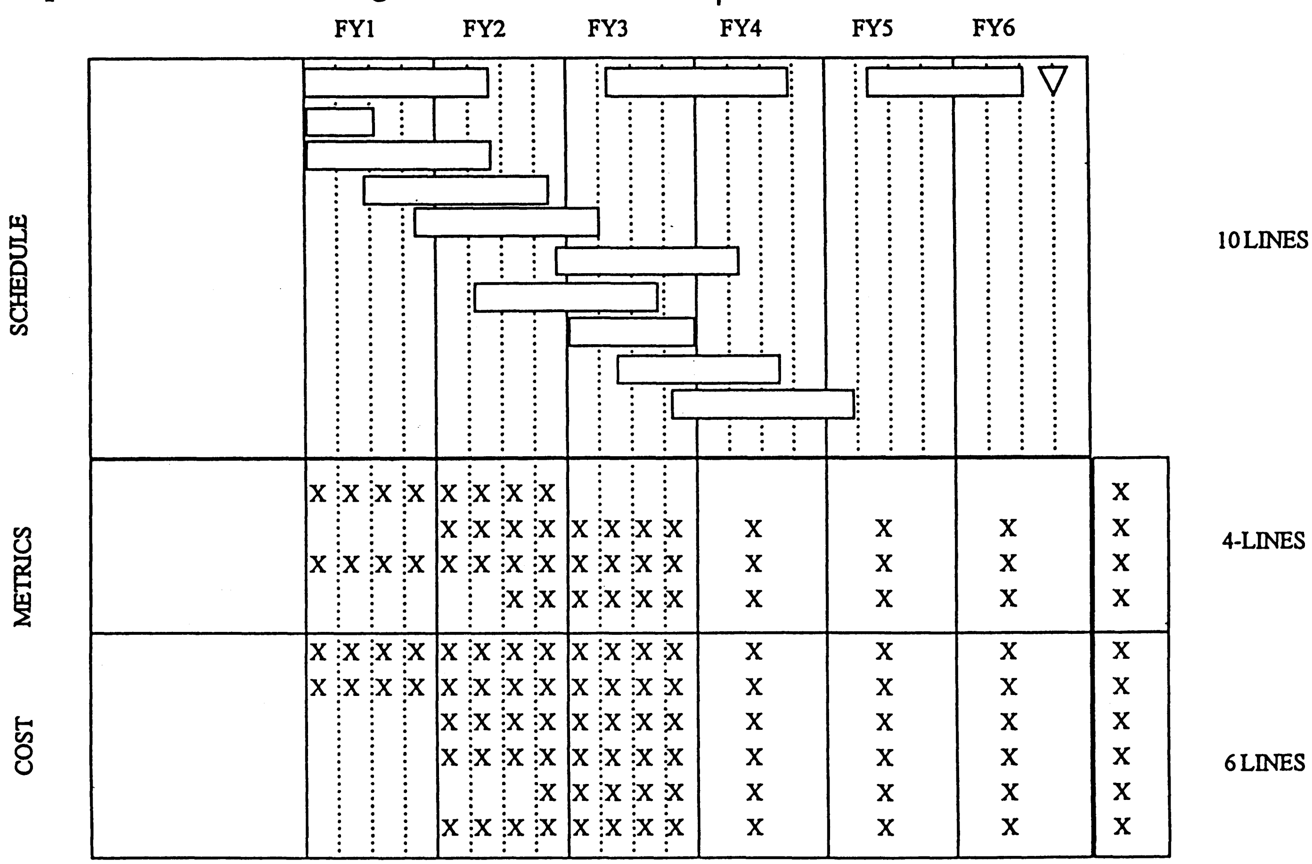


Figure 2. One-Pager Template

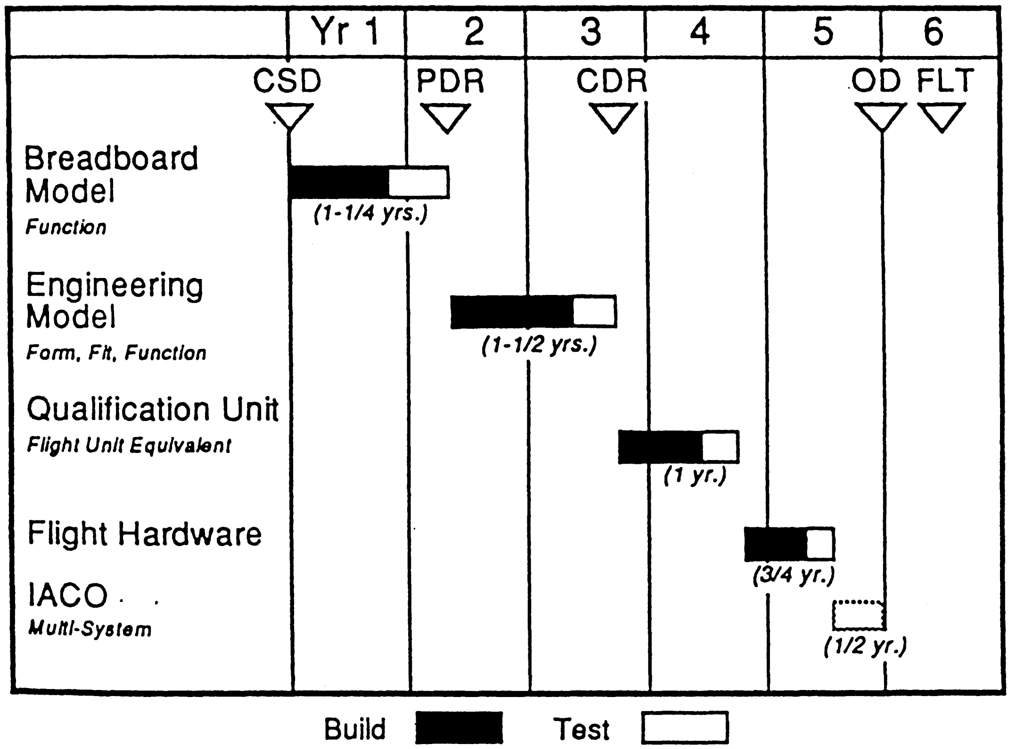
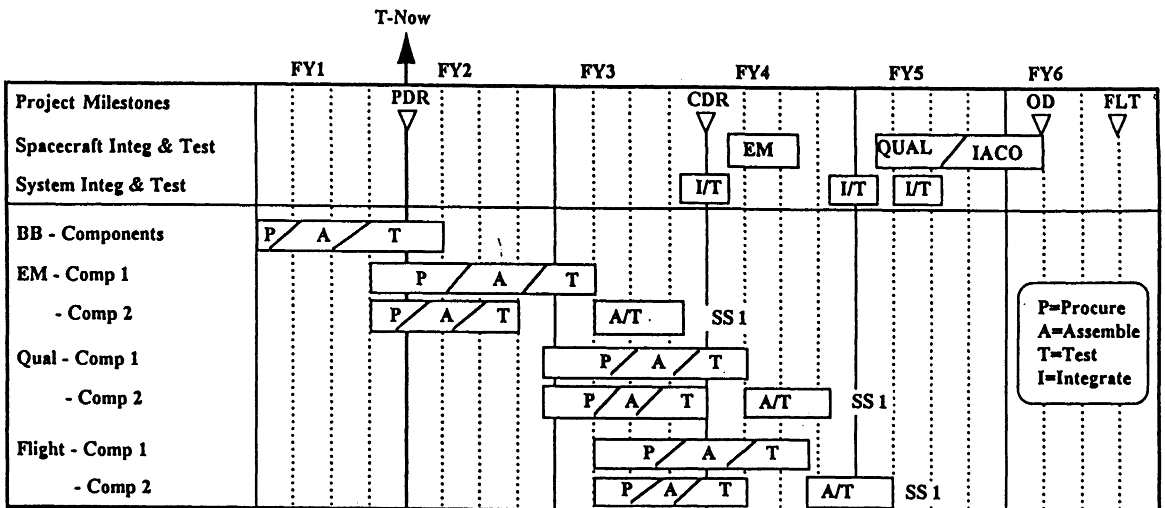


Figure 3. Single System Hardware Schedule Template
(About 5 1/2 Years From CSD to Flight)

Figure 3 shows a single system hardware schedule template which possesses the desired characteristics. Definitions of engineering models, qual units and flight hardware were provided earlier in this article. A breadboard model is built to support the preliminary design of a system. It is often a crude version of the actual flight component, but its primary purpose is one of proof-of-concept. IACO (integration, assembly and checkout) includes all labor and material required to assemble the multiple systems into flight packages and perform checkout of those flight packages. A similar single system software schedule template also exists, but is not displayed here.

Figure 4 shows an example of a completed one-pager. Starting at the top, several major project milestones and the multi-system hardware/integration/test program, or "backbone" have been identified. We have also used a hardware schedule template to select Subsystem 1 breadboard, engineering model, qual unit and flight hardware components. Subsequent discussions on selecting cost and metrics data will reference this example.

The next step in building a one-pager is selecting the appropriate cost baseline. The selected cost data must be concise and relatable to the schedule and metrics sections of the one-pager. Regardless of the source of the data, the first thing you ought to do is try to determine how the cost estimates were developed and identify the underlying assumptions. Make some common-sense



	FY1 Q1	FY1 Q2	FY1 Q3	FY1 Q4	FY2 Q1	FY2 Q2	FY2 Q3	FY2 Q4	FY3 Q1	FY3 Q2	FY3 Q3	FY3 Q4	FY4	FY5	FY6	Total
BB/EM Drawings Released	20	40	50	75	55	15	5									260
Qual/Flt Drawings Released							50	80	60	15	10	5				220
Test Completions				8	10	5	3	3	5	7	7	7	9			64
NS Specs Released			5	3			3	5								16
Total Parts Delivered	150	150			1000	520			800	1400	720	120				4860
S/C A - Eng/Other Labor	1.6	1.8	2.1	2.6	3.0	3.5	3.8	3.7	3.6	3.4	2.9	2.2	4.0	2.2		40.2
S/C A - Mfg Labor	.2	.4	.5	.8	1.7	1.7	1.8	1.8	1.8	4.0	6.4	6.2	6.0	.5		33.8
S/C A - Purchases	.4	.1	—	1.0	1.5	1.0	—	3.0	3.0	3.0	3.0	—	—	—		16.0
Total	2.2	2.3	2.6	4.4	6.2	6.2	5.6	8.5	8.4	10.4	12.3	8.4	10.0	2.5		90.0
(FY subtotal)	11.5				26.5				39.5							

Figure 4. Subsystem 1 One-Pager

observations to calibrate the level of risk flexibility inherent in the cost estimates. If cost data is available by functional break, combine related labor categories into a few summary cost elements appropriate to the one-pager you are constructing.

For example, if you have cost data with ten functional breaks and examination of the data indicates that three are related to engineering, four are related to manufacturing, and the remaining three don't appear to be related, you might want to combine this data into three summary cost elements: engineering, manufacturing and other. Then allocate the indirect costs (overhead, G&A, etc.) to the summary elements. Show a stream of actuals (if actuals exist) by quarter. A good rule of thumb is to collect quarterly data for at least one year prior to and two years after Tnow.

Figure 4 shows cost data at the appropriate level for that one-pager. After you lay out the summary costs, you should examine the time phasing of the data to test your expectations as to what that phasing ought to look like. For example, does engineering tend to peak around CDR and prior to manufacturing?

The final section of the one-pager to be completed is the metrics baseline. Metrics are quantifiable work indicators used to describe a plan or measure progress against a plan, and as such, supplement cost and schedule data. You should select metrics that are relatable to the development and manufacturing processes and to product deliveries. They should be phased quarterly for at least one year prior to and two years after T_{Now}, and should include total at completion. (Growth in metrics totals are almost certain indicators of problems.) As with both schedule and costs, make common sense observations about the data to identify any risk or flexibility inherent in the baseline plan. Some typical metrics used in one-pagers are as follows:

1. Drawing Releases—A measure of how the design is maturing. May be accumulated by end item and/or by fidelity.
2. Test Completions—A measure of how the design verification process is maturing. May be accumulated by end item and/or fidelity.
3. Parts Spec Releases—Another measure of how the design is maturing. May also be accumulated by end item and/or fidelity.
4. Parts Delivered—A measure of the magnitude of the work occurring within the parts procurement schedule.

If the item chosen for this one-pager uses non-standard parts, every effort should be made to ensure that they are included in the metrics you select. Unlike standard or off-the-shelf parts, non-standard parts are designed to meet and be tested against full-up requirements, and require their own unique development effort. They may comprise as little as 10 percent of the total parts, yet be as much as 90 percent of the total cost. Figure 4 shows the completed one-pager example with metrics included.

The next step in developing a one-pager is "scoring" the data in the baseline plan. Here we are concerned with the ability of the data to tell a story, not whether the story it tells makes sense. Ten items are to be scored, each worth a possible ten points using the following scale:

9-10 points: Little or no improvement possible
7-8 points: Improvement desirable, but not mandatory
5-6 points: Improvement mandatory
1-4 points: Little or no value in data provided

The first five items involve the schedule:

1. Backbone—The ability to tie products from completion through the next level of integration to flight.
2. Logic—The ability to follow the basic flow of effort within fidelity and from fidelity to fidelity, including contractors.
3. Correct Tabs—Assurance that the schedule tabs reflect the "drivers" for this one-pager. Generally intended to be product-oriented.
4. Near Term Density—The degree to which front end progress can be measured meaningfully on a quarterly basis.

5. Clarity—The general appeal of the schedule. The degree to which the level of detail is enough but not too much.

The next three items involve cost:

6. Completeness—The degree to which all numbers add horizontally and vertically.

7. Correct Tabs—Assurance that proper staffing categories are depicted, that labor and overhead dollars are visible, and that subcontractor and material items are identified–all at the appropriate level of detail.

8. Front End—Actuals by quarter are included and that at least near term quarterly data is laid out.

The final two items involve metrics:

9. Correct Tabs—Assurance that the proper indicators are identified. Can help clarify schedules and should relate in some fashion to the cost breakout.

10. Front End Completeness—Actuals and quarterly data are included. Degree to which all numbers add horizontally.

Examine the data found in Figure 4 and do your own scoring. You should find that the data used in the example scores very high.

The use of "scoring" criteria with which to evaluate the one-pager data has resulted in some unforeseen but very favorable consequences. There are times when, because the data you were provided is poor, you have to go back to the person who provided it and ask for something better. If, rather than relying on a subjective statement about the quality of the data, you are able to indicate that the data was examined and evaluated against a uniform set of standard criteria, your request for additional data may be received much more favorably.

The next step in preparing a one-pager is testing the baseline plan to determine if it makes sense from a top-down perspective. You are essentially addressing the following three questions:

1. Does the schedule make sense?

2. Is the cost phasing plan consistent with the schedule?

3. Is the metrics plan consistent with the schedule?

Does the schedule make sense? Assuming the schedule satisfied the scoring criteria, the major test here is whether the length of the activity bars makes sense with respect to one another.

Is the cost phasing plan consistent with the schedule? Engineering, manufacturing and vendor cost plans have unique cost profiles, or relationships, with the schedule. Prior to determining whether the cost phasing plan is consistent with the schedule, you should review your knowledge of these profiles and relationships. Next, examine the one-pager data and formulate a set of expectations based on your understanding of what should be occurring as indicated by the schedule activities. Finally, test the credibility of the data versus your expectations. Figure 5 shows the schedule activities used in our one-pager example with an expected engineering cost profile plotted based on what the schedule indicates is occurring. The actual cost plan is then laid in at the bottom for comparison. In the Figure 5 example, the engineering cost plan passes the credibility test.

Is the metrics plan consistent with the schedule? Here you might examine the plan to see if:

1. Drawings for the appropriate fidelities are being released soon enough to properly support the assembly of those fidelities.

2. Test completions coincide with the testing activity bars in the schedule.

3. Non-standard parts spec releases for each fidelity lead the commencement of procurement cycle.

4. Parts deliveries occur during the latter half of the procurement cycle and support the assembly process.

An examination of Figure 4 shows the metrics data is reasonably consistent with the schedule.

The final step in completing a one-pager is measuring or assessing the risk inherent in the baseline plan. Although we have challenged and questioned the individual pieces of data used to construct the baseline plan, and have tested the plan to see if it made sense from a top-down perspective, we have

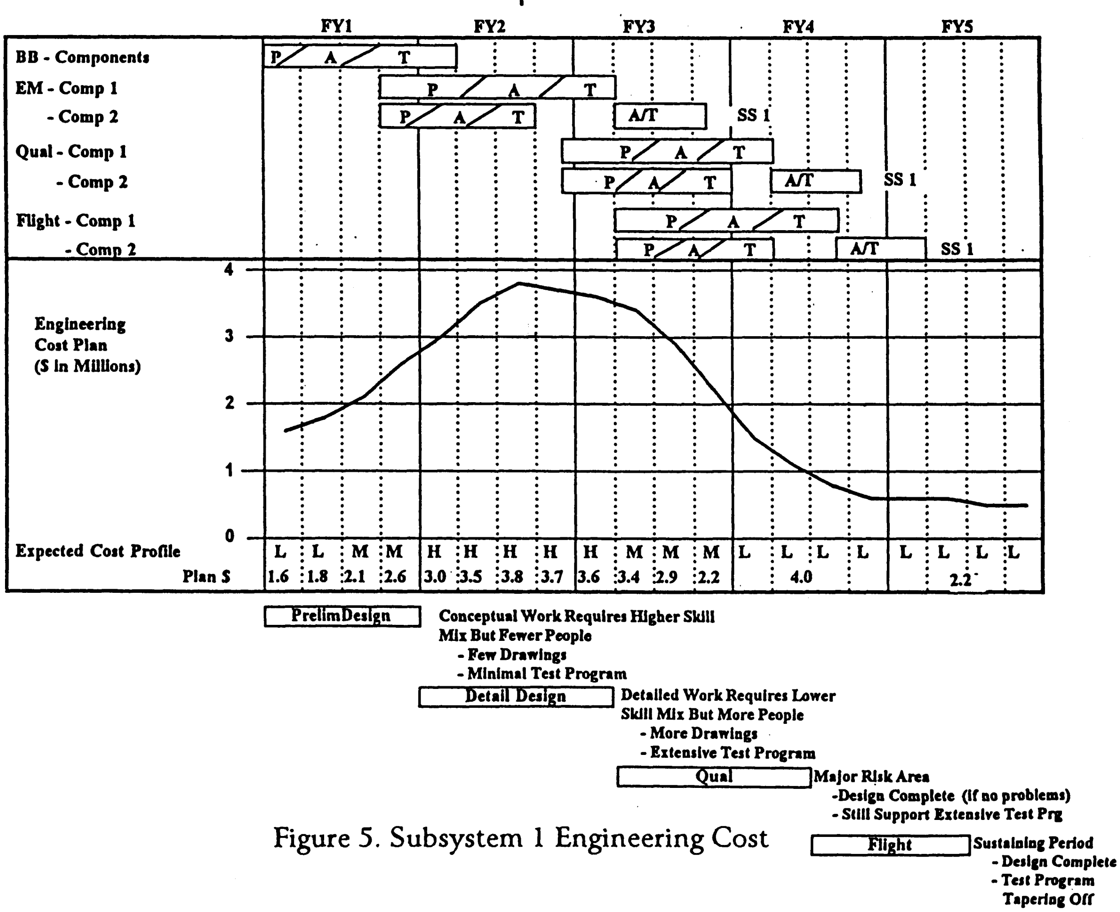


Figure 5. Subsystem 1 Engineering Cost

not yet determined the level of risk that is inherent in the plan. A plan may appear logical yet still possess a certain amount of risk. The decision as to how much risk may be tolerated in a program is often the product of political, budgetary and philosophical constraints. Risk must be assessed in terms of schedule, cost and metrics. We will refer to Figure 4 to demonstrate how risk in the baseline plan is evaluated. The following lists various aspects of schedule, cost and metrics, and ranks the attendant level of risk as low (L), medium (M) or high (H).

Schedule Risk

BACKBONE	RANK
Adequacy of test program	L
Time to complete integrated tests	L
Overlap/parallelism within integrated tests	M

While the integrated test program is generous (covers all fidelities), some overlap exists between qual/flight that merits noting.

Schedule Risk

SUBSYSTEM	RANK
Time to complete Breadboard	L
Time to complete EM	L
Time to complete Qual	L
Overlap/parallelism	M

While adequate time for completion of each fidelity appears available, once again, the overlap in the qual and flight programs merits noting. Early budget constraints may have forced this overlap, however, if future budget/schedule relief is granted, this area might be reevaluated.

Schedule Risk

OVERALL SCHEDULE	RANK
Overall concern level	M-L

Cost Risk

ENGINEERING WORK FORCE	RANK
Adequate EPs to support EM (CDR)	L
Adequate EPs to support Qual	M

Although the profile/shape of the curve appears as would be expected, the rapid tapering off after CDR assumes a successful EM program.

Cost Risk

MANUFACTURING WORK FORCE & PURCHASES	RANK
Plan consistent with schedule	L

OVERALL COST	RANK
Overall concern level	L-M

Metrics Risk

METRICS	RANK
EM drawing timeliness	L
Qual drawing timeliness	M
Parts deliveries timeliness	L
Test completions timeliness	M

Sixty-five percent of the EM drawings are complete at PDR and prior to assembly of component 1. However, the majority of the qual/flight drawings are completed during the EM test program. Ideally, you would prefer to have EM results available prior to starting the qual/flight drawings; however, this is most often not the case. Parts deliveries are consistent with the schedule. There is some concern with test completions because of the overlap between qual and flight.

Metrics Risk

OVERALL METRICS	RANK
Overall concern level	M-L

This completes the process of building a one-pager.

The one-pager was designed to fill the need of NASA program/project managers for a system that will facilitate timely, accurate top-down program/project assessments required to establish and/or assess the program's baseline plan, determine progress against the plan and assess planning alternatives. This article explains the process of building a one-pager to establish the baseline plan. While a discussion of how to use the one-pager to assess planning alternatives is beyond the scope of this article, it would be useful to show how simply but powerfully one-pagers can determine progress against a baseline plan.

Consider once again the example found in Figure 4. Suppose that T_{Now} is one year later, and the project manager wants a top-down assessment of the status of Subsystem 1. What do you do?

The first thing you might want to do is compare the actuals from the past year to the baseline plan as reflected in the Subsystem 1 one-pager. Figure 6 shows an easy way to make this comparison with a Plan vs. Actuals sheet; the actual assessment is quite simple. As shown in Figure 6, the overall schedule drifted approximately four months in a 12-month period, suggesting that only eight months worth of baseline schedule was accomplished. Thus, the schedule accomplishment ratio (SAR) would be approximately 61 percent.

$$SAR = \frac{6.2 + 6.2 + (2/3 * 5.6)}{26.5} = \frac{16.2}{26.5} = .61$$

Ninety-one percent of the costs in the baseline plan were expended. Thus, the spending ratio (SR) is 91 percent.

$$SR = \frac{24.2 \text{ (Actual Cost)}}{26.5 \text{ (Planned Cost)}} = .91$$

Therefore, the overall accomplishment ratio —a rough measure of how efficiently the project is working—is 67 percent.

$$AR = \frac{.61 \text{ (SAR)}}{.91 \text{ (SR)}} = .67$$

The number of drawings and non-standard parts specifications have grown by 16 percent and 25 percent, respectively, indicating a probable impact to both engineering labor and purchases cost.

	PLAN	CURRENT	
BB/EM Drawings	260	305	
Qual/Flt Drawings	220	250	
Total Drawings	480	555	+ 16%
NS Specifications	16	20	+ 25%

Only 60 of the 130 planned Qual/Flight drawings have been released. This, coupled with the previous observations, implies future engineering cost growth. Test completions appear consistent with overall schedule status.

The total number of parts required has increased by 13 percent, suggesting potential procurement cost growth.

	PLAN	CURRENT	
Parts	4,860	5,500	+ 13%

In summary, it appears that engineering overspent the plan by 15 percent due to design problems, and manufacturing labor and purchases costs lagged due to the slip in design products. These simple observations indicate that Subsystem 1 has become a significant problem requiring immediate attention.

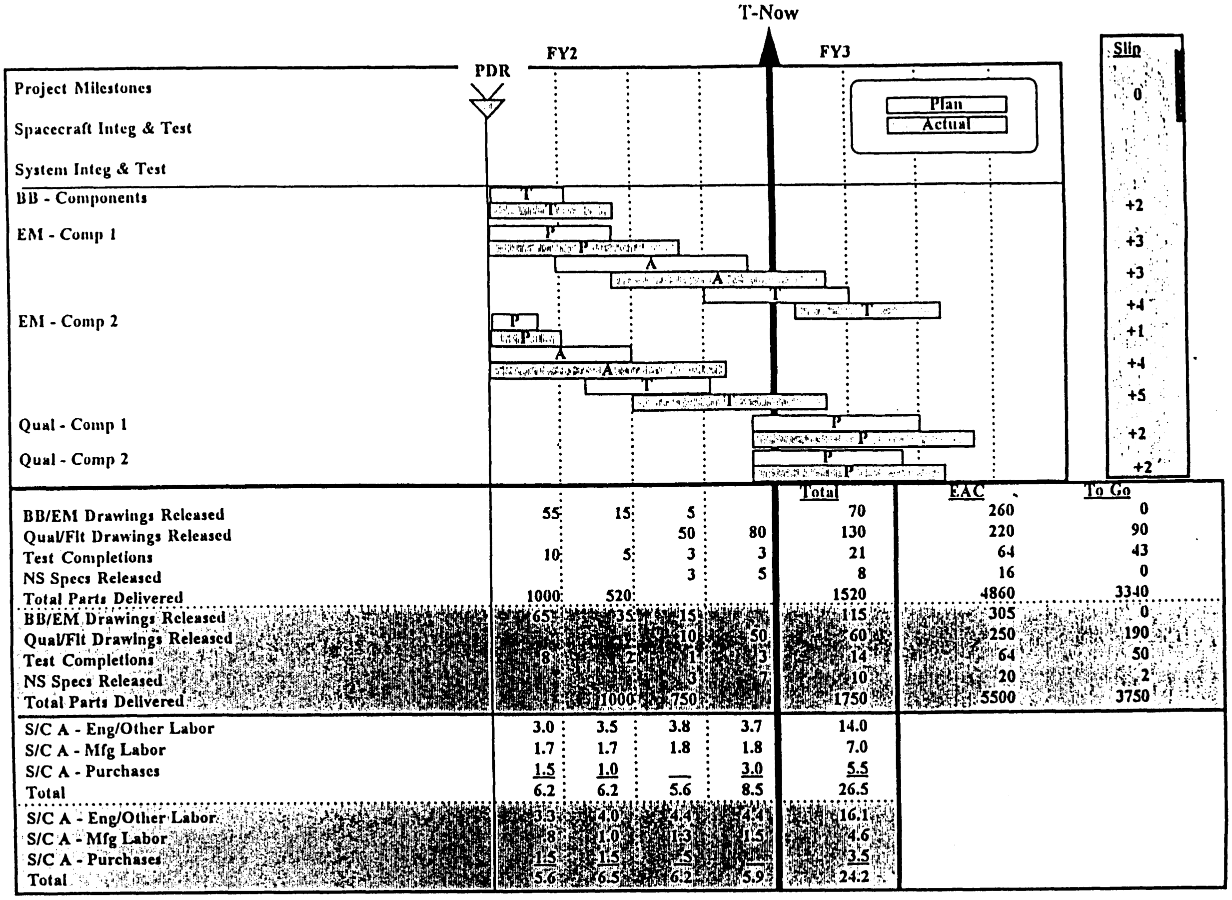


Figure 6. Subsystem 1 Plan vs. Actuals

It should be apparent that the one-pager system is more than just a tool. It is a process and a discipline that require both the preparers and the users to constantly probe, question, test, assess and ultimately, learn. If a program or project chooses to use the one-pager system to establish a baseline plan (and later to assess progress against that plan or assess planning alternatives), the users (managers, engineers and analysts) will soon discover that they have learned their program and the manner in which the cost, schedule and technical aspects fit together to an extent they might not have otherwise thought possible.

More importantly, they will be well on the way to developing a "feel" for the program, something that is crucially important but so often lacking. Finally, they will have at their disposal a powerful tool that permits them to manage their program more effectively.