Pipelining Your Project

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Measuring Progress Seems Like Such a Good Idea!

Moving things along according to plan, managing resources and risks to get things done, and earning value is what project managers do. Many of these "doings" appear like a project flow because most project scheduling is the familiar waterfall finish-to-start task linkage. A waterfall laid out linearly is much like a flow along a pipeline, and that is the analogy that this paper develops. We can 'tap into' the pipeline very conveniently at the task-linkage junction points and measure how much is going by. Measures can be for volume, rate of arrival, resources consumed, date of arrival, and other metrics that may be interesting to the project manager.

A few examples that lend themselves well to pipeline measures are:

a. Writing and obtaining approval of various documents for design, test, and validation.

b. Running tests or inspections or validation on design, development, or production results.

c. Delivery, rollout, or distribution of results and deliverables. Most projects of any size have many results to roll into the business, or distribute to customers, suppliers, or partners.

Objects To Count & Measure	
Activity	**Countable Objects**
Requirements	Interviews, validations completed; measurable requirements cataloged or entered into database
Documents	Outlines, drafts, document reviews, document approvals completed
Designs	Functional, technical approach, preliminary, final, validated & approved
Hardware Build	Model, evaluation & test sample, pre-production units, production units
Software Build	Prototype object, test object, configuration object, production code object
R&D Experiments	Experiment design, experiment execution, fail, pass
Test and Verification	Scripts outline, script detail, execution steps: execute, fail, pass

Planning a Pipeline

Pipeline plans are usually grids of data, typically set forth in a spreadsheet, and organized as planning rows and dated columns. Each planning row usually as the same information elements, but typically one row displays a different timeliness of the data from that on another row

Pipeline Plans	
Plan	**Plan Interpretation**
Baseline	The baseline plan is the plan you start with and the intended plan for the project. It is unchanging until you rebaseline. Rebaselining is only done when the operating plan is so at variance with the baseline that measuring against the baseline is no longer meaningful.
Operating Plan [OP]	The operating plan [OP] is the actual plan that you are trying to meet. The OP only differs from the baseline because of adjustments to take into account replans not so severe that a rebaseline is needed. The operating plan can be changed frequently so that it represents your current best estimate of the plan for the project
Current Forecast	The current forecast is the plan for the week or period ahead that might be different from what is in the operating plan for that period, but overall, the operating plan still governs. The current forecast accommodates very short-term perturbations in plan but not so severe as to invalidate the operating plan
Actual Performance	The actual numbers measured at the time of execution
Variance to Baseline	The Actuals – Baseline. A negative number usually indicates poor performance compared to the baseline
Variance to OP	The Actuals – OP. A negative number usually indicates poor performance compared to the baseline

The data values that appear in the grid cells at the intersection of a planning row and a date column are the keys to the usefulness of the pipeline. Typically, the data value is either a count or a rate of something that must be tracked, or its cost. Sometimes the cell value is a concatenated value-set from two values of both count and cost.

Pipelining EVM metrics

Experience practitioners know that the usual way to go about reporting metrics in an EVM system [Earned Value Measurements system] is to apply a set of formulas that compute the variances to cost and schedule and forecast the estimates to-complete and at-

complete. Many project management sources have these formulas, including the author's text on quantitative methods cited in this paper.

Every earnings concept has to include at least two participants and a process to link them. One person "burns" resources to accomplish the tasks and then makes claim to the accomplishment; the other participant verifies the claim and awards the "earn". Various processes have been devised to handle the claim, verification, and award. For examples, the reader is referred to the author's book, "Quantitative Methods in Project Management".[1]

A Pipeline for Earn and Burn

Since this paper is about pipelines, let's try one here to demonstrate what we have discussed so far. To build a pipeline, we need four elements:

- A timeline for things to flow along, a timeline is our pipe
- A way of measuring the flow, and of course
- We need to define what it is that is going to flow along the pipeline.
- And a way to claim the results and report to the pipeline owner

Let's imagine this example:

- A project with two sets of deliverables, the first set valued at $20K and the second costing $30K,
- The sets to be delivered sequentially, Set-1 and Set-2
- The project manager reports having a favorable schedule variance of $10K
- And an unfavorable cost variance of $15K.

EVM Project at First Reporting Milestone		
Report Metric	**Metric Interpretation**	**Forecast**
Favorable schedule metric, $10K ahead of schedule	$10K worth of deliverables, presumably from the first set, was completed early, and their value claimed early	$40K of value unclaimed and due at project end
Unfavorable cost metric, $15K over cost plan	At this reporting milestone, cost was $15K more than planned, at least $25K in total [$10K for the earned value and $15K for the unplanned cost].	$25K of budget remaining to complete the $40K of remaining value

Is this project in trouble because of the $15K unfavorable cost variance, or can we take the day off because the project is ahead of schedule by $10K? With the report provided, a planner cannot say for certain.

[1] "Quantitative Methods in Project Management" published 2004 by J. Ross Publishing, USA

Pipeline Example EVM

Let's pipeline the simple project we have just described. Consider this grid that shows the project report at the end of Period 1. We assume each reporting period covers two operating periods. In the grid below, reporting Period 1 occurs at the end of the Ops 2 period:

Traditional EVM Two-deliverable Set Project.
Grid cells = $Kvalues of plan and actual earnings

		Period 1		Period 2		Period 3	TOTAL
	Ops 1	Ops 2	Ops 3	Ops 4	Ops 5	Ops 6	
Baseline Plan Set 1		$0		$20		$0	$20
Baseline Plan Set 2		$0		$0		$30	$30
Operating Plan Burn	$5	$5	$5	$5	$10	$20	$50
Actual Burn	$10	$15					$25
Earning Claim		$10					$10
Earning Variance to Baseline		$10					-$40
Burn Variance to OP		$15					-$25
Earn/Burn Actual		0.40					0.40

In the TOTAL column, in the bottom three rows, we see $40K remaining value to be earned, $25K budget remaining, just as we described in the table and text above. We also see a very inefficient earn/burn ratio of 0.4.

Testing Program Pipeline Example

Almost every project has some kind of testing or quality assurance program. For this reason, the following example has a universal application.

The following grid is an example of a pipeline for a testing program. Here are the program particulars:

- The total earnable value for the testing program is $150K. Each testing step is not individually tracked for cost.
- There are 1000 testing steps to be passed, but the test manager has evaluated the risk and determined that it is likely that only 300 steps will pass the first time attempted, leaving some 700 to be executed at least a second time.
- By the end of the second pass, 500 of the 1000 steps will have passed, leaving 200 steps, 20%, to be passed on the third try.
- Overall, there are 1900 test step executions: 1000 + 700 + 200.
- For this example, it is assumed that the steps are equally complex; so no weighting is applied to differentiate among steps.

We can assume that the test team has just finished period 3 and is forecasting period 4.

Testing Program Pipeline.
Total Value at Period 6 completion $150K
Grid cells = Test Step Completion
Test Step completion planned as 30% first pass, 50% second pass, 20% third pass
1.9 Executions per passed step, 1000 steps, 1900 executions

	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	TOTAL
Baseline	200	300	500	500	300	100	1900
Operating Plan	200	300	350	400	400	250	1900
Forecast [period]	200	325	310	380			1215
Actual Performance	192	320	310				822
Variance to Baseline	-8	20	-190				-178
Variance to Plan	-8	20	-40				-28

Take note of the various plans:

a. The baseline is set up to achieve 1900 executions in 6 periods.
b. The project manager has modified the operating plan from period 3 onward based on two periods of actual performance.
c. The forecast [period] is looking one period ahead.

From the grid we see that not only do the 650 executions in the plan for periods 5 and 6 need to be accomplished, but the accumulated variance needs also needs to be worked. To do all this, the productivity must be improved about 7%:

- (650 + 48)/(650) = 1.07

Pipelining Starts and Finishes

In 1997 the author and his colleague, James Sumara[2], implemented a modified version of the traditional EVM that we labeled "Time-centric Earned Value"[3]. Admittedly not as robust as the cost-centric EVM, the time-centric earned value focuses attention on the activity surrounding the WBS deliverables, measuring the activity "start" and "end" as leading indicators of value attainment.

Principles of Time-Centric EVM System

A WBS is constructed for all the deliverables, but not all deliverables are tracked for their start-finish. The project manager picks deliverables for EVM measurements that are material to the value proposition of the project.

[2] James Sumara was with Harris Corporation on the corporate staff charged with improving management quality in the operating divisions. He is now with Eaton Corporation as an engineering director.
[3] The reader is referred to the original paper on this topic **"**Earned value--the next generation--a practical application for commercial projects" presented to the Program Management Institute National Symposium meeting in Chicago. The paper was judged one of a "best of show". It is available on-line at the author's website, www.sqpegconsulting.com, or at www.pmi.org in the PMI® Knowledgebase by author name.

The budget plan is a traditional cash flow plan: that is, "funding in" and "consumption out" over time. Consequently, no value attainment is measurable by managing cash flow.
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Project Example for Time-Centric EVM

Let's return to the project discussed in the traditional EVM discussion: two sets of deliverables to be delivered sequentially. Now the focus will be on distinctly recognizable starts and ends.

Let us say that in the first set, there are 10 units to start/end, and in the second set there are 20. Recall that at the end of the first measurement period the project manager reported the cost over plan and some part of the first set ahead of schedule.

With time-centric metrics the report might be:

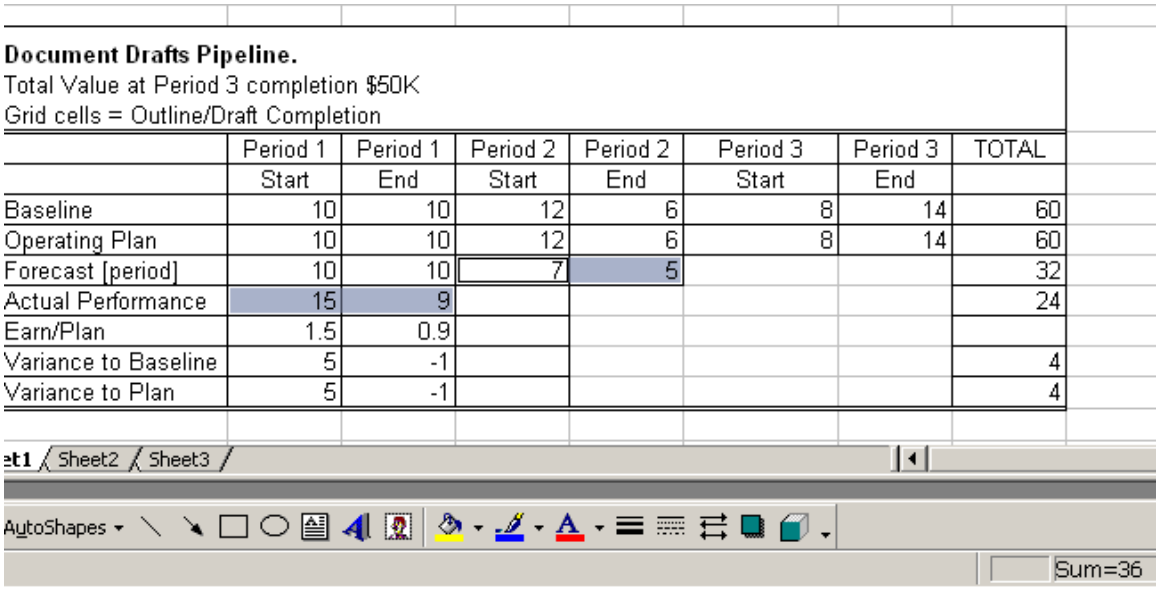
- 10 starts from Set-1 claimed [as planned]
- 8 of 10 ends from Set-1 claimed, so 2 of 10 are perhaps late
- And 5 of 20 starts from Set-2 claimed early
- And perhaps 1 Set-2 end has been completed of the 5 Set-2 starts.

The five starts from Set-2 contribute nothing to the traditional EVM claim, nor does the effort put toward the two lagging deliverables from Set-1, but their cost is in the actuals reported, thereby contributing to the cost-over-plan at the first report.

Pipeline Presentation of Project with Start/End

Lets assume that the deliverables we have been discussing in the example project are document drafts, for which an approved outline is needed before preparing the draft. We are not going to measure the outline separately; completion of the draft includes completion and approval of the outline that goes with the draft.

As before, let's say that there are three periods in this project. Here is a pipeline for this project with the start/end metrics we have discussed. Note that the Actual Performance is claim for completion and value earning for a start or end:



Document Drafts Pipeline.
Total Value at Period 3 completion $50K
Grid cells = Outline/Draft Completion

	Period 1 Start	Period 1 End	Period 2 Start	Period 2 End	Period 3 Start	Period 3 End	TOTAL
Baseline	10	10	12	6	8	14	60
Operating Plan	10	10	12	6	8	14	60
Forecast [period]	10	10	7	5			32
Actual Performance	15	9					24
Earn/Plan	1.5	0.9					
Variance to Baseline	5	-1					4
Variance to Plan	5	-1					4

Take a close look at the cells that are highlighted. The author used the control key to select these cells. Then look to the lower right of the picture. You will see in the tray the figure 36. Before selecting the cells, the author did a right-click on the tray and selected Sum from the drop-down box that appears. What we now see in the tray is the sum of the highlighted cells. This summing capability of disparate cells is one of the strong analysis features of using an electronic spreadsheet for the pipeline.

Applying Standard Work Units to Time-Centric EVM

Standard work units add a weight to the start/end metrics. For each deliverable, the project team assigns a complexity, usually no more than exceptional, high, medium, and low. A standard unit of effort is assigned to low, like say 20 hours, and then a multiplier applies the correct weighting to the other complexities. Perhaps 2, 4, 8 are the factors respectively for medium, high, and exceptional. Example: a deliverable of exceptional complexity is planned for 8 x 20 hours, 160 hours.

Assume for example that the deliverables of Set-1 are low complexity and of Set-2 are medium complexity. The value proposition of each set is:

- 10 units x 20 hours for Set-1 [200 unit-hours]
- And 20 units x 20 hours x 2 complexity for the second set [800 unit-hours]

At the first reporting milestone, recall that 8 of 10 are completed from Set-1, and 1 of 20 from Set-2 is completed, so a value claim of 160 unit-hours is made for the Set-1 deliverables and 1 deliverable at 40 unit-hours is claimed for Set-2, for a total claim of 200 hours.

Pipeline Presentation of Project with Work Units

When the pipeline is presented with work units, we value only the "end". There is no measurable work to a "start"; the measured work is the "end". Each Set-1 "end" is multiplied by 20 hours, and each Set-2 "end" is multiplied by 40 hours. As we discussed above, the total value of the plan in work units is 1000.

Document Drafts Pipeline.
Total Value at Period 3 completion $50K
Grid cells = Outline/Draft Completion

	Period 1 Start	Period 1 End	Period 2 Start	Period 2 End	Period 3 Start	Period 3 End	TOTAL
Baseline	0	200	0	240	0	560	1000
Operating Plan	0	200	0	240	0	560	1000
Forecast [period]	0	200	0	200			400
Actual Performance	0	200					200
Variance to Baseline	0	0					0
Variance to Plan	0	0					0

Summary and Conclusions

Pipelining is a quantitative methodology for making measurements along the way especially when there are repetitive tasks, tasks with special value, and tasks for which the flow within the project is key to project success. Pipelining presumes that there are key dates, deliverables tied to those dates, and a value obtained if the date-count can be achieved. Pipelining is intuitive, easy to implement with a spreadsheet, and provides many insights into the project progress.

About the Author

John Goodpasture is a project practitioner, author, and teacher who began his career in the Department of Defense managing complex national security programs. Leveraging that experience, he practiced program management as Director of System Engineering and Director of Programs at communications and defense systems firm Harris Corporation. Subsequently, he became Vice President for Systems and Processes at Lanier Professional Services. After being certified as a PMI PMP, he took up responsibilities as principal and founder at Square Peg Consulting. Author of two books in the field, numerous magazine and web articles, and many published professional papers in project management, John is an invited speaker at many events.