

# (EVM-4025) Fully Integrated Earned Value and CPM Schedule Analysis at a Causal Level

## A New Analytical Approach

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## Who am I?

- Over 40 years in **Construction: building; infrastructure; industrial; institutional; commercial; residential**
- **Former Contractor; now Consultant (20 yrs.) Revay**
- Expert: Project Management (**GSC**); CPM & Earned Value Performance Analysis; Risk; Forensic Analysis (**CFCC**); Contract Delivery; Dispute Res.
- **Published author:** Book on EVM/CPM, articles (AACE and other), presentations to industry
- **Successfully applied these analytics on major construction projects and programs**
- "Something You Don't Know About Me"

REVAY

Our focus:  
making  
construction  
better.

In an industry too often  
burdened with conflict,  
we can lighten the load.

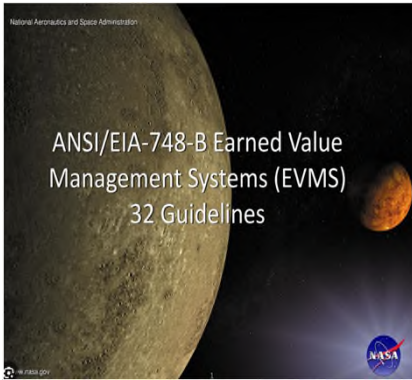


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2

**AAACE** INTERNATIONAL Existing EVM is ineffectual for planning & control



**But widely used?**



*“An Earned Value Management System will **effectively integrate schedule and cost elements for optimum program planning and control.** [SAE International]*



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3

**AAACE** INTERNATIONAL Construction industry failing – improved EVM needed!

**McKinsey report (2016)?**



MCKINSEY GLOBAL INSTITUTE  
**REINVENTING CONSTRUCTION:  
A ROUTE TO HIGHER  
PRODUCTIVITY**



- **“Productivity below other industries**
- **Projects regularly over budget and time targets**
- **Reinvention required: Integrated, Advanced Performance analysis and KPIs**
- EVM should serve as a source of **performance “truth”**

Requires causal understanding

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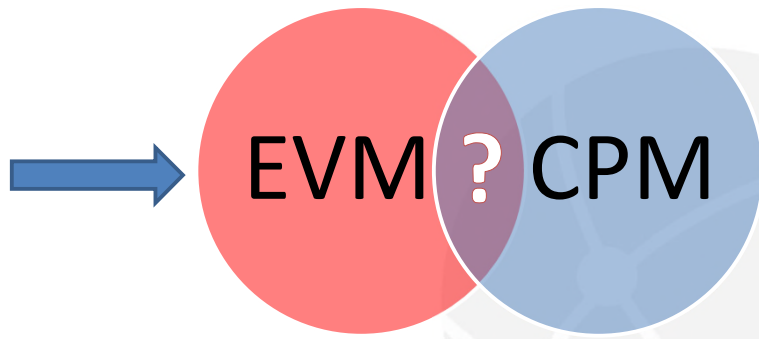
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# Challenge: EVM and CPM not Integrated

## Analytical Silos



## Integrated Causal Analysis



5

5

# New analytics integrate performance analysis

● ***Reinvention*** required:  
***Integrated, Advanced***  
***Performance analysis***

Meets McKinsey challenge




6

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## Contents of Presentation




**1.0 The Problem: Deficient EVM**

1. EVM Primer
2. A Worked Example
3. Failed EVM Promise: Is that all there is?



**2.0 The Solution: New Causal EVM**

1. New Causal Duration and Cost Formulas
2. New EV Metrics connect Time to Causal Inputs
3. Integrated EVM/CPM Analysis



**3.0 Implications & Path Forward**

1. Rethinking Root Causes
2. Commit to deterministic R-L, CPM schedules

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# 1. The Problem: Deficient EVM Theory & Practice

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## 1.1 EVM Primer

- i. Core principles: PM benefit, Cost-Schedule Integration, Root Causes
- ii. Analytics

## 1.2 A Worked Example

- i. Worked EVM Example by a Project Manager

## 1.3 Failed Promise

- i. Post Mortem on failed project
- ii. Problems & unanswered questions

9

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- EVM for the **Construction** Industry
- **Performance Activities**: mainly labor (but also equipment and machines performing work)
- Assume best practice, bottom-up, **fully Resource Loaded (R-L)** CPM Schedules available (optimal condition for EVM analysis)

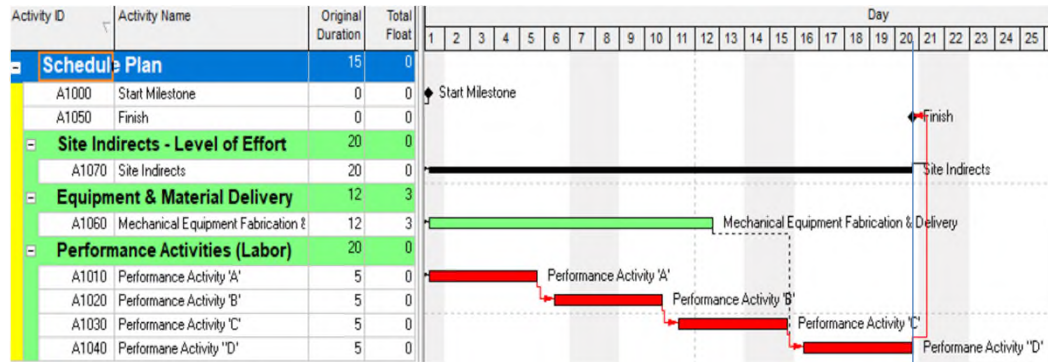
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## Performance Activities: "Control the Hours & Control the Project"



11

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## 1.1 EVM Primer

**NDIA**  
National Defense Industrial Association  
Integrated Program Management Division

Earned Value Management Systems  
EIA-748-D Intent Guide

**SYSTEMS MANAGEMENT STANDARD**

EIA-748™	REV. D
Issued	1998-06
Revised	2019-01
Superseding EIA-748C	

Earned Value Management Systems

EIA-748-D

- Electronic Industries Alliance (EIA)
- 32 Guidelines define best practices in EVMS

AAACE Best Practices BDR-14  
VARIANCE ANALYSIS AND REPORTING

AAACE Best Practices BDR-13  
ESTIMATE AT COMPLETION (EAC)

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- **Project planning & control benefits strongly by ...**
- **Integrating Schedule and Cost**
  - “provide **strong benefits for program enterprise planning and control.**”
  - “**effectively integrate** the work scope of a program with the **schedule and cost** elements for **optimum program planning and control.**”
  - The **primary purpose** of the system is to **support integrated program management.**” [SAE International]

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- ***Proactive management:***
  - *Early risk identification, corrective action, replanning*
  - *Requires root causes to be effective*
- The root cause is the core issue—the **highest-level cause**—that sets in motion the **entire cause-and-effect reaction** that ultimately **leads to the problem(s)**. [American Society for Quality]

14

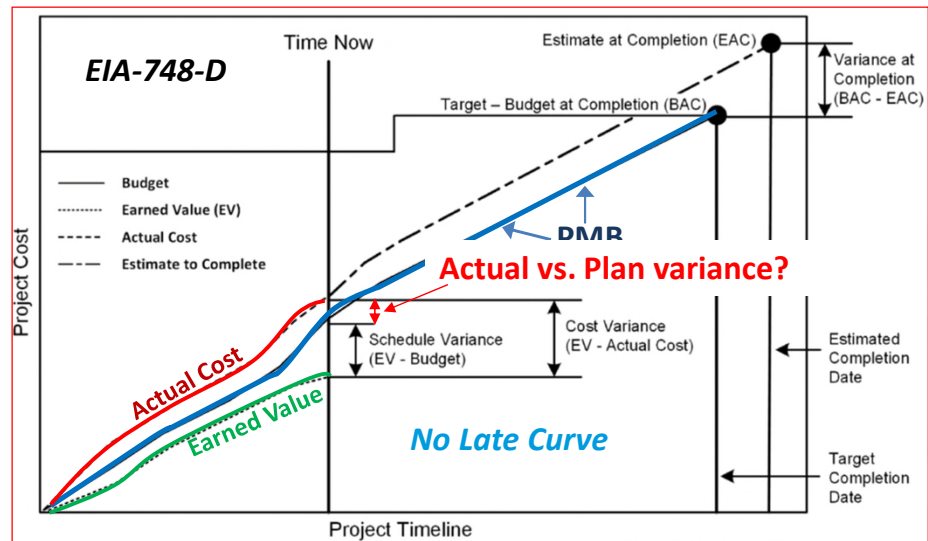
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# AAACE EV Theory: Summary Analysis (EIA-748)

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- **Axes (time/cost)**
- **PMB – Time/Cost Performance goal**
- **EV at “Time Now”**
- **Earned v. Expended**
- **Historical Perform.:**
  - **CV Primary metric(1<sup>st</sup>)**
  - **SV is variance from PMB (2<sup>nd</sup>)**
  - **CV, SV neg.**
- **Cost Forecast**
- **Time Forecast**
- **No Late Curve?**



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# AAACE Cost Variance Primary & Reliable

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- CV & CPI are **primary, reliable** EVM metrics
- Schedule (time) analysis deferred to CPM
- Both are “**Cost Performance**” metrics
- CPI ( $= E \div A$ ) is cost “**efficiency**” or **productivity**
  - **$CPI < 1.00$  unfavorable**
- EIA-748-D distinguishes “**Efficiency Variance**” (based on hours) from “**Labor Rate Variance**”
- “**Efficiency**” Var. is focus here because it is a causal performance factor (dollars can distort)

16

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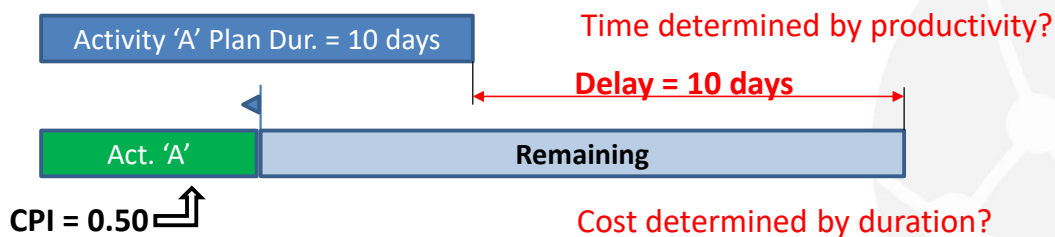
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## Despite deference to CPM scheduling ...

- If CPI is 0.50 “work will **likely ...**
  - **take twice as long** to finish, and
  - **probably cost more** due to **extended duration.**

**WRONG!**



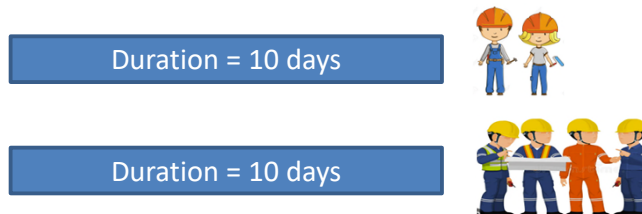
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## Increased resources lower CPI - no time benefit

- “Any **added resources** will ... **Dangerously wrong!!!**
  - have a **permanent negative** impact on **cost efficiency** and ...
  - produce **no positive critical path schedule results.**




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## Schedule Variance Secondary & Unreliable


- SV measures variance from PMB - the **performance measurement objective!!!**
- **But SV secondary to CV and considered unreliable.** 
- ***SPI not recommended after 80% of the work” because ultimately equals 1.0***
- SV not for time analysis, which “***requires assessment of the network critical path***”


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## EVM doesn't require CPM scheduling?!

- ***“Critical path analysis preferred indicator of long-range projections, but a trend analysis of ... SV can provide valid indication of current and near-term performance.***
- ***“While [CPM] quite capable, the application of basic earned value management techniques does not require the use of any particular scheduling methods.***  [EIA-748]


 Core Principle Integration of  
Schedule and Cost?

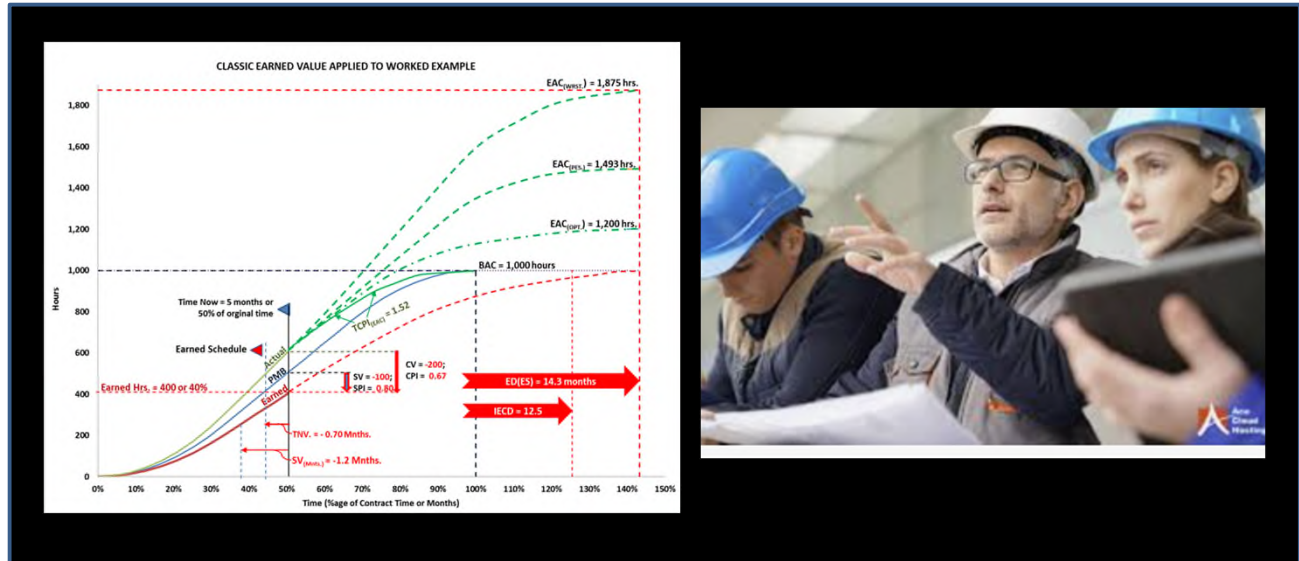
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# AAACE 1.2 PM's Worked EVM Example

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# AAACE Resource-Loaded CPM Schedule

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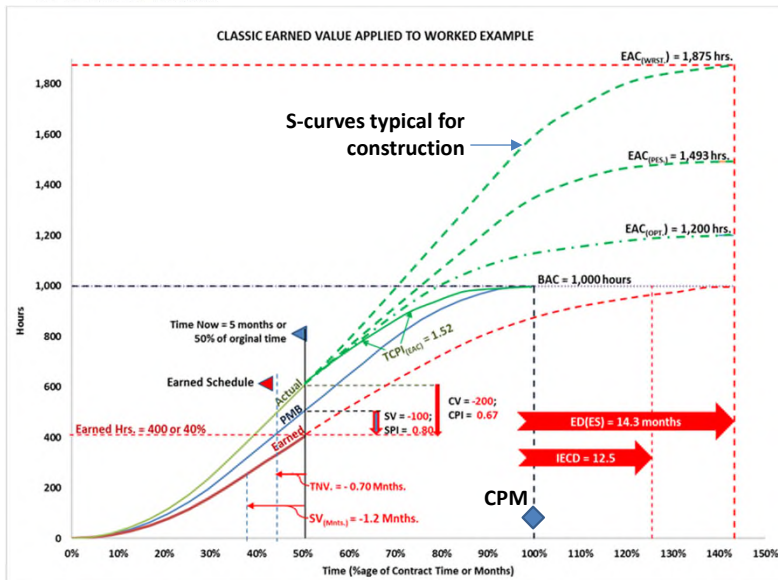
- Project Manager had benefit of ***fully resource loaded (R-L) CPM*** and performance data
- If analytics deficient in this case, existing EVM analysis is inherently limited

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# AAACE PM's EVM Analysis at 50% Time



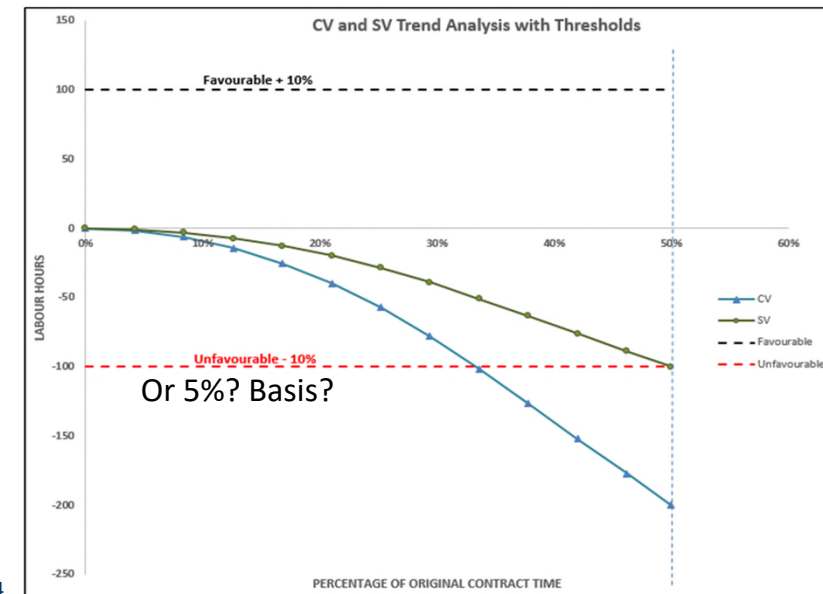
- Labor hrs. on Y-axis
- CPI = 0.67; SPI = 0.80
- Low productivity, low output (accomplishment)
- Neg. trends worsening (curves)
- SV (var. from PMB) secondary to cost
- TNV = ~1 m. (float cons.)
- Cost forecasts (which one?)
- ES Delay forc. = 4+ m.
- EVM Schedule forc. 2.5m
- Contractor => no delay
- TCPI = 1.52 (PMB implications?)

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# AAACE No Connection between CV & SV



- EVM says there is no direct connection between CV and SV?
- Actionable intelligence to improve performance?
- Arbitrary thresholds

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- Project was completed ***over budget and delayed.***
- ***What caused failure? Was it avoidable?***
- ***Root Causal understanding of performance problems?***
- No ***actionable performance intelligence*** provided by EVM analysis to mitigate?
- ***SV Secondary to Cost so what to say about PMB?***
- ***SV not reliable.***

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- ***Contractor's schedule forecasts*** timely completion – so defer to CPM?
- ***CV and SV not connected?***
- Which threshold for SV & CV?
- Increase ***resources to mitigate?*** EVM says "***no***", no resource variance for analysis
- Which formula for ***Cost over-run? Pick one.***

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## 1.3 Failed EVM Promise: Is that all there is?



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## Failure of Core Principles

### Recall ...

**EVM Core Principles: Planning and Control & Cost/Schedule Integration**

- **Provide strong benefits to project planning & control**
  - "provide *strong benefits for program enterprise planning and control.*"
- **Integrate Schedule and Cost**
  - "*effectively integrate* the work scope of a program with the *schedule and cost* elements for *optimum program planning and control.*"
  - The *primary purpose* of the system is to *support integrated program management.*" [SAE International]

- **Schedule and Cost not integrated:**
  - Dollar (\$\$) Cost variance primary focus
  - Time analysis deferred to CPM
- **Not beneficial to Planning and Control:**
  - Little actionable intelligence to understand & mitigate performance problems

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AAACE RP 86R-14: “**Root cause of variances must be investigated**”



- **Performance Fog:** without root causes, limited planning and control

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- How to **fully integrate** EVM & CPM to provide root **causal performance** analysis of time & cost
- Why is the **PMB**, and **SV**, not **primary objective**?
- Might **CV and SV be interconnected** so as to **causally explain schedule (PMB)** performance variance.
- Why is there not a **Resource Variance** EVM metric?

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- What *root causally determines duration* of a labor activity?
- Is there a *deterministic threshold for the PMB?*
- What is the connection between the *duration and cost* of a *labor activity*?

31

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## 2. The Solution: New Analytics – EVM Fully integrated with CPM at a Causal Level


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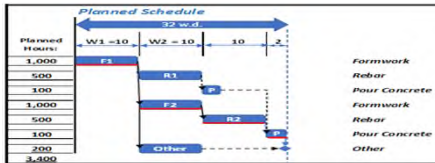
$$Causal\ Duration = \frac{Quantity}{Productivity \times Resources}$$

2.1 New Causal Duration & Cost Formulas

$$RV = Actual - Planned$$

$$EV_{Causal}: SPI = CPI \times RPI$$

2.2 New EVM Metrics connect Time to Causal inputs



2.3 Integrated EVM/CPM Causal Analysis

33

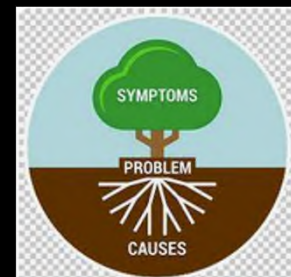
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$$Causal\ Duration = \frac{Quantity}{Productivity \times Resources}$$



$$(Labor)Cost = \frac{Quantity}{Productivity} \times \$Labor\ Rate$$



34

34

## What Causes the Duration of a labor activity?

### Output Based Duration

- What is the causal, deterministic basis for output?

$$\text{Activity Duration} = \frac{\text{Quantity}}{\text{Daily Output}} = \frac{10,000 \text{ (s.f.)}}{1,000 \text{ (s.f.)}} = 10 \text{ days}$$

### Input Based (Causal) Duration

- Productivity and the Rate of Resource Supply determine labor time duration per following formula:

$$\text{Activity Duration} = \frac{\text{Quantity}}{\text{Productivity} \times \text{Resource Supply}} = \frac{10,000 \text{ s.f.}}{10 \frac{\text{s.f.}}{\text{hrs.}} \times 100 \frac{\text{hrs.}}{\text{day}}} = 10 \text{ days}$$

Output = 1,000 sf./d

## Different Duration Outcomes

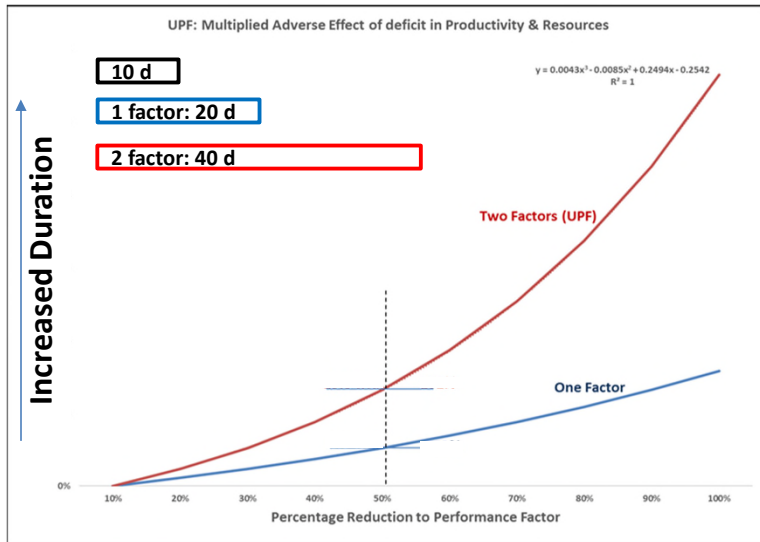
$$\text{Activity Duration} = \frac{\text{Quantity}}{\text{Productivity} \times \text{Resource Supply}}$$

- Activity duration varies as productivity & res. vary
- If **productivity < plan** and **resources = plan**, duration increases
- Prod. < plan** and **Res. < plan**, worst case duration increase
- Negative and positive prod and res could offset and have no duration effect (depends on magnitude)

ACTIVITY DURATION: EFFECT OF VARIANCE FROM PLANNED RESOURCE OR PRODUCTIVITY TARGETS per CAUSAL FORMULA

		PRODUCTIVITY		
		Below Plan	Per Plan	Above Plan
R E S O U R C E S	Below Plan	Longer Duration (worst case)	Longer duration	Longer, Shorter or No change
	Per Plan	Longer Duration	Planned duration	Shorter Duration
	Above Plan	Longer, Shorter or No change	Shorter Duration	Shorter Duration (best case)

## Duration effect of Productivity & Resource Deficits



$$Duration = \frac{10,000 \text{ s.f.}}{5 \frac{\text{s.f.}}{\text{hr.}} \times 50 \frac{\text{hr.}}{\text{day}}} = 40d$$

Both factors 50% below plan:  
Exponential growth

$$Duration = \frac{10,000 \text{ s.f.}}{5 \frac{\text{s.f.}}{\text{hr.}} \times 100 \frac{\text{hr.}}{\text{day}}} = 20d$$

1 factor 50% below plan  
Linear growth

37

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## Labor cost determined by Productivity – Not Time!

**Output Cost formula**  $Cost(\$) = Duration(d) \times (Burn Rate)RRS \frac{\text{hrs.}}{d} \times Labour Rate \frac{\$}{\text{hr.}}$

**Causal Duration Formula**  $(Burn Rate)RRS \left(\frac{\text{Hrs.}}{d}\right) = \frac{Quantity(s.f.)}{Duration(d) \times Productivity\left(\frac{\text{s.f.}}{\text{hr.}}\right)}$

$$Cost(\$) = \cancel{Duration(d)} \times \frac{Quantity(s.f.)}{\cancel{Duration(d)} \times Productivity\left(\frac{\text{s.f.}}{\text{hr.}}\right)} \times Labour Rate\left(\frac{\$}{\text{hr.}}\right)$$

$$Cost(\$) = \frac{Quantity(s.f.)}{Productivity\left(\frac{\text{s.f.}}{\text{hr.}}\right)} \times Labour Rate\left(\frac{\$}{\text{hr.}}\right)$$

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## Correcting EVM cost assumptions

### Per EVM ...

- If CPI is 0.50 "work will likely ...  
 – take twice as long to finish, and **WRONG!**  
 – probably cost more due to extended duration."



### CORRECTION PER NEW FORMULAS:

If CPI = 0.50, then,

- Duration will be twice as long if the Rate of Resource supply does not change.  
Increased resources could totally offset the time effect of lower productivity (per duration formula)
- Cost will be doubled but not because of extended duration. Per new formula, productivity - not time - determines cost.

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## Correcting EVM Cost Assumptions (cont'd.)

### Per EVM ...

- "Any added resources will have a permanent negative impact on cost efficiency and will produce no positive critical path schedule results."



WRONG!

### CORRECTION PER NEW FORMULAS:

- Added resources do not necessarily impact productivity
- Added resources may produce a positive critical path schedule result and should always be considered in cases of lagging output

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## Forecasting Duration & Cost with new formulas

PLAN:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Total Hrs:	Hourly Rate:	Total Cost:	Forecasted Duration:	Prod.:												
F1 Formwork	100	100	100	100	100	100	100	100	100	100																								
Formwork:	Early Mitigation? E=77%										D.V. = -3																							
Reduced Resources	77	77	77	77	77	77	77	77	77	77	77	77	77												1,000	\$50.00	\$ 50,000	13	10					
	E=77%																																	
Reduced Productivity	100	100	100	100	100	100	100	100	100	100	100	100	100																					
Red. Prod. & Res.	E=58%										D.V. = -7																							
	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	1,300	\$50.00	\$ 65,000	13	7.69												
	E=58%										D.V. = -7																							
	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	1,300	\$50.00	\$ 65,000	17	7.69													

$$\text{Cost} = \frac{10,000 \frac{s.f.}{hrs.}}{7.69 \frac{s.f.}{hrs.}} \times \$50 \text{ per hr.} = \$65,000$$

$$\text{Activity Duration} = \frac{10,000 \frac{s.f.}{hrs.}}{7.69 \frac{s.f.}{hrs.} \times 77 \frac{hrs.}{day}} = 17 \text{ days}$$

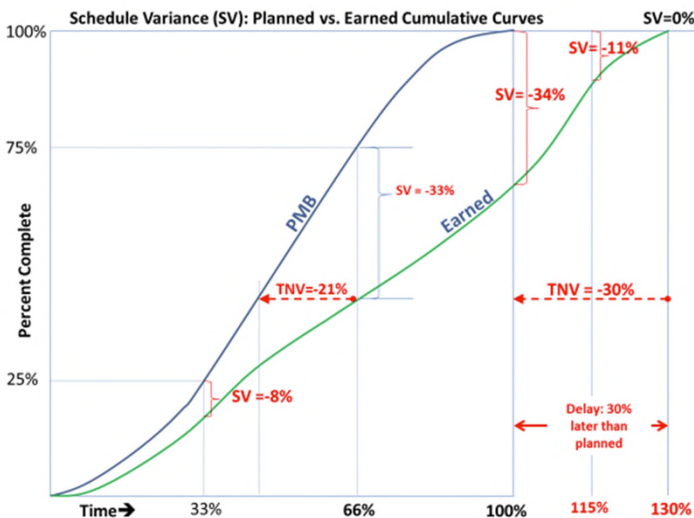
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## SV/SPI Primary Metrics because PMB is Objective



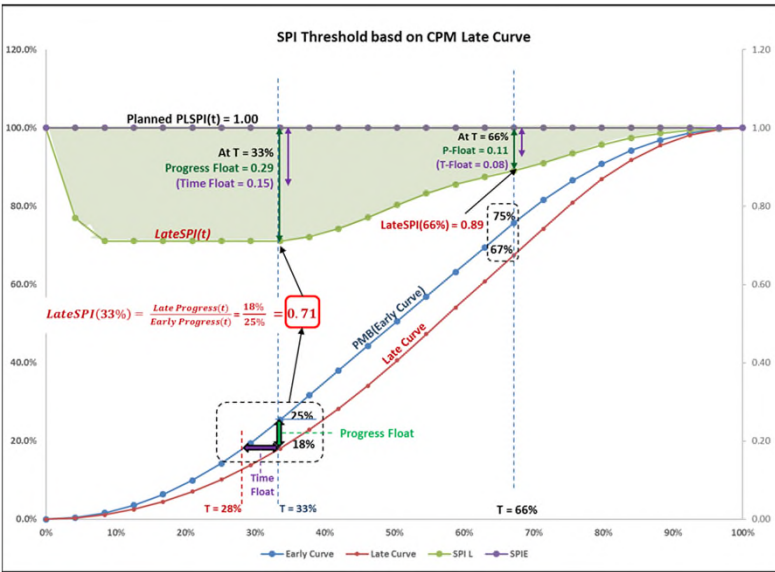
- Recall EVM: “SPI not recommended after 80% of the work” because ultimately equals 1.0”
- If a deficit in project progress there is deficit in time vs. (PMB) THE PERFORMANCE OBJECTIVE!!
- Root cause of negative SV/SPI, which translates to time variance, is always productivity (CV/CPI) and/or resources (RV/RPI)

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# AAACE CPM Late Curve is SV Threshold



- CPM **Late Curve**: all activities start on late date. Likely critical after.
- Late curve is **SV(PMB) threshold!**
- Threshold @ 33% of time: **SPI = 0.71**
- Any **float consumption increases time risk** (path convergence)

43

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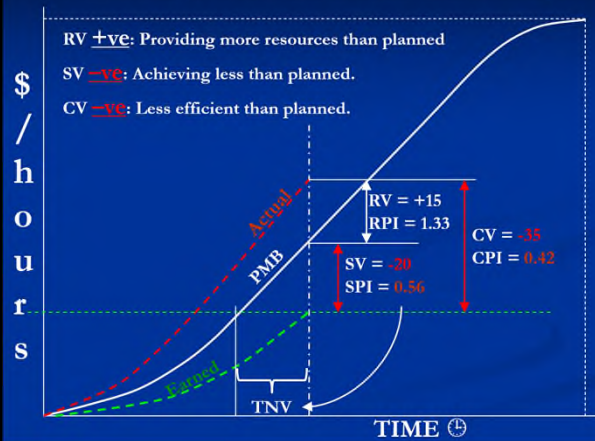
43

## AAACE 2.2 New EV Metrics connect Time to Causal Inputs

$$SPI = CPI \times RPI$$

$$SV = CV + RV$$

### Integrated CPM/EVM Analysis

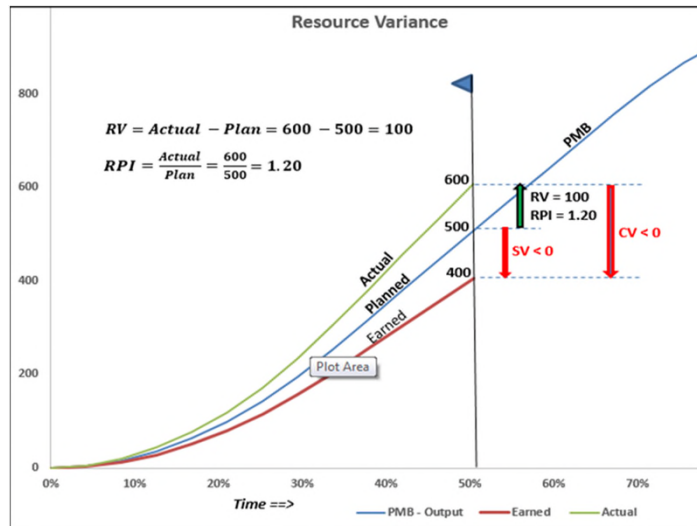


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## Resource Variance: the Missing Metric



- **Resource Variance (RV) = Actual hours – Planned hours**
- **Resource Performance Index (RPI) = Actual ÷ Planned hrs.**

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## New Causal EVM Formulas

$$\textcircled{C} CV + RV = (Earned - Actual) + (Actual - Planned) = Earned - Planned$$

$$\textit{Schedule Variance (SV) = Earned - Planned,}$$

$$\text{Output Variance } \textcircled{SV} = \textcircled{CV + RV} \text{ Variance in Causal Inputs}$$

$$\textcircled{C} CPI \times RPI = \frac{Earned\ Value}{Actual\ Value} \times \frac{Actual\ Value}{Planned\ Value} = \frac{Earned}{Planned}$$

$$\textit{Schedule Performance Index (SPI) = \frac{Earned}{Planned}}$$

$$\text{Output } \textcircled{SPI} = \textcircled{CPI \times RPI} \text{ Variance in Causal Inputs}$$

46

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# Integrated Cost & Time Formulas

OUTPUT

CAUSAL INPUTS

$$\text{Duration (Time)} = \frac{\text{Quantity}}{\text{Productivity} \times \text{Resources}}$$

$$\text{Cost} = \frac{\text{Quantity}}{\text{Productivity}} \times \text{Labor Rate}$$

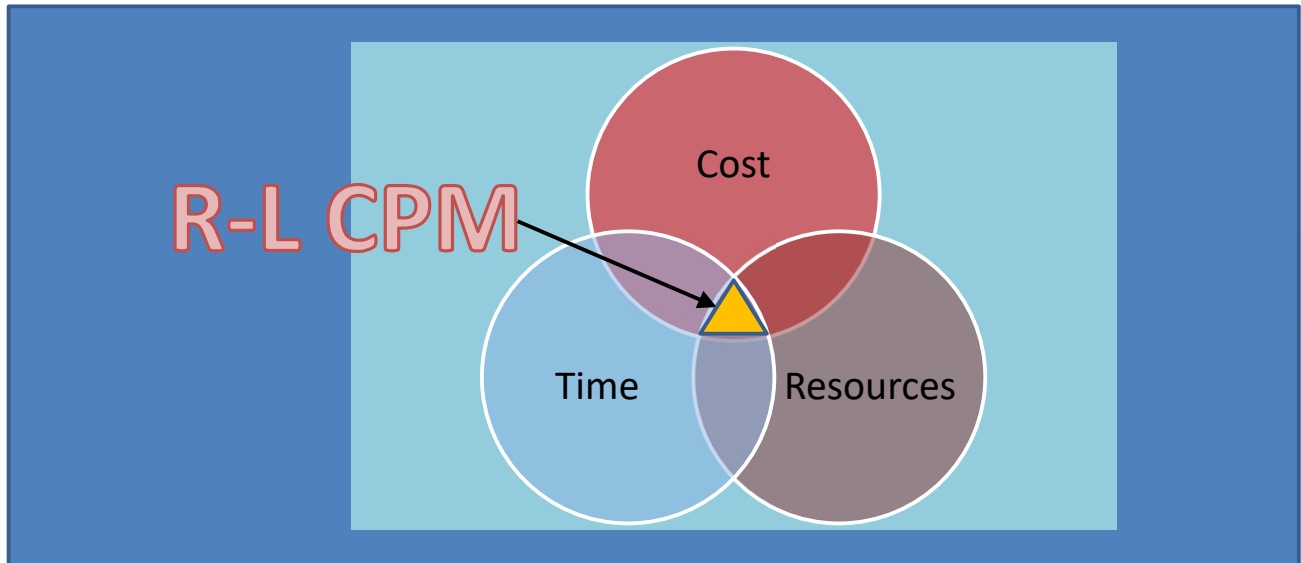
$$\text{EVM} \left\{ \begin{array}{l} \text{SPI (Progress)} = \text{CPI (Productivity)} \times \text{RPI (Resource Supply)} \\ \text{SV} = \text{CV} + \text{RV} \end{array} \right.$$

47

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# 2.3 Integrated EVM/CPM Analysis



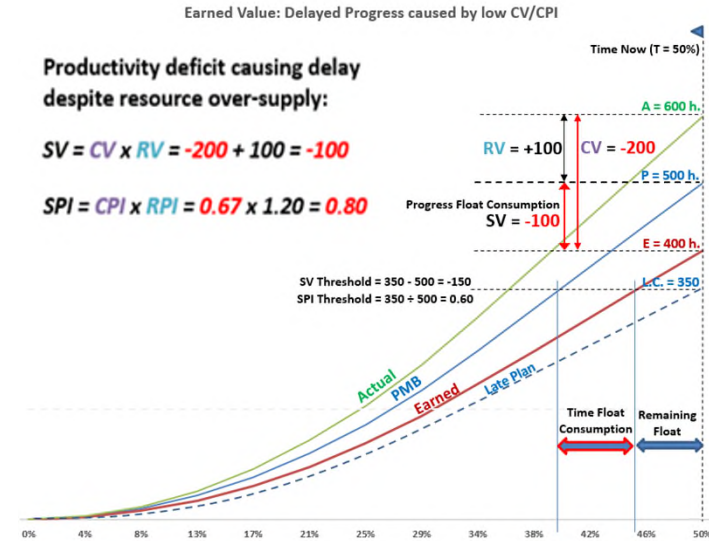
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## Interconnected Metrics: Productivity Problem causing Neg. SV

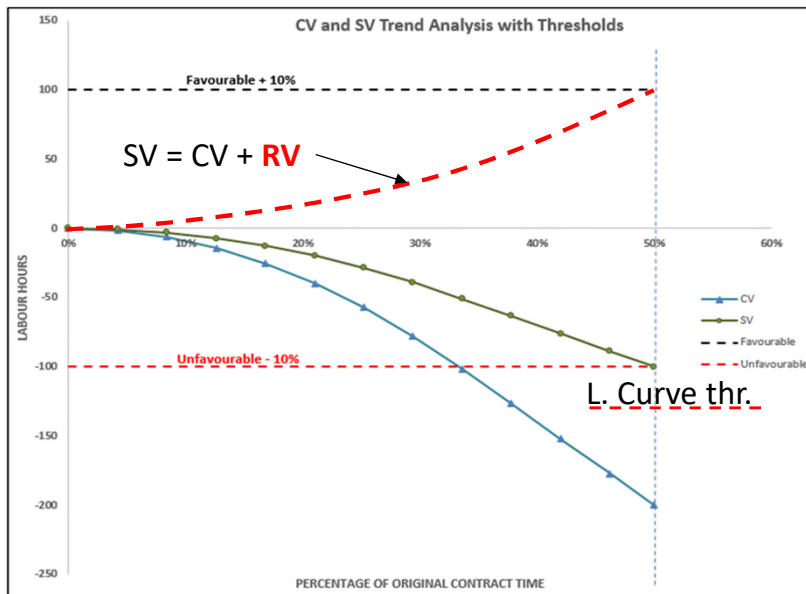


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- **Progress deficit (-SV)** result of **low productivity (-CPI)**, somewhat offset by **+ve resource supply (+RPI)**
- **-SV translates to -TNV**
- **Float consumption risk**
- SV is approaching Late Curve threshold
- Cause of negative productivity (CPI), and mitigation key to **recovery of progress & PMB**
- If CPI returns to favorable, resource cost will not increase if resources added and SV will improve

49

## Connection between CV & SV

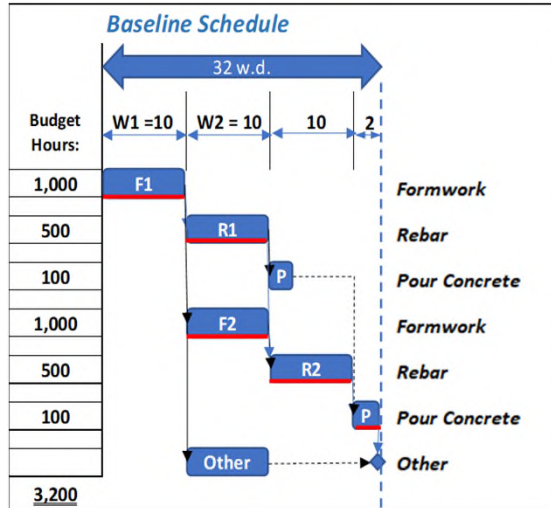


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- Calculate RV
- Late Curve threshold

50

## AAACE CPM “Windows” Analysis using new Integrated Analytics



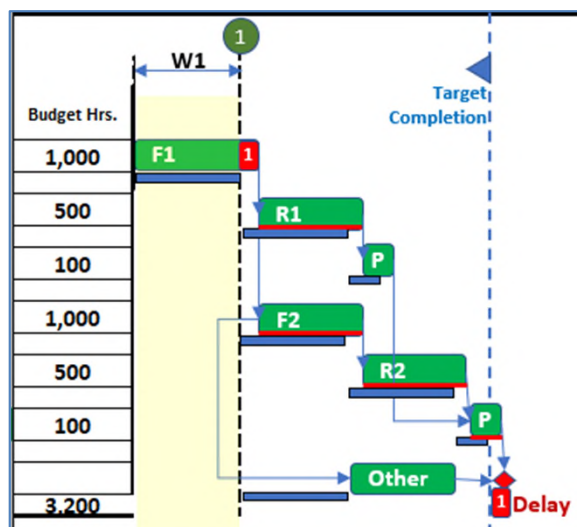
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- Schedule duration = 32d
- 10-day updates (“Windows” of time)
- Baseline loaded with labor hours.

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## AAACE Windows Analysis: First Update



52

- Formwork **not completed** per plan
- Contractor **forecasts 1 day** to complete
- **Unexamined forecast?**

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# Root Cause: RV/RPI-Caused Delay

RESOURCE PLAN:

	1	2	3	4	5	6	7	8	9	10
F1 Formwork	100	100	100	100	100	100	100	100	100	100

ACTUAL:

F1 Formwork	77	77	77	77	77	77	77	77	77	77
-------------	----	----	----	----	----	----	----	----	----	----

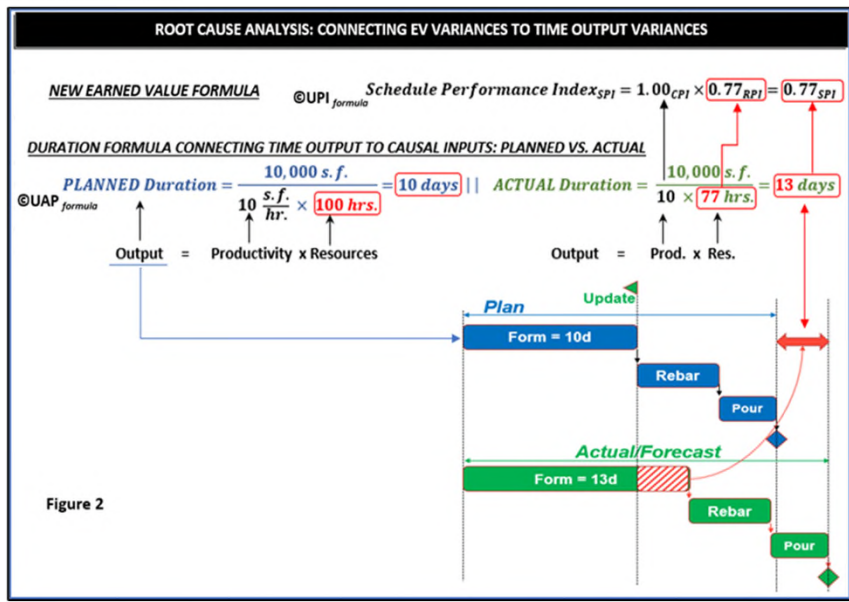
%age Complete:	Earned Hours:	Actual Hours:	Planned Hours:
77%	770	770	1,000

Resources are Direct Cause of delay

$Res.Var. = Actual - Planned = 770 - 1,000 = -230$        $RPI = 0.77$   
 $Sch.Var. = Earned - Planned = 770 - 1,000 = -230$        $SPI = 0.77$   
 $Cost Var. = Earned - Planned = 770 - 770 = 0$        $CPI = 1.00$

$SPI = CPI \times RPI = 1.00 \times 0.77 = 0.77$

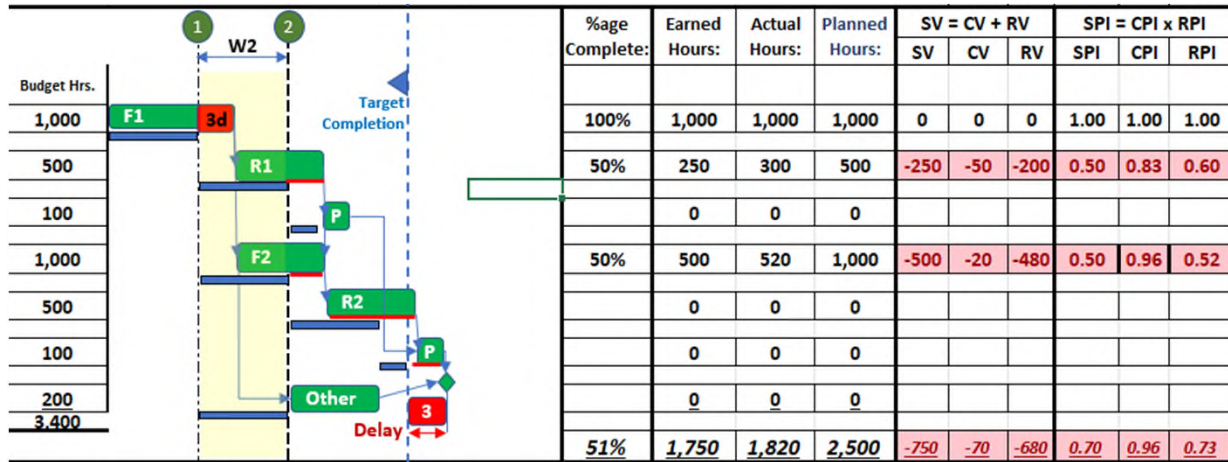
# Duration formula calculates longer duration



- RPI 0.77 - 23% fewer hours than planned to date.
- Causal Duration formula forecasts 3-day delay



## Window 2: No mitigation & Rebar Risk!!



$$F1 \text{ Rebar Duration Plan} = \frac{12 \text{ t.}}{0.024 \times 50} = 10d$$

$$F1 \text{ Rebar Duration Forecast} = \frac{12}{0.019 \times 43} = 20d$$

55

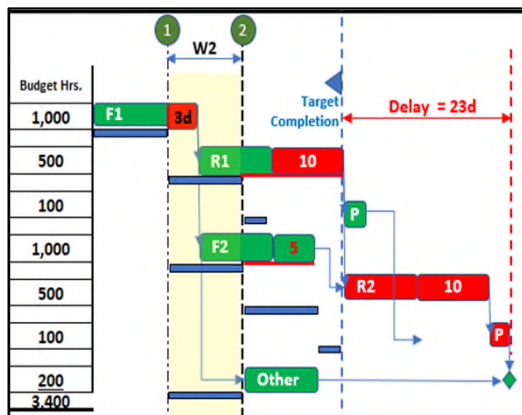
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55



## Root causal analysis: re-consider forecast

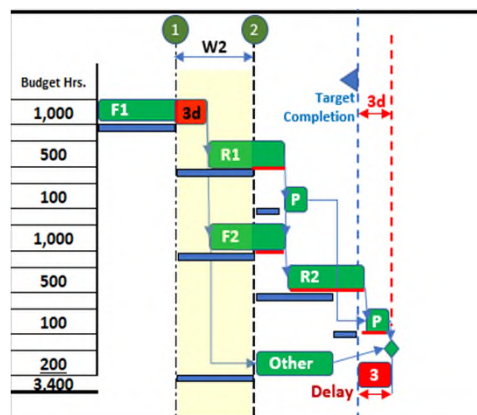
### Durations Per Causal Formula



Forecast adjusted based on Current Productivity and Rate of Resource supply

56

### Contractor Forecast



Assumes baseline remaining duration.

- Unless performance improves, delay will be 23 days instead of 3
- Use causally-based early warning to mitigate!!!

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56



# Large D-B-B Project: Fully Resource Loaded

All of this on D-B-B Projects!!!

	MATERIALS		LABOR		TOTAL BUDGET	
	Material Qty	Units	Material Budget	Planned Labor manhours		
<b>PHASE 1</b>			<b>CAD 20,122,702</b>	<b>395,559</b>	<b>CAD 16,232,072</b>	<b>CAD 36,354,774</b>
<b>YWP</b>			<b>CAD 667,554</b>	<b>17,085</b>	<b>CAD 672,384</b>	<b>CAD 1,339,938</b>
Skim Slab	2,546	m <sup>3</sup>	CAD 320,712	3,178	CAD 116,304	CAD 437,016
Concrete	1,080	m <sup>3</sup>	CAD 219,564	2,928	CAD 146,376	CAD 365,940
Rebar	178	tonnes				
Walls	60	m <sup>2</sup>				
SOG	4,588	m <sup>2</sup>	CAD 127,278	10,980	CAD 409,704	CAD 536,982
Round Columns	-	pcs				
Suspended Slabs	-	m <sup>2</sup>				
<b>BRB</b>			<b>CAD 181,518</b>	<b>3,465</b>	<b>CAD 143,895</b>	<b>CAD 325,412</b>
Skim Slab	13	m <sup>3</sup>	CAD 75,006	394	CAD 14,409	CAD 89,415
Concrete	437	m <sup>3</sup>	CAD 88,097	1,175	CAD 58,731	CAD 146,828
Rebar	72	tonnes				
Walls	56	m <sup>2</sup>				
SOG	813	m <sup>2</sup>	CAD 18,415	1,896	CAD 70,755	CAD 89,169
Round Columns	-	pcs				
Suspended Slabs	228	m <sup>2</sup>				
<b>DFS</b>			<b>CAD 3,177,613</b>	<b>61,392</b>	<b>CAD 2,533,224</b>	<b>CAD 5,710,838</b>
Skim Slab	1,065	m <sup>3</sup>	CAD 1,376,136	7,219	CAD 264,253	CAD 1,640,389
Concrete	7,214	m <sup>3</sup>	CAD 1,463,760	19,517	CAD 975,842	CAD 2,439,602
Rebar	1,188	tonnes				
Walls	11,924	m <sup>2</sup>				
SOG	6,056	m <sup>2</sup>	CAD 337,717	34,655	CAD 1,293,129	CAD 1,630,846
Round Columns	-	pcs				
Suspended Slabs	2,789	m <sup>2</sup>				
<b>1PG</b>			<b>CAD 1,049,801</b>	<b>20,413</b>	<b>CAD 840,005</b>	<b>CAD 1,889,806</b>

57

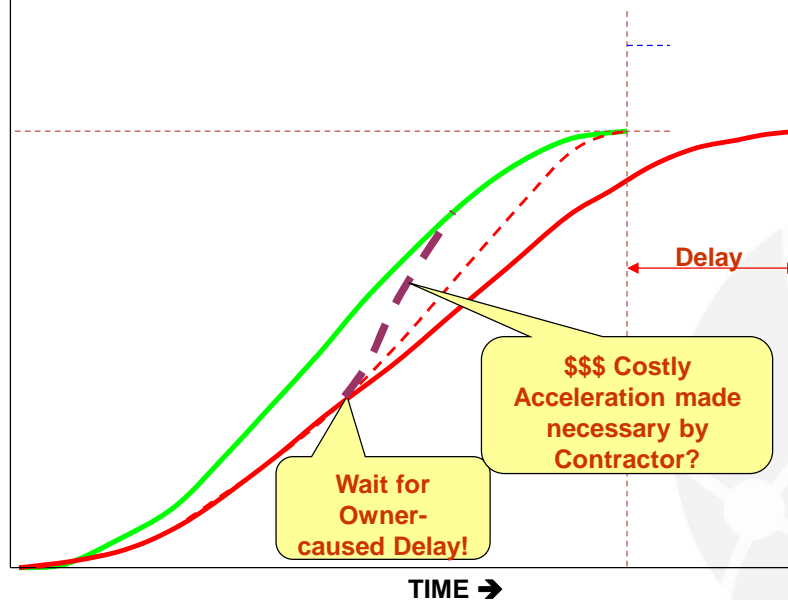
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57



# Lagging Progress – Time & Claims Risk!

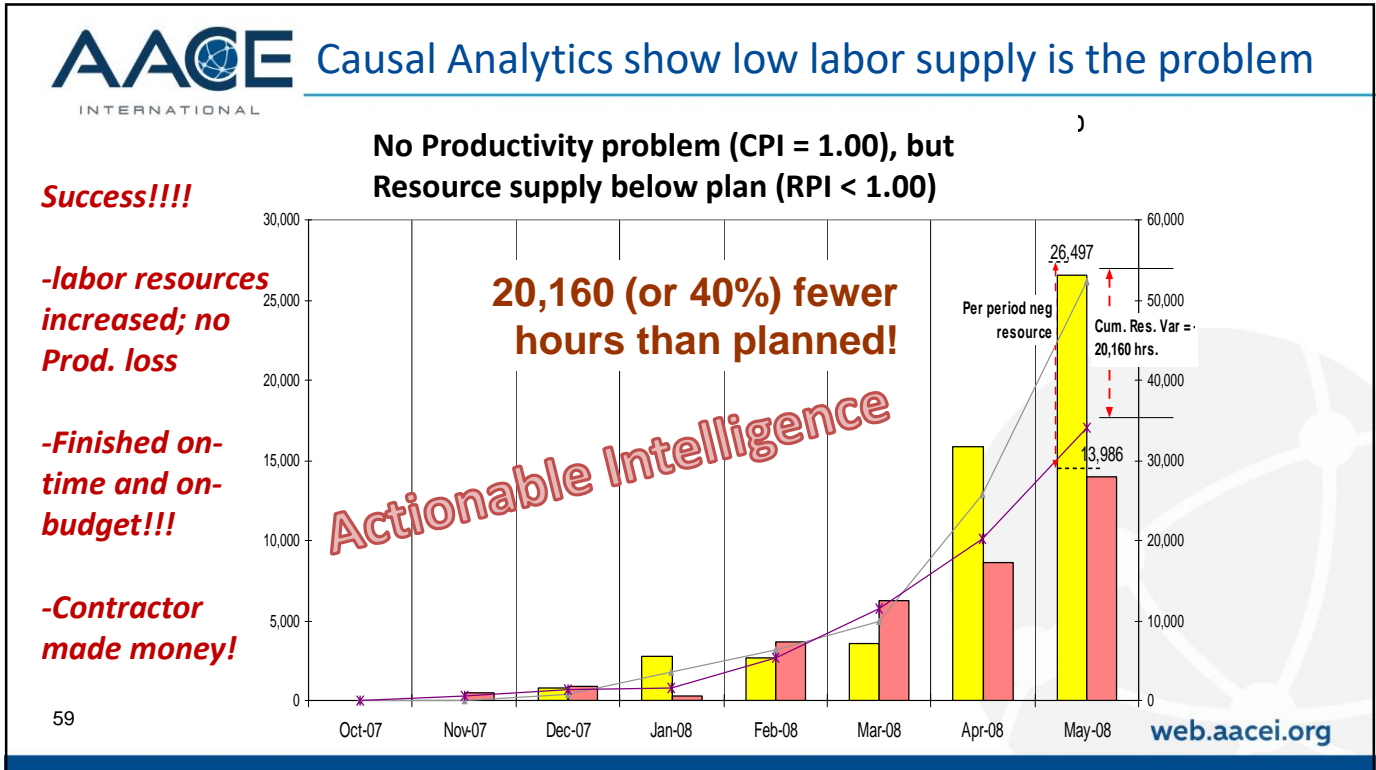
- Compliant R-L CPMs
- "Riding the Late Curve"
- Higher risk!
- Acceleration claim? **Low productivity caused by owner?**
- Waiting Game for owner delays



58

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58



59

## 3. Implications & Path Forward

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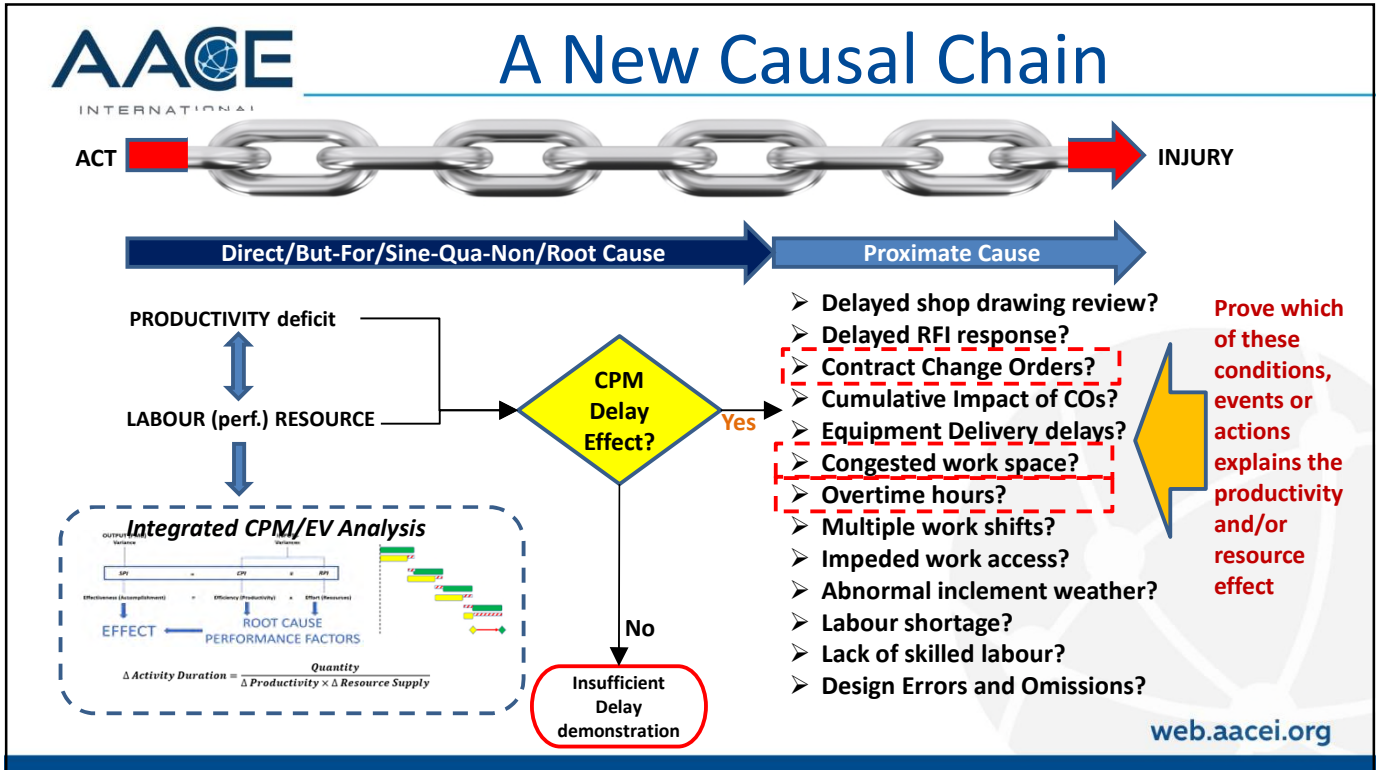
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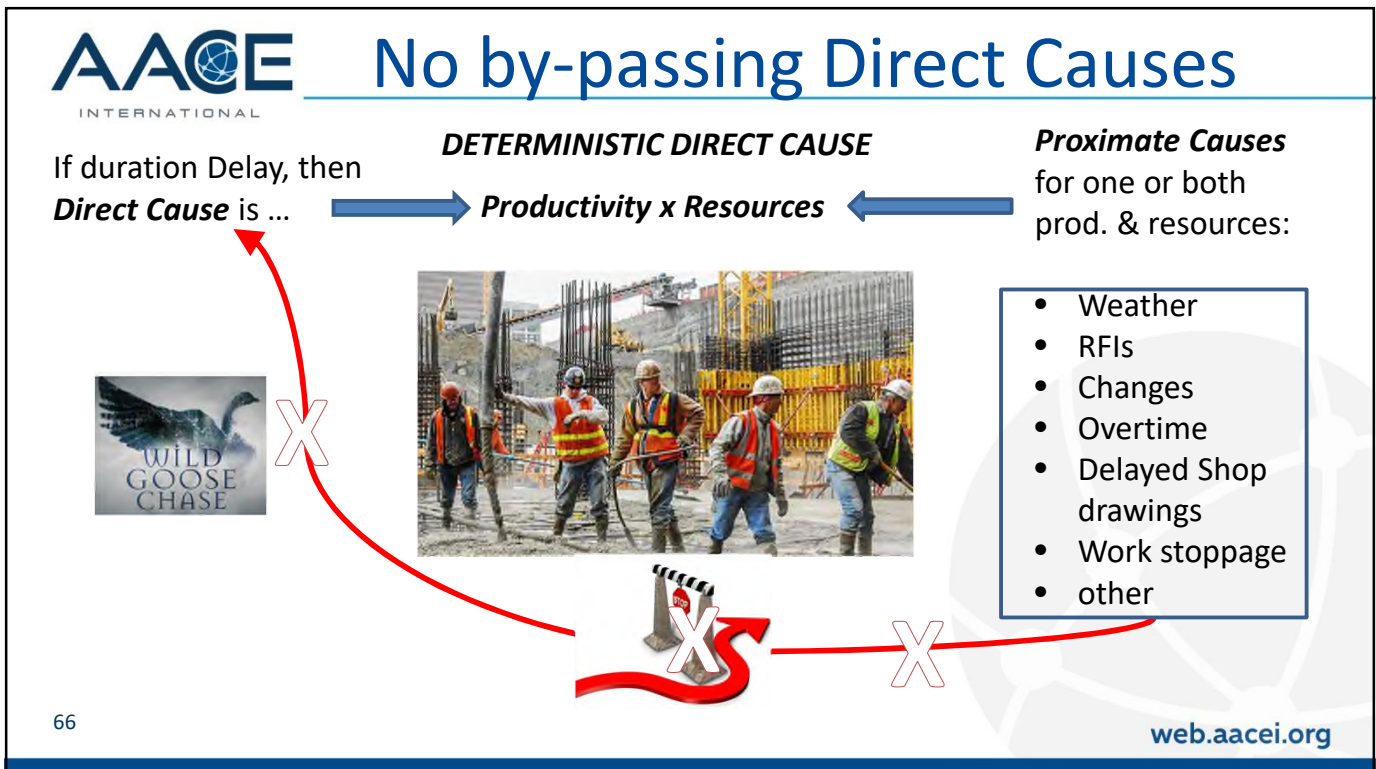








65



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**ENR**

Engineering News-Record

Critics Can't Find the Logic in Many of Today's CPM Schedules

- ❑ *schedules lack mathematical coherence or common sense*".
- ❑ ... there is *"confusion, delayed projects and lawsuits"*, ... instead of being an important planning and control instrument, schedules ... used as *"tools for claims"*.

Plotnick, Wickwire, et. al.

Performance Path cleared with R-L Schedules and New Analytics  
 Transparency → Accountability → Action → Improved Performance

**Root Causal Analysis:**

**Reliable Resource-Loaded CPM schedules & EVM analytics create Performance Transparency!**



- ... there’s a new challenge to **sound reasoning about causes and effects**. While awareness of the **need for a causal model** has grown ..., many ... would like to **skip the hard step of constructing ... a causal model and rely solely on data**
- “**Statistics alone cannot tell which is the cause and which is the effect. ... big data is profoundly dumb about causes and effects**”
- if we are in possession of a **causal model**, we can often **predict the result of an intervention**

[Judea Pearl, The Book of Why – The New Science of Cause and Effect]

### Integrated Project Delivery



### The Benefits of Prefabrication in Construction

#### Public-Private Partnerships (P3)

New Procurement Strategies - The Future of Procurement  
**Procurement** Can Create Strategic Supplier Relationships for a Strong Competitive Advantage. EY Works With Businesses to Develop Resilient **Procurement** Strategies for Profitability, Supply Chain Solutions, Sourcing Strategy.



69

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69

- **PMB** is **primary time and cost objective** in a **performance-based** system.
- **Productivity and resources** are Root causal performance factors data
- New EVM and CPM formulas **fully integrate** performance analysis
- **Early warning** of off-trends and causes premised on **deterministic** analysis.
- Effective **risk avoidance and mitigation** possible.
- Dramatically **improved project planning and control**
- Analytics compel **rethinking of causation**
- Challenge of getting reliable **resource loaded schedules** must be met.
- **Buyers of construction** can **effect change**, but need encouragement

70

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70



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**(EVM-4025) Fully Integrated Earned Value & CPM Schedule  
Analysis at a Causal Level – A New Analytical Approach**

**Gerard Boyle  
[gboyle@revay.com](mailto:gboyle@revay.com)**

71

71