"Schedule Analysis and Predictive Techniques Using Earned Schedule"

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Agenda

1) Introduction & Basic ES Predictors: **Kym** – 15 min
2) ES to Schedule Analytical "Bridging" Techniques: **Eleanor** – 10 min
3) Advanced Risk and Outcome Prediction Techniques using ES: **Walt** – 15 min
4) Wrap up and Q&A **All** – 5 to 10 mins

So, what's the problem?

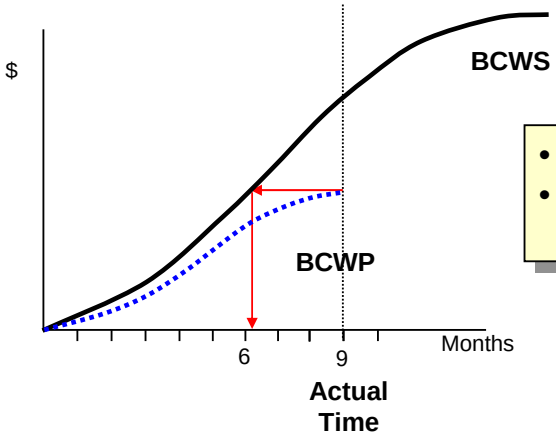
- Traditional schedule EVM metrics are good at beginning of project
  - Show schedule performance trends
- But the metrics don't reflect real schedule performance at end
  - Eventually, all "budget" will be earned as the work is completed, no matter how late you finish
    - SPI improves and ends up at 1.00 at end of project
    - SV improves and ends up at $0 variance at end of project
  - Traditional schedule metrics lose their predictive ability over the last third of project
    - Impacts schedule predictions, EAC predictions
- **Project managers don't understand schedule performance in terms of budget**
  - Like most of us!

Determining Earned Schedule

How Much Schedule Did I Earn?

- **Earned Schedule** = cumulative **earned value** in **time units** as established by the value of cumulative BCWP on the BCWS curve
  - Partial units of time are calculated
- Can be calculated graphically or with tabular data

EARNED SCHEDULE = ~6.1 months



- **Actual time is 9 months**
- **The earned schedule is 6.1 months**

Earned Schedule: The Schedule Indicators

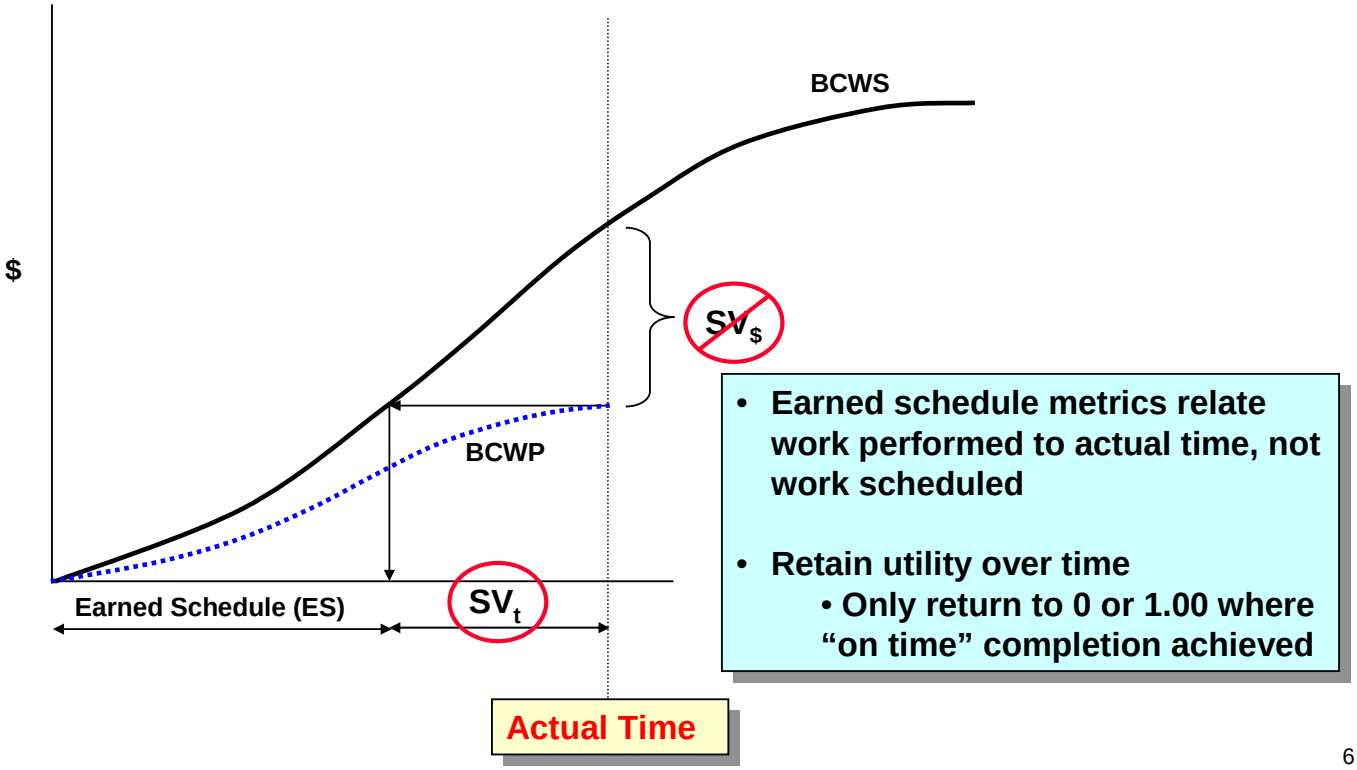
- The Earned Schedule Indicators
  - Schedule Variance (time):

    SV(t) = ES – AT, where AT = actual time
  - Schedule Performance Index (time):

    SPI(t) = ES / AT
- Key Points:
  - ES Indicators constructed to behave in an analogous manner to the EVM Cost Indicators, CV and CPI
  - SV(t) and SPI(t) not constrained by BCWS calculation reference
  - SV(t) and SPI(t) provide duration based measures of schedule performance

IPPM

$SV_{\$}$ versus SV_t



- **Earned schedule metrics relate work performed to actual time, not work scheduled**
- **Retain utility over time**
  - **Only return to 0 or 1.00 where "on time" completion achieved**

ES vs EVM Schedule Indicators and Predictors

Earned Schedule	Earned Value
SV(t) and SPI(t) valid for entire project, including early and late finish	SV($) and SPI($) validity limited to early finish projects
Duration based predictive capability analogous to EVMs cost based indicators	Limited prediction capability No predictive capability after planned completion date exceeded
Facilitates Cost – Schedule Management (using EVM and ES)	EVM Management focused to Cost

"Further Developments" in Earned Schedule

- Calculation of IEAC(t): short form

$$IEAC(t) = \text{Planned Duration} / SPI(t)$$

- Planned Duration for Work Remaining

$$PWDR = \text{Planned Duration} - \text{Earned Schedule}_{cum}$$

  - Analogous to the EVM BCWR

- Calculation of IEAC(t): long form

$$IEAC(t) = \text{Actual Time} + \left(\frac{PDWR}{\text{Performance Factor}} \right)$$

"Further Developments" in Earned Schedule *(continued)*

- IEAC(t) long form formula
  - Provides full alignment to the EVM IEAC($) predictor
  - Allows performance factors other than SPI(t) to be developed and utilised for predicting final schedule outcomes
    - Including non EVM based formulae (i.e. schedule based PF)
  - PWDR resolves to zero at project completion
- IEAC(t) formulae overcome flaws in pre-Earned Schedule, schedule predictive techniques using EVM
  - e.g. **Planned Duration / SPI($)**

"Further Developments" in Earned Schedule *(continued)*

- **Pre ES formulae and results algebraically flawed**

"... there is little theoretical justification for EVM practitioners continuing to use the pre ES predictors of schedule performance. Conversion to and use of the ES based techniques is strongly recommended."

- See
  - *"Further Developments in Earned Schedule"* paper (Henderson) for detailed explanation
  - "*Earned Value Project Management Method and Extensions*" (Prof. Frank T Anbari, Phd, George Washington University) for comprehensive description of pre ES, schedule prediction techniques using EVM

"Further Developments" in Earned Schedule *(continued)*

- Analogous forward looking" Earned Schedule indicator to the CPI TO GO is calculated as:

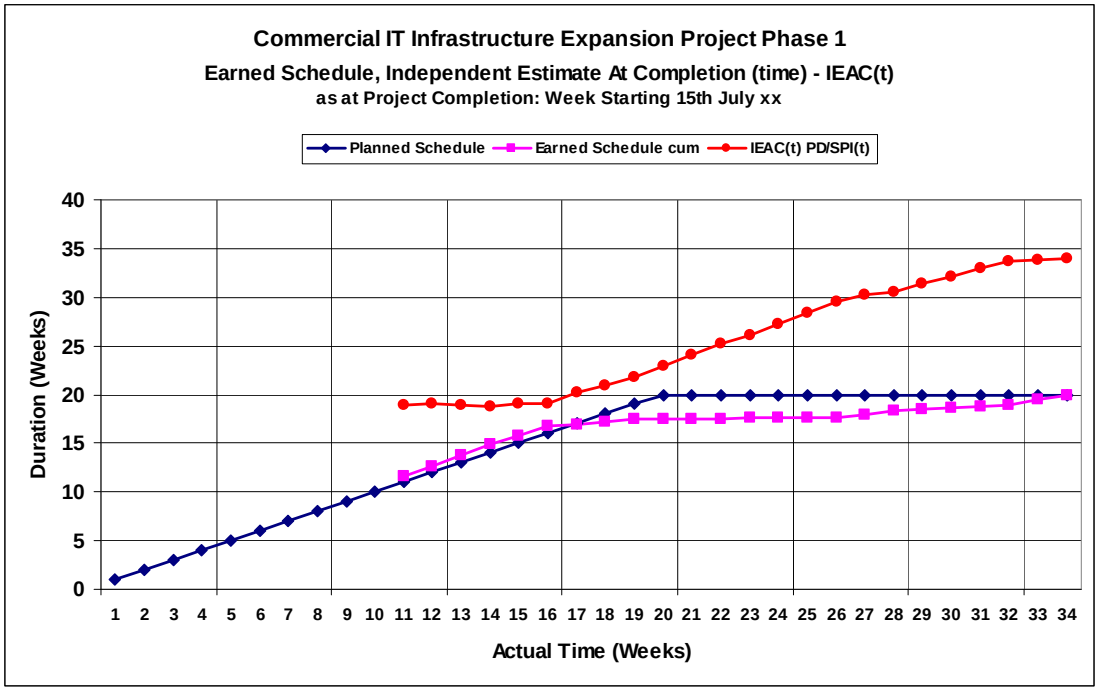
$$SPI(t)_{TO\ GO} = \frac{Planned\ Duration - ES_{cum}}{Planned\ Duration - Actual\ Time}$$

- The ES analogous TO COMPLETE CPI indicator is calculated as:

$$To\ complete\ SPI(t) = \frac{Planned\ Duration - ES_{cum}}{EAC(t) - Actual\ Time}$$

- Provides full Earned Schedule parity with EVM cost indicators

IEAC(t) Predictions using ES Techniques:
Weekly Plots of IEAC(t) - Late Finish Project Example

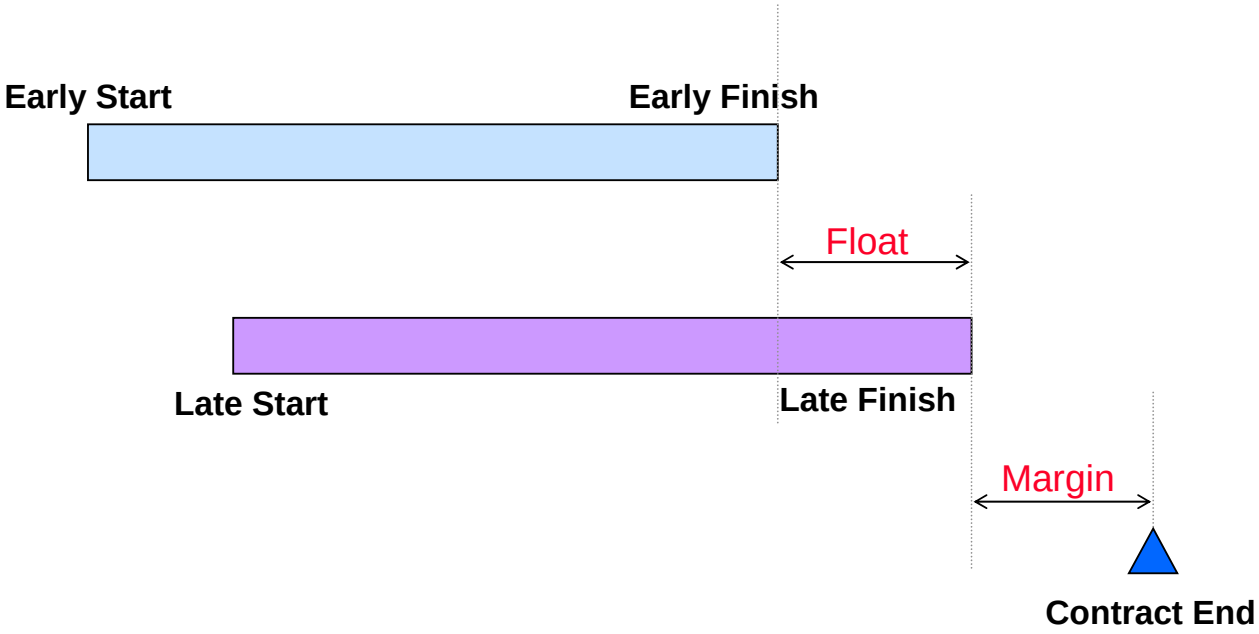


Earned Schedule Metrics and the Integrated Master Schedule

Benefits of Earned Schedule

- **Makes common sense!**
- **Easier concept to grasp**
  - Schedule variance metrics in terms of time rather than $
- **More stable metric**
  - Retains trend until end of project
  - Retains predictive utility
    - Use to predict duration
    - Can be used to improve EAC predictions
  - Check of contractor's schedule realism
- **Bridge between EVM and the integrated master schedule**

Float and Margin



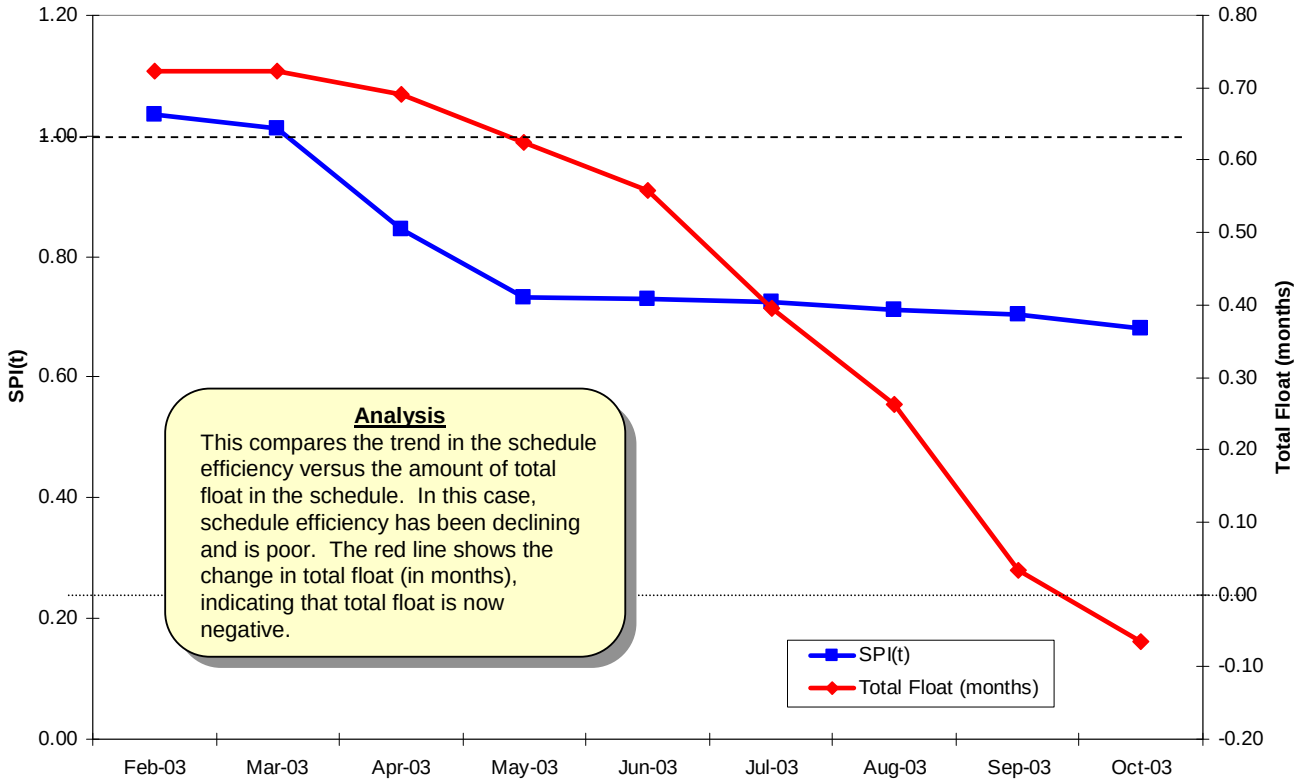
Compare Total Float to SPI(t)

SPI(t)	TF	
>1	>0	Ahead of schedule
<1	<0	Behind schedule
>1	<0	Critical activities behind, but total work ahead (priority problem)
<1	>0	Critical activities ahead, but total work behind (future trouble)

Adapted from Humphreys & Associates, Project Management Using Earned Value

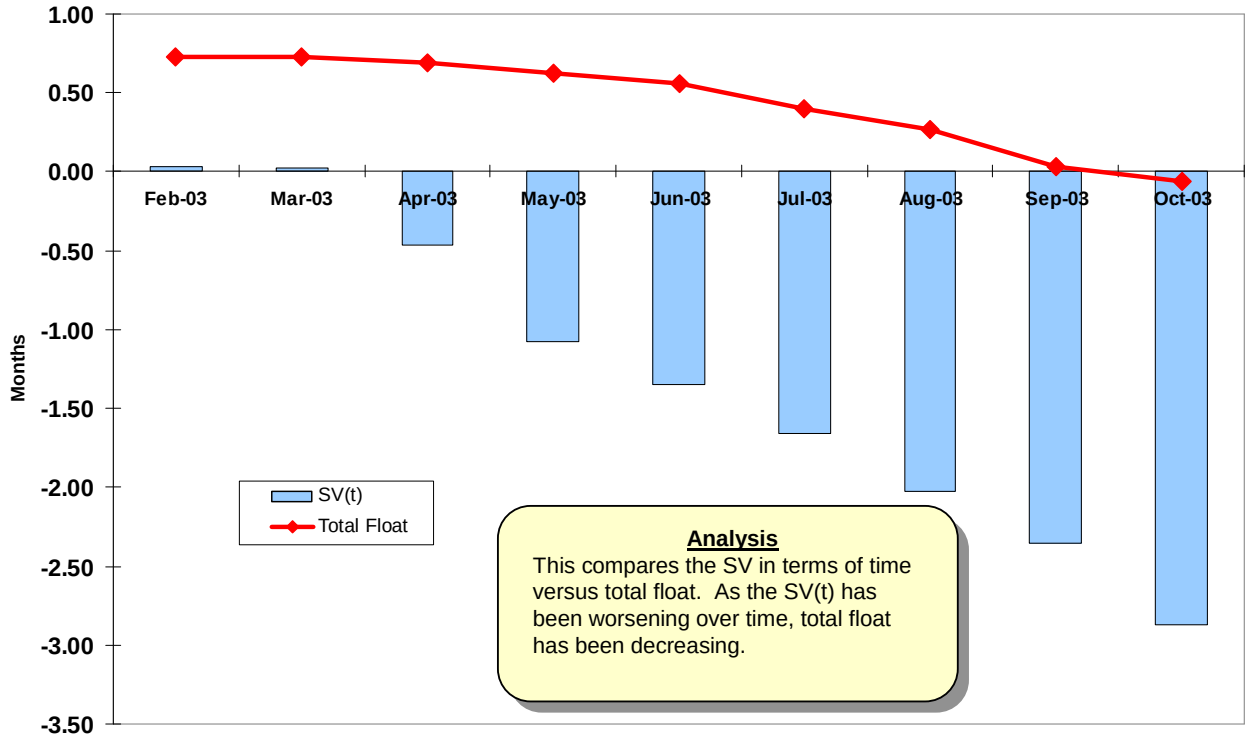
NOTIONAL DATA

SPI(t) versus Total Float



NOTIONAL DATA

Schedule Variance and Total Float



Conclusions

- ***Earned Schedule***
  - a powerful new dimension to Integrated Project Performance Management (IPPM)
  - a breakthrough in theory and application

the first scheduling system

Risk Planning & Outcome Prediction

Using Earned Schedule

IPMC 2004
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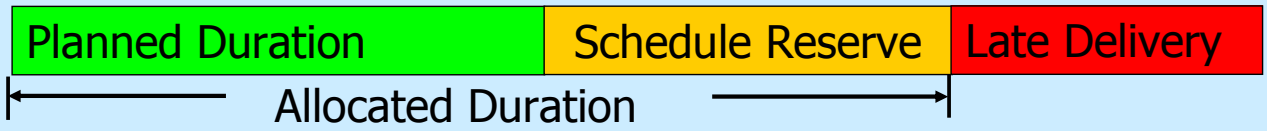
Risk & Prediction

- **Earned Schedule yields reliable indicators**
- **ES facilitates statistical applications**
  - **Statistical Process Control (SPC)**
  - **Risk Planning**
  - **Outcome Prediction**
- **Expectation**
  - **Improved schedule planning**
  - **Enhanced project control**

Basics

- **Schedule Prediction: $IEAC(t) = PD / SPI(t)_c$**



- **Schedule Ratio: SR = AD / PD**

  where ***AD = Allocated Duration***

  PD = Planned Duration

- **Schedule Reserve = AD – PD**
- **Divide IEAC(t), AD & PD by PD:**

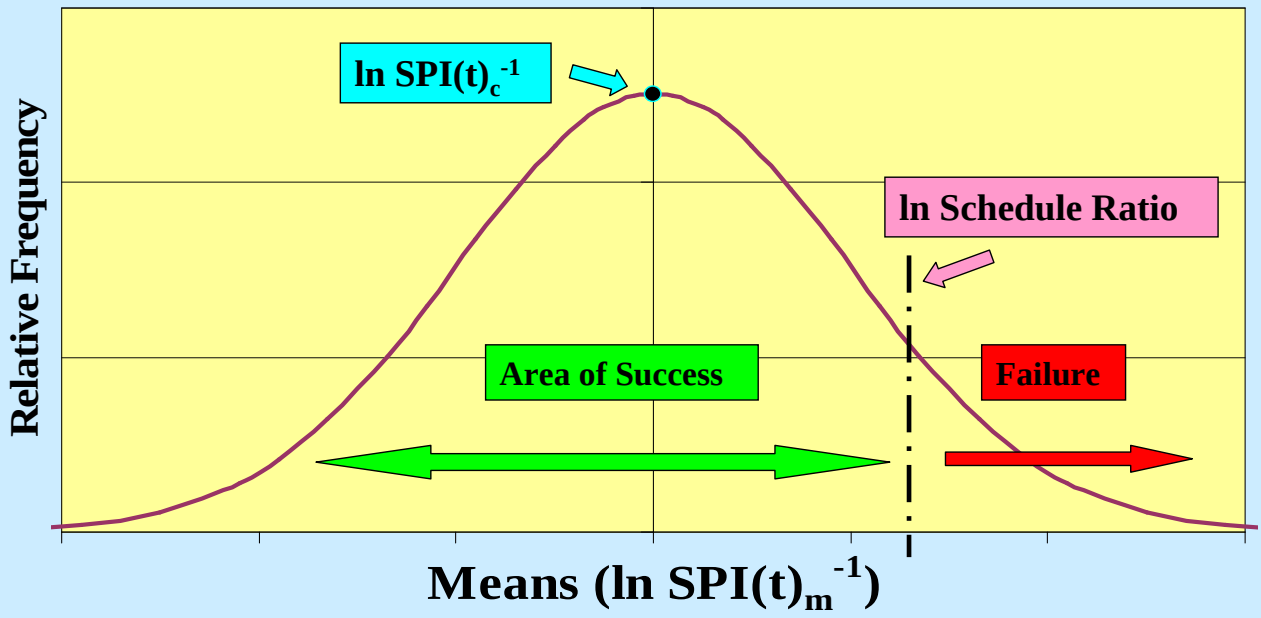
$SPI(t)_c^{-1}$, SR & 1.0

Basics *(continued)*

- **Performance Prediction**

$SPI(t)_c^{-1} \leq 1.0$	Plan Achieved
$1.0 < SPI(t)_c^{-1} \leq SR$	Customer Satisfied
$SR < SPI(t)_c^{-1}$	Late Delivery

Probability of Success



Risk Planning

- **Risk mitigation $\Rightarrow$ *Schedule Reserve***
- **Data needed**
  - **Performance variation from similar historical project *[Standard Deviation = σ_H]***
  - **Planned Duration of new project *[provides the number of performance observations (n)]***
  - **Variation of Means ($\ln SPI(t)_m^{-1}$) = $\sigma_H / \sqrt{n} = \sigma_m$**
  - **Probability of Success Desired *(PS)***

Risk Planning *(continued)*

- **Calculation**

  PS $\Rightarrow$ Z ***(use Normal Distribution Tables or Excel)***

  $Z = (\ln SR - \ln SPI(t)_c^{-1}) / \sigma_m$

  where $SPI(t)_c^{-1} = 1.0$ for plan

  $SR = \text{antilog}(Z * \sigma_m)$

  Schedule Reserve = AD – PD

  = SR * PD – PD

Schedule Reserve = (SR – 1) * PD

Risk Planning *(continued)*

- **Example Calculation**
  - **Data:** $\sigma_H = 0.4$, $PD = 36$ mo, $PS = 90\%$
  - **Calculation:**

$\sigma_m = 0.4 / \sqrt{36} = 0.0667$

$PS = 90\% \Rightarrow Z = 1.2816$

$\text{Schedule Ratio} = \text{antilog}\,(1.2816 * 0.0667)$

$= 1.0892$

$\text{Schedule Reserve} = (1.0892 - 1) * 36 \text{ mo}$

$= \underline{3.2 \text{ months}}$

Conclusion

- **ES facilitates advanced Project Management methods**
- **Methods lead to improved**
  - **Project & Risk Planning**
  - **Management Information**
  - **Project Control**

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6) EVM: Earned Value Management, Japanese Society for Project Management, 2003

Appendix - Earned Schedule: The Formulae

- ES_{cum} is the:

  Number of completed BCWS time increments BCWP exceeds + the fraction of the incomplete BCWS increment

- $ES_{cum} = C + I$ where:

  C = number of time increments for $BCWP \geq BCWS$

  $I = (BCWP - BCWS_C) / (BCWS_{C+1} - BCWS_C)$

- $ES_{period}(n) = ES_{cum}(n) - ES_{cum}(n-1)$