



# **EVM and Critical Chain Project Management (CCPM)**



Larry Leach, PMP

208-345-1136

**Advanced-Projects.com**

Lawrence\_leach@hotmail.com

# Objective

*Demonstrate* how **Earned Value Management (EVM)** and **Critical Chain Project Management (CCPM)** work together to improve project planning and control.

# NASA Earned Value Management

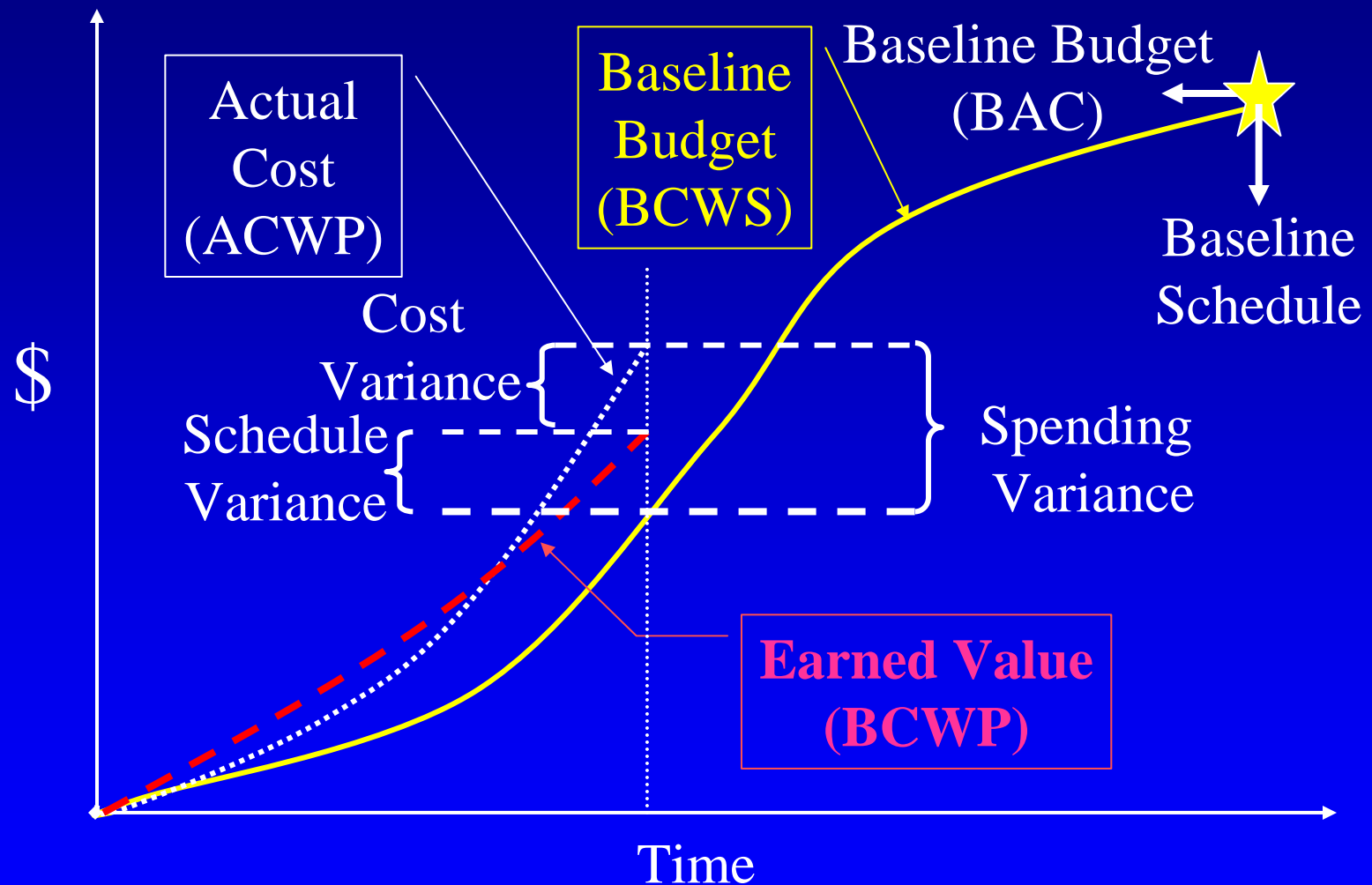
**EVM** is an integrated management control system for assessing, understanding and quantifying what a contractor or field activity is achieving with **program dollars**.

- **Integrates** technical, cost, schedule, with risk management.
- Allows objective **assessment and quantification** of current project performance.
- Helps **predict** future performance based on trends.

**EVM** provides project management with objective, accurate and timely data for effective **decision making**.

<http://evm.nasa.gov/brochure.pdf>

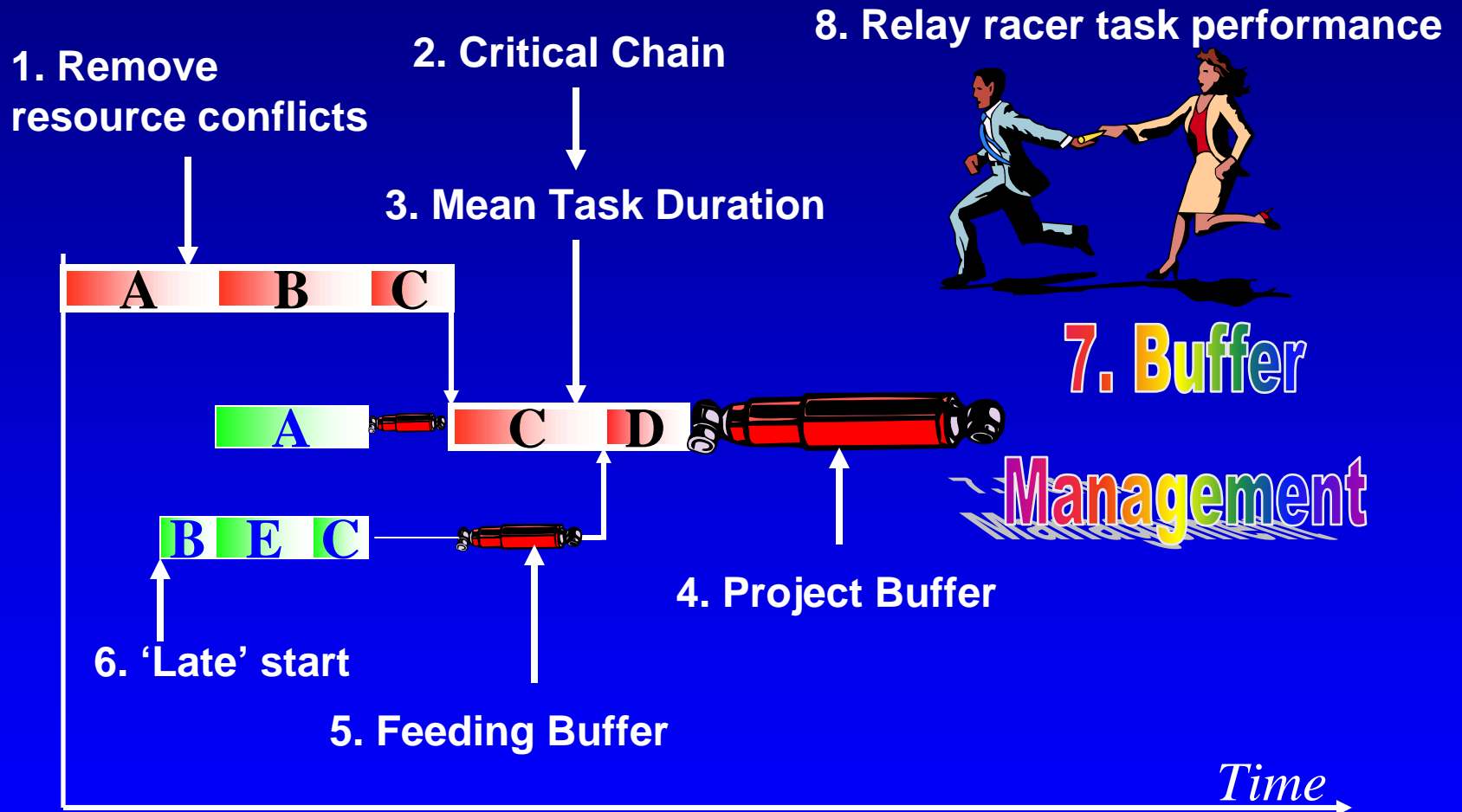
# Standard Earned Value Picture



# Critical Chain Project Management (CCPM) Is More Than a *Network Analysis Technique*

- Changes **planning**, **measurement**, and **execution** approach.
- Focuses on **variation** and **dependent events**.
- Implements **behavior** to reduce project time waste:
  - External to task
    - Synchronization (inputs).
    - Queuing.
  - Internal to task
    - Student syndrome.
    - Parkinson's law.
    - Bad multi-tasking.

# Critical Chain Project Management



# CCPM Schedule Control

- Frequently status with estimates of *Remaining Duration* for working tasks:
  - Simple.
  - Forward looking.
- Calculate impact on project buffer tracing task chains forward: *buffer penetration*.
- Compare to pre-set thresholds for action:
  - **Green:** no action
  - **Yellow:** plan buffer recovery.
  - **Red:** implement buffer recovery.

# Project Status Simplified and Forward Looking: Remaining Duration

Concerto 4.0 - Microsoft Internet Explorer provided by AT&T WorldNet Service

File Edit View Favorites Tools Help

Address <http://localhost/conweb/TU.htm> Go

ConcertoWeb Username: ResAdmin Server Name: concerto My Profile Log Off

Sys Admin DB Central Project Central Task Mgt Execution Views Resource Portal P2P

Task List | [Assign Task Mgrs](#) Help

Task Manager: Corvin

Projects: All Projects

Start Date: 2/15/2002 + Days: 30

Related Links:  
[Task Level Priorities By Task Mgr](#)  
 Get Data

Print Preview  
 Export to Excel  
 Advanced Sort  
 Advanced Filters

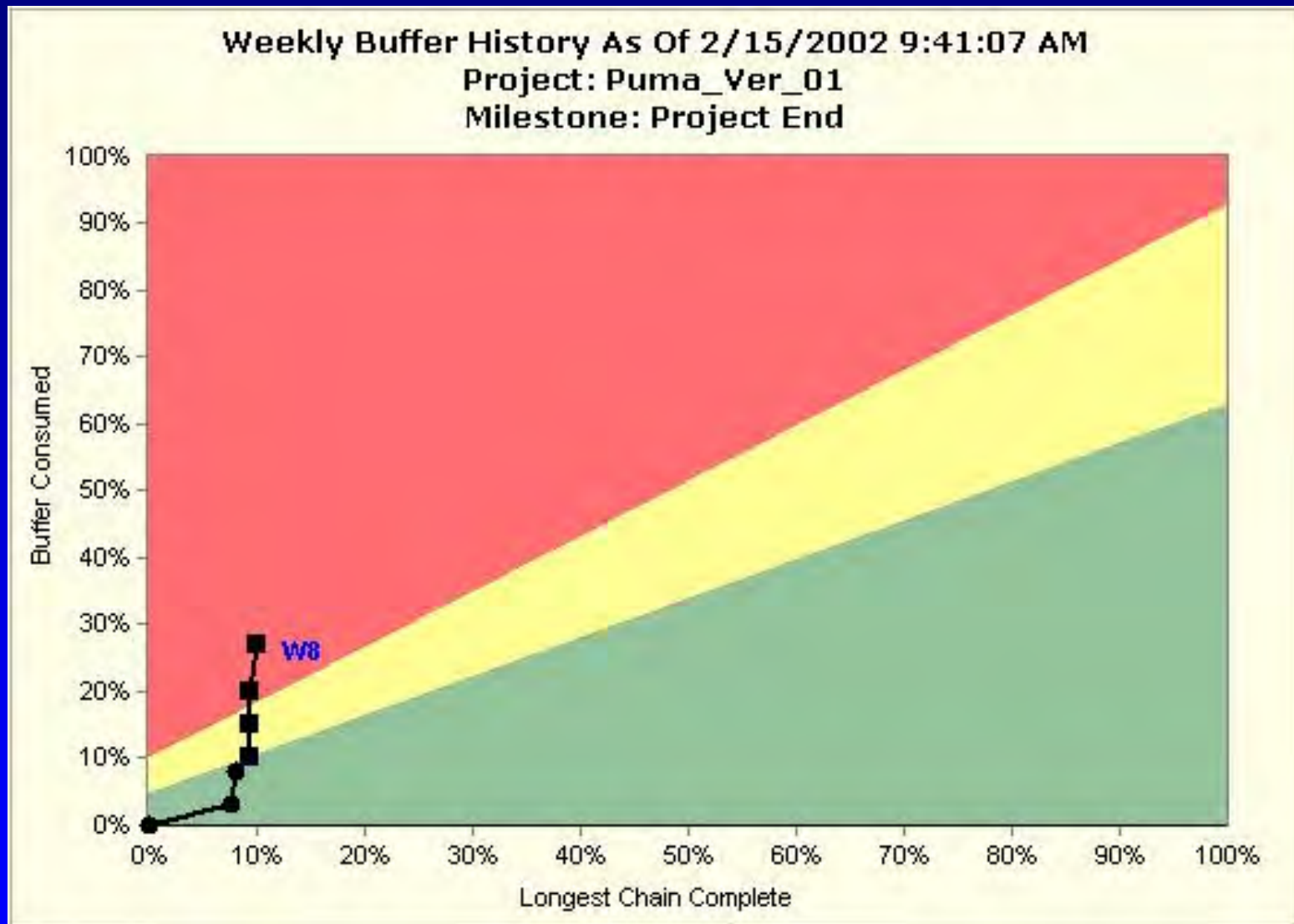
T/T	Task Mgr	Project Name	MSP Task ID	Task Desc	Earliest Arrival	Resource Notes	Task Status	Remaining Duration		Date
	Corvin	fox_ver_01	9	<a href="#">F1/Module 2 SW Coding</a>	2/15/2002	celia	IP	9d		2/15/2002
	Corvin	Cheetah_ver_01	9	<a href="#">F1/Module 2 SW Coding</a>	2/15/2002		IP	9d		2/15/2002
	Corvin	fox_ver_01	36	<a href="#">F2/Module 2 SW Coding</a>	2/26/2002		NS	9d		
	Corvin	Cheetah_ver_01	36	<a href="#">F2/Module 2 SW Coding</a>	2/26/2002		NS	9d		
	Corvin	coyote_01	36	<a href="#">F2/Module 2 SW Coding</a>	3/15/2002		NS	9d		

< [Previous Page] Page 1 Of 1 [Next Page] >

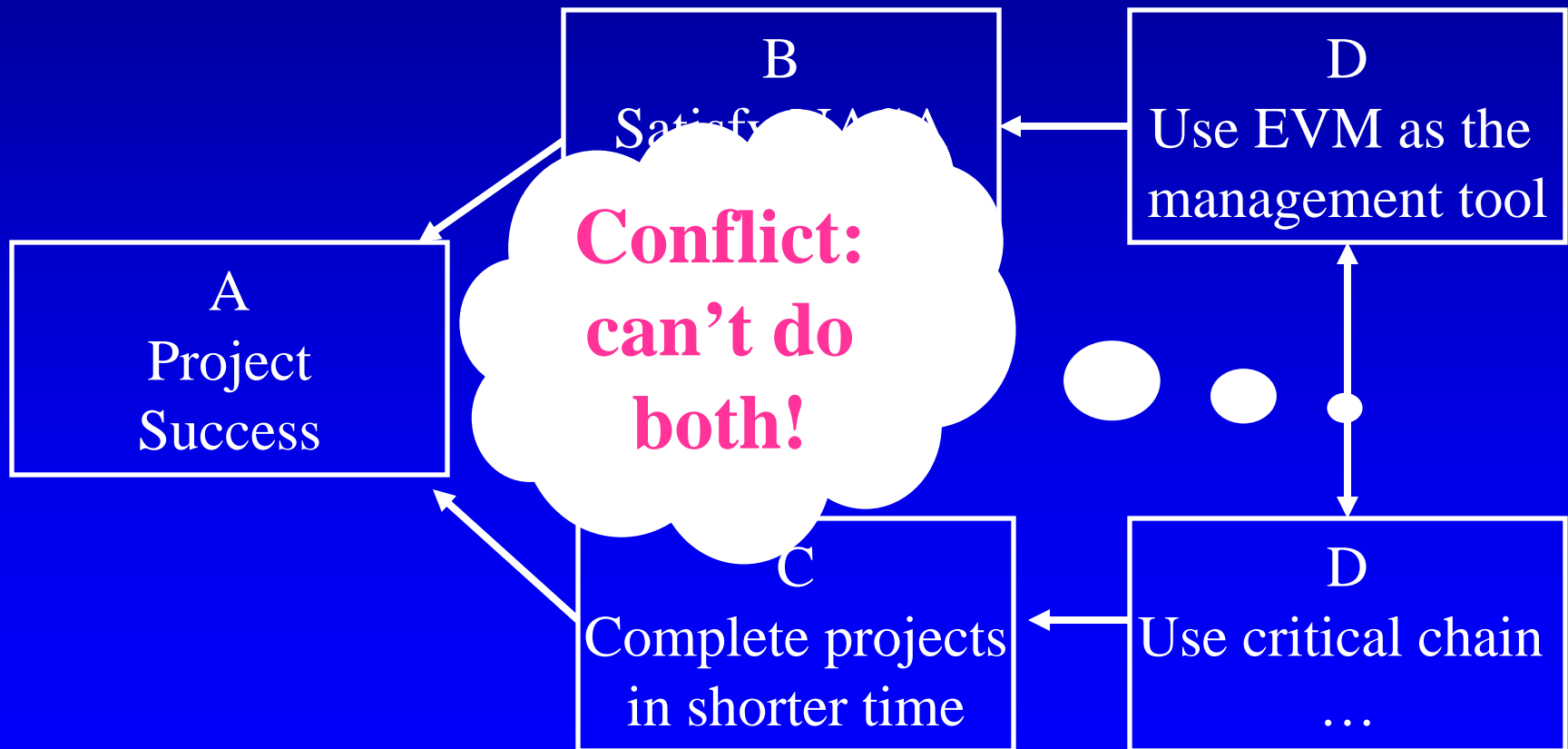
**Change status**

**Remaining duration**

# Critical Chain Fever Charts Tracks Schedule Progress



# What's the problem?



# Why might it appear we can't do both?

## EVM

- Focus on cost.
- Values work based on cost.
- Assumes **incremental value** from a project.
- Integrates cost and schedule.
- Specific requirements to use EV.
- No buffers (small management reserve).

## Critical Chain

- Focus on schedule.
- Prioritizes work based on schedule impact.
- Places **value only on throughput**, usually requires task and project completion.
- No cost elements.
- No requirement to use CCPM.
- Schedule buffers.

# Pros and Cons of EVM

## Pros

- Proven.
- Compelling logic.
- NASA requirement.
- Integrates cost and schedule.
- Easy cost projection (CPI).

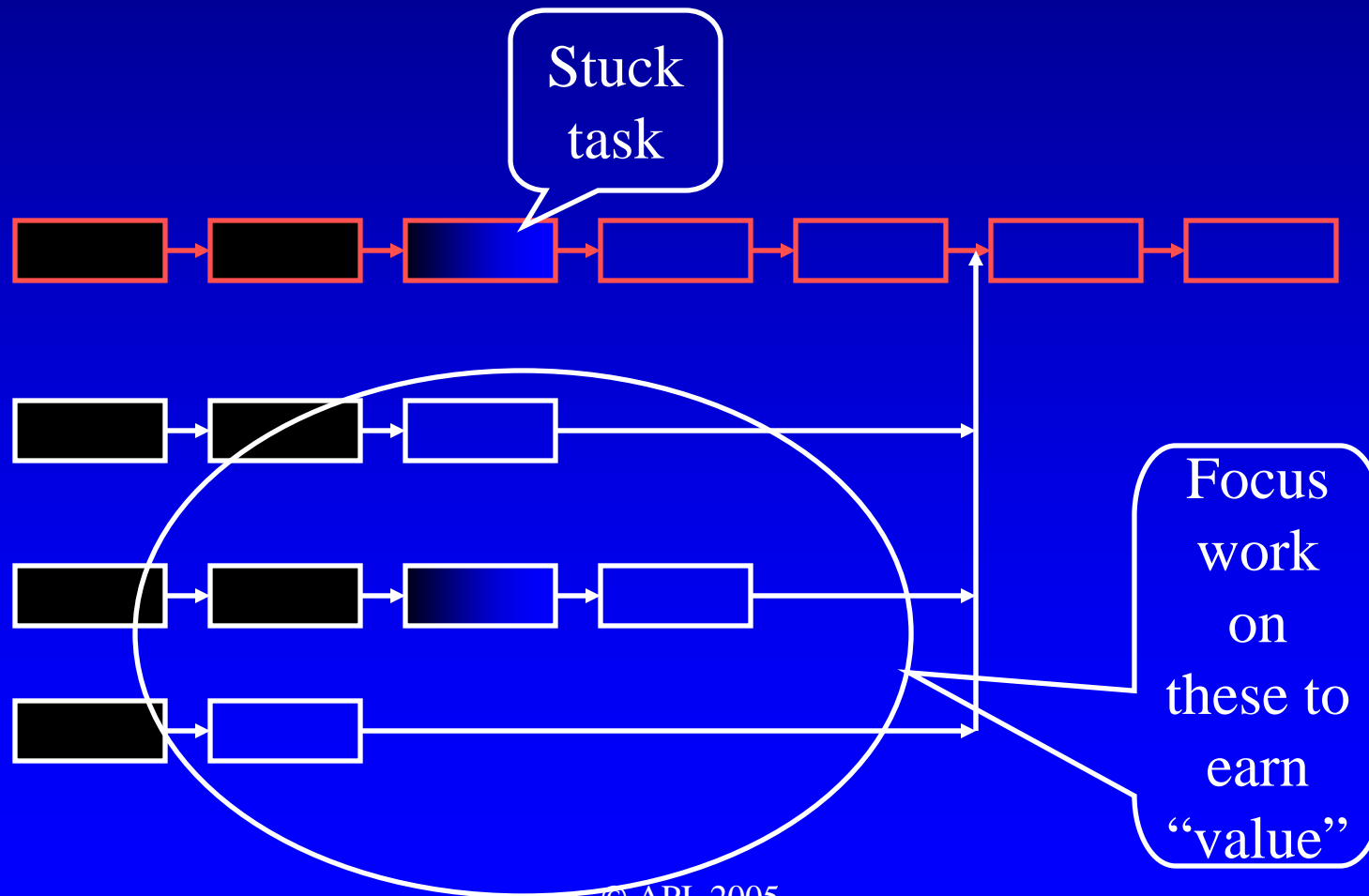
## Cons

- Many large projects that have used EVM have large cost and schedule over-runs.
- Does not address critical path.
- Deterministic.
- Ambiguous on Early Start/Late Finish.
- Implementation can get complex.
- Can drive wrong behavior.
- Schedule variance problems.

# Problems with the *so-called* schedule variance (SV) and schedule performance index (SPI).

- What are the **SV** (BCWP-BCWS) and **SPI** (BCWP/BCWS) when a project completes on schedule?
- What are the **SV** and **SPI** when a project completes in twice the baseline schedule time?

# EVM can drive management to work on the wrong tasks.



# SV and SPI Problems

- Does not address the critical path.
- Weights performance on cost, not on schedule impact.
- Ambiguous if baseline BCWS (PV) should be ES or LF.
  - Actual schedule determined by task finish.

# Pros and Cons of Critical Chain

## Pros

- Simple schedule tracking.
- Track record of accelerating projects.
- Focus on work needed to complete projects.
- Manages variation.

## Cons

- New.
- Not proven in NASA environment.
- Does not address cost.

## Example of CCPM Project Improvement: Pearl Harbor Nuclear Submarine Overhaul

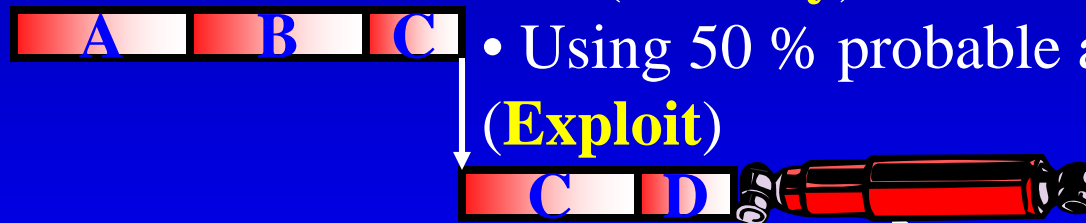
METRIC	BEFORE CCPM	AFTER CCPM	IMPROVEMENT
<b>ON-TIME (Scheduled Availabilities)</b>	40% (8 of 20)	93% (25 of 27)	↑ <b>133%</b>
<b>Average Cost per Job (incl. overtime)</b>	\$6,113	\$4,700	↓ <b>23%</b>
<b>Man-Days</b>	3,741	2,202	↓ <b>41%</b>
<b>Job Completion Rate (same time period)</b>	180 (93%)	220 (99%)	↑ <b>22%</b>
<b>Overtime</b>	28.75%	12.5%	↓ <b>57%</b>
<b>Customer Backlog</b>	110	83	↓ <b>25%</b>

# Critical Chain

Critical chain differs from critical path by:

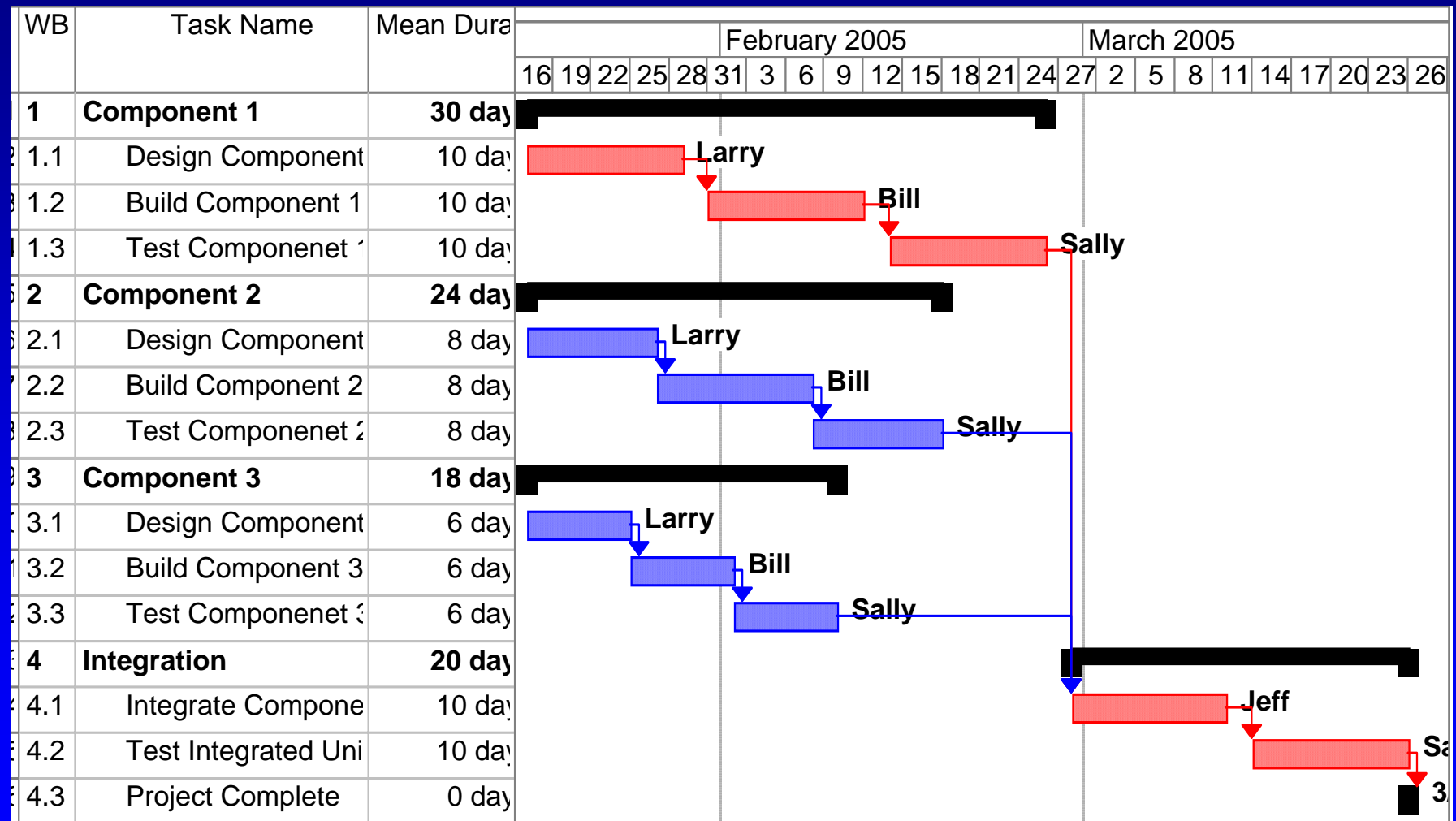
- Resolving resource contentions first (**Identify**)

- Using 50 % probable activity times (**Exploit**)

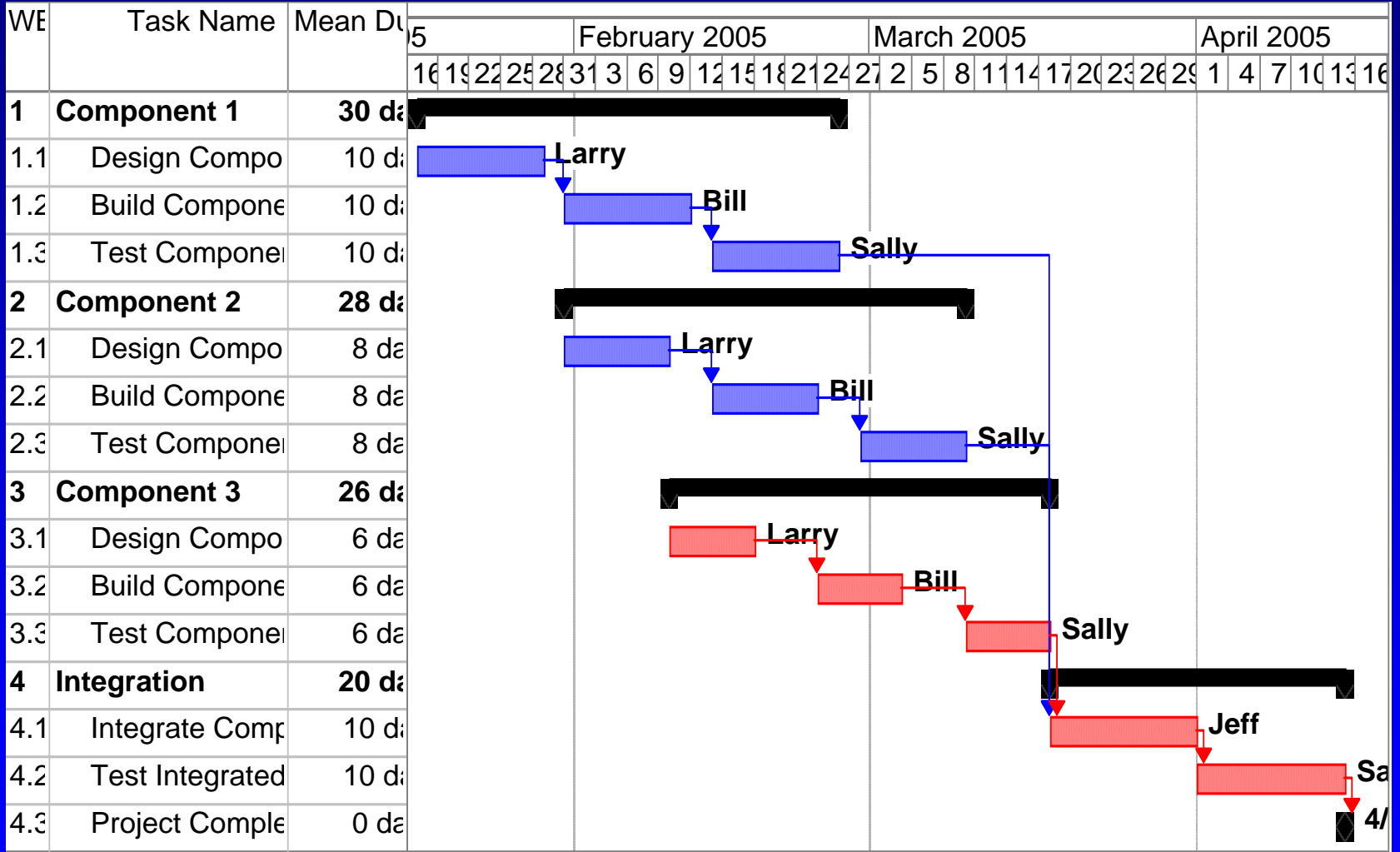


(Smaller) aggregated  
Buffer at end of chain  
(**Exploit**)

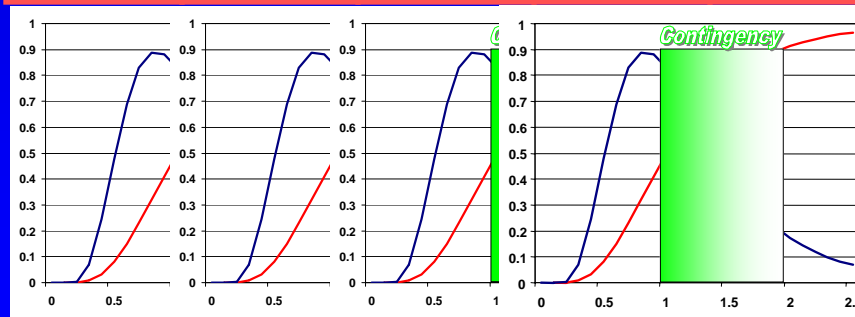
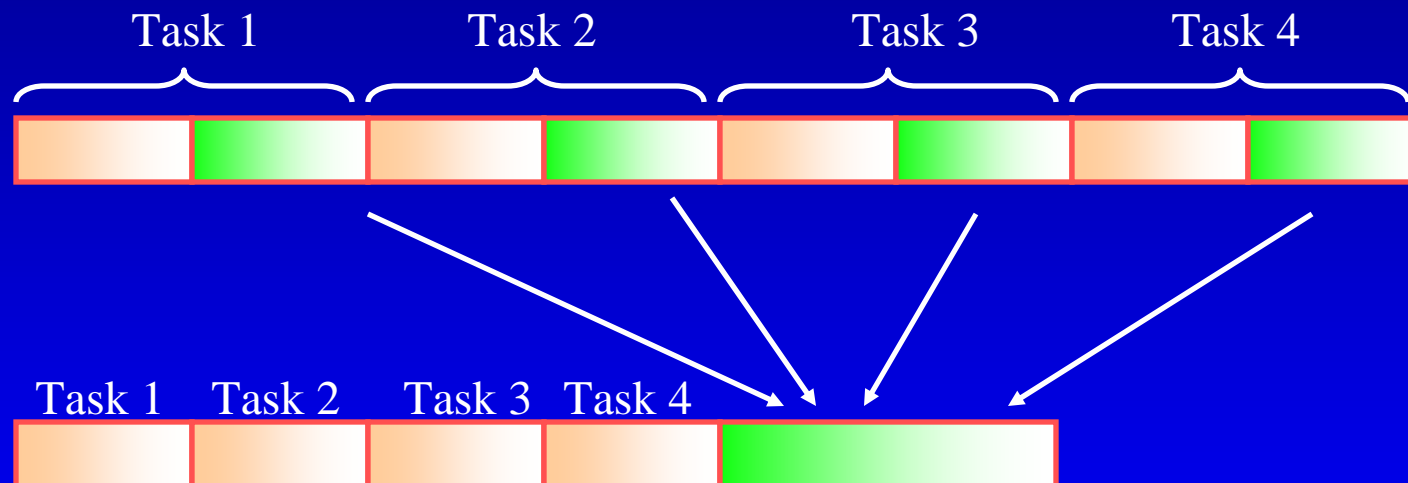
# Identify: Is the critical path the constraint?



# Resource Leveled Critical Path

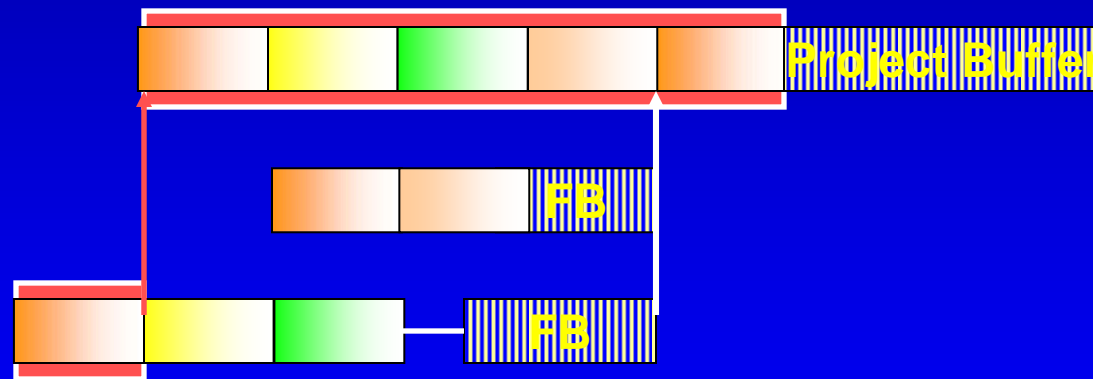


***EXPLOIT*** variation by taking contingency out of each task, and moving it to the end of the chain.

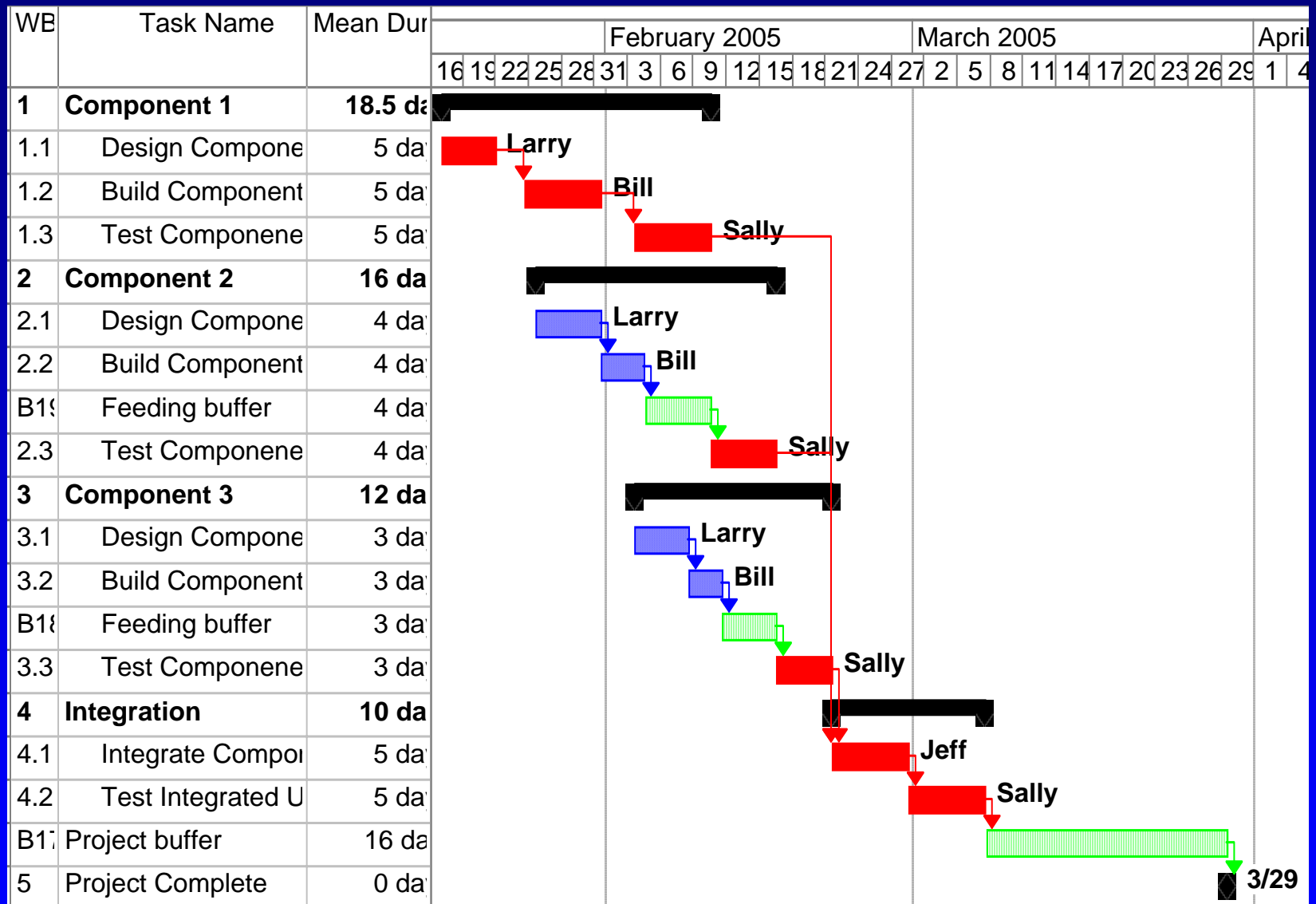


- Combining variances
- Central limit theorem

# Subordinate Merging Paths With 'Feeding Buffers'



## Example project as a CCPM schedule.



# Task Managers Get Clear Priorities And Warning About Upcoming Hot Potatoes

ConcertoWeb Username: ResAdmin Server Name: concerto Change Password Log Out

Sys Admin Data Central Updates **Execution Views** Resource Portal P2P

Portfolio Status | Project Control | P2P Control | Task Level Priorities By: Task Mgr | Resource | Project Help

Task Manager: Sanjeev

Projects: All Projects

Start Date: 2/15/2002 + Days: 30

Task Status  
☒ Not Started  
☒ In Progress  
☐ Completed

Print Preview  
 Export to Excel  
 Advanced Sort

Create Report

Project Name	MSP Task in	Task Description	Task Mgr	Task Status	Resource	Notes	Earliest Arrival	Remaining Duration	% CCCB Pen	% CMSB Pen	% CCFB Pen	Last Update Date	Ready To Start	Comments
1 <a href="#">Pur...</a>	2	<a href="#">F1/High Level/Review/Approve</a>	Sanjeev	IP	Jim		2/15/2002				00	2/15/2002		Customer approval in
2 <a href="#">Cheetah ver 01</a>	27	<a href="#">F2/High Level/Review/Approve</a>	Sanjeev	IP	Mike		2/15/2002	2d	10	17	100	2/15/2002		Document revised for
3 <a href="#">Jaguar 01</a>	29	F2/Data Design	Sanjeev	NS			2/15/2002				00	2/15/2002	Y	
4 <a href="#">Cheetah ver 01</a>	31	F2/Module 1 LL Design	Sanjeev	NS			2/19/2002				00		N	
5 <a href="#">Jaguar 01</a>	27	F2/High Level/Review/Approve	Sanjeev	NS			2/26/2002	5d		59	100	2/3/2002	Y	

Priorities

Current work

Upcoming hot potato

# Multi-project CCPM

# Consider Unloading Ships...

Five ships arrive. Each requires 5 person-days to unload. Each owner wants his ship unloaded ASAP. You have five people to unload the ships. Simple...assign one to each ship.



Starting each one right away (the sooner you start...) each ship is unloaded on the end of the fifth day.

# Now, let's stagger the projects...

Put all five resources on ship 1 the first day, ship 2 the second day, etc. Result:

Ship	New (days)	Old (days)	Saved
1	1	5	4
2	2	5	3
3	3	5	2
4	4	5	1
5	5	5	0

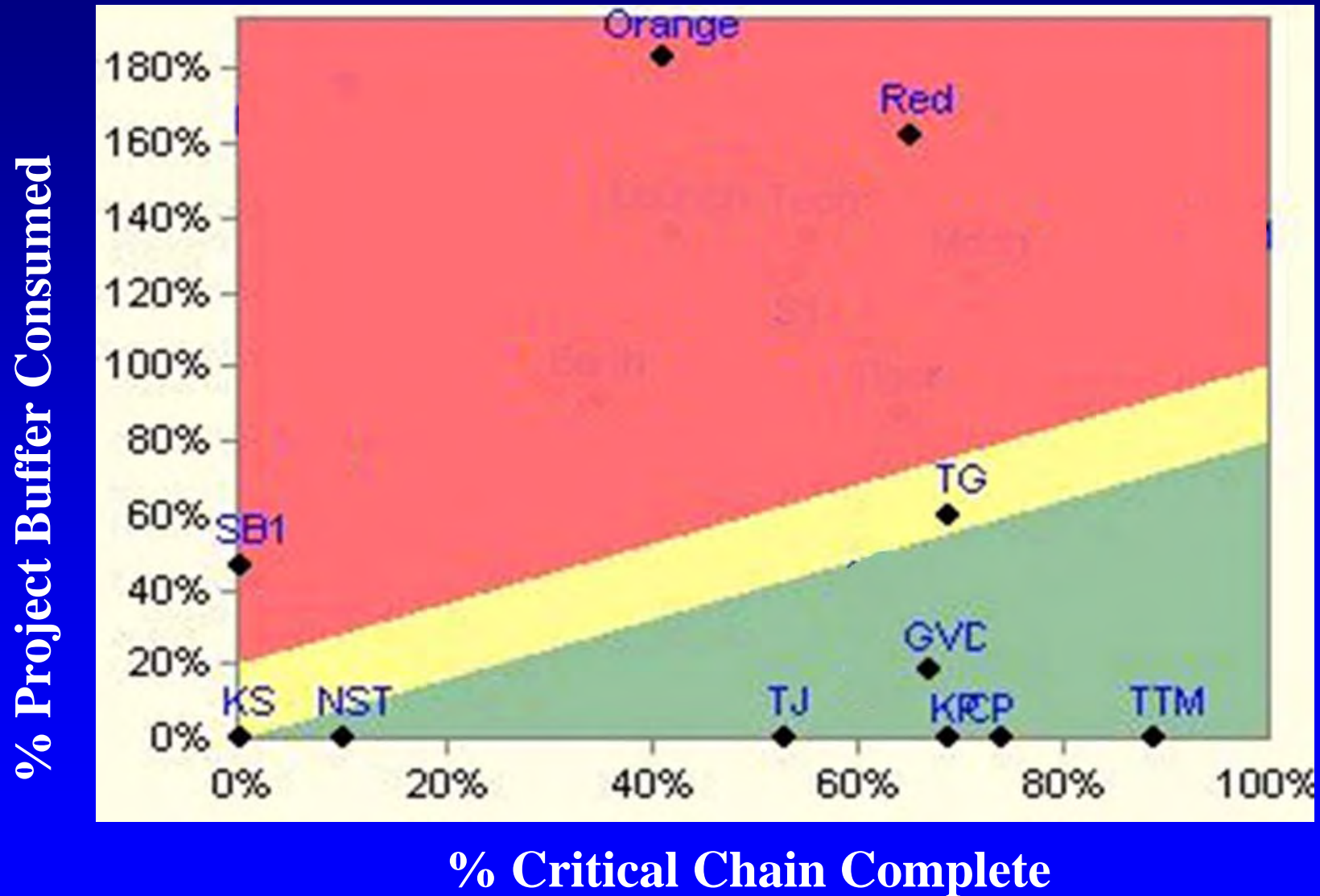
Nobody loses. Four of five clients done sooner.

Cost = \$ 0

# Critical Chain Multi-project 'Pulls' Projects

- **IDENTIFY:** Multi-project resource constraint
- **EXPLOIT:** Prioritize projects (Drum)
- **SUBORDINATE:** Delay some project starts *to complete all projects sooner.*

# Schedule Buffer Fever Chart



# When are you going to be done?

#	Project	Due Date	Buffer Penetration (%)	Estimated Completion Date
12	Orange	2/15/05	185	4/15/05
7	Red	6/10/05	160	10/10/05
23	TTM	4/15/05	0	3/12/05
13	CP	7/15/05	0	5/15/05

# Project Teams Get Information on Where to Focus

Project Chain View - Microsoft Internet Explorer provided by AT&T WorldNet Service

Project Chain View

Project Manager: Matti Herzberg

Project: [Puma Ver 01](#)

Start Date: 2/15/2002 + Days: 30

Task Status  
☒ Not Started  
☒ In Progress  
☐ Completed

Print Preview  
 Export to Excel  
 Advanced Search

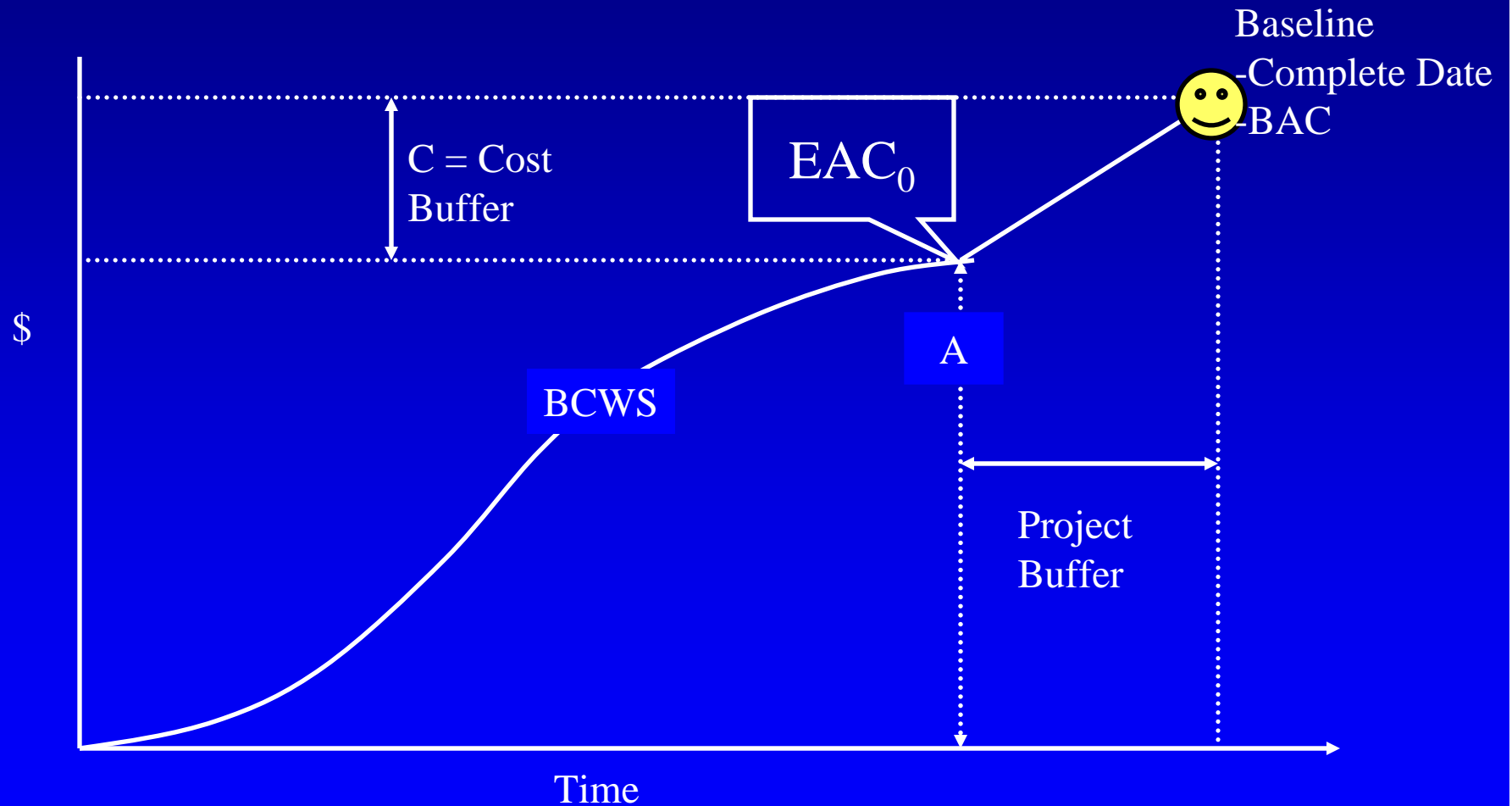
Create Report

Focus here to recover

T/T	MSP Task ID	Task Desc	Task Mgr	Task Status	Resource Notes	Earliest Arrival	Remaining Duration	% PB Pen	% MB Pen	% FB Pen	Last Update Date	Comments
1	3	F1/High Level/Review/Approve	Sanjeev	IP	Jim	2/15/2002	10d	27	41	44	2/15/2002	Customer approval in
2	8	F1/Module 2 LL Design	Sridhar	NS		3/1/2002	10d	27	41	44		
3	39	F2/Module 3 LL Design	Sridhar	NS		3/15/2002	20d	27	41	44		
4	11	F1/Module 3 LL Design	Sridhar	NS	Celia,Don	3/1/2002	12d	23	35	33		
5	27	F2/High Level/Review/Approve	Mutu	IP	Shai	2/15/2002	5d	15	24	0	2/15/2002	Shai started today
6	29	F2/Data Design	Mutu	IP	Brandon	2/15/2002	10d	12	19	0	2/15/2002	
7	19	F1/Design Test Plan	Daryl	NS		2/15/2002	10d	12	19	0		
8	5	F1/Module 1 LL Design	Sridhar	NS		3/1/2002	15d	12	19	0		
9	4	F1/Data Design	Mutu	NS		3/1/2002	15d	12	19	0		
10	45	F2/Design Test Plan	Daryl	NS		2/15/2002	10d	3	6	0		
11	53	Phase 1 Hardware Design	Shai	IP	Susan	2/15/2002	2d	1	4	41	2/15/2002	
12	54	Phase 1 Hardware Development	Mark	IP	Shai	2/19/2002	1d	1	4	41	2/15/2002	
13	55	Phase 1 Components Fabrication	Guy	NS		2/20/2002	8d	1	4	41	11/3/2001	
14	58	Phase 1 Assembly	Guy	NS		3/4/2002	2d	1	4	41	2/16/2002	
15	59	Phase 1 Test	Paul	NS		3/6/2002	10d	1	4	41		
16	57	Phase 1 Test Development	Paul	NS		2/20/2002	8d	0	2	37		
17	47	F2/Design Test Documentaion	Darcia	NS		3/1/2002	7d	0	2	0		
18	46	F2/Design Test Scrip	Daryl	NS		3/1/2002	5d	0	0	0		

Local intranet

# Critical Chain and Earned Value Can Work Together

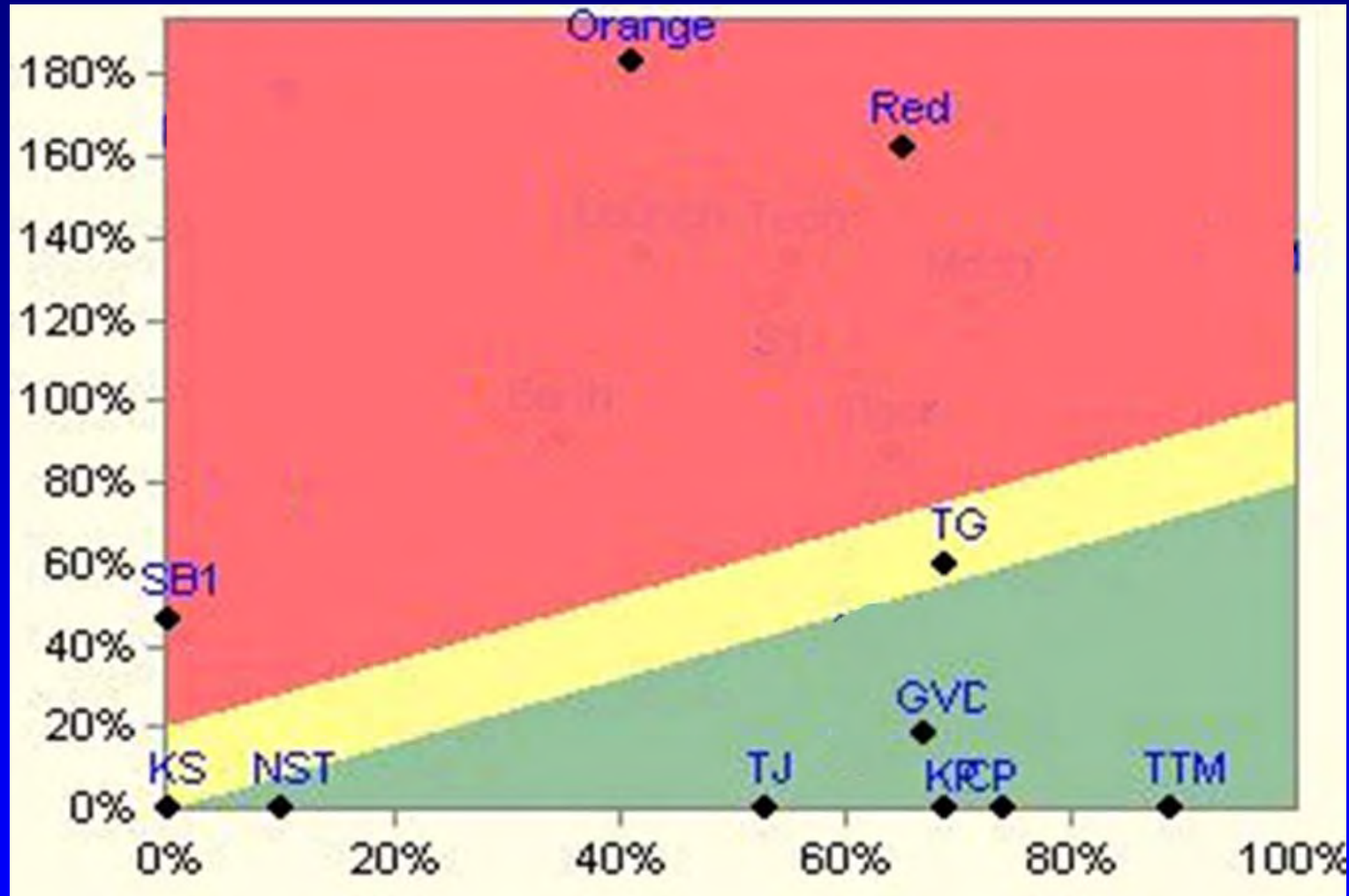


# Cost Buffer

- Use mean cost estimates for tasks.
- Size cost buffer using uncertainty analysis, e.g.
  - Bias plus SSQ
  - PERT
  - Monte Carlo
- Cost buffer penetration:
  - **Cost Variance (CV)**
  - $\% = 100 * CV / (\text{Cost Buffer})$
- Projected total cost =  $EAC_0 / CPI$

# Cost Buffer Fever Chart

**% Cost Buffer =  $100 * CV / \text{Buffer}$**



**% Work Complete =  $BCWP / (BAC - \text{Buffer})$**

# How much is it going to cost?

#	Project	BAC With Buffer	Buffer Penetration (%)	Work Complete (%)	EAC*
12	Orange	\$250K	185	45	\$456K
7	Red	\$3,560K	160	65	\$5,313K
3	GVC	\$3,125K	20	67	\$2,687
13	KP	\$1,200	0	69	\$960K

\* Assumes 25% cost buffer.

# Calculating Estimate at Completion (EAC)

This method uses the same approach (and therefore assumptions) as dividing the budget by the CPI.

$EAC_0$  = Initial Mean Estimate for All Tasks

$b$  = Cost buffer as fraction of  $EAC_0$

$P$  = Cost buffer penetration, as fraction

$P = CV/Buffer = CV/(p * EAC_0)$

$W$  = Work complete as a fraction =  $EV/EAC_0$

$BAC = EAC_0 * (1+b)$

**$EAC = BAC * (1+b(P/W))/(1+b)$**

# Management Action to Buffers

		Cost Buffer	
		Red	Green
Schedule Buffer	Red	Implement no-cost or low-cost schedule acceleration and cost saving that will not affect schedule, assess additional acceleration vs. project Throughput value.	Implement schedule acceleration, including actions that increase cost.
	Green	Implement cost savings that make sense relative to project Throughput value.	Take no control action.

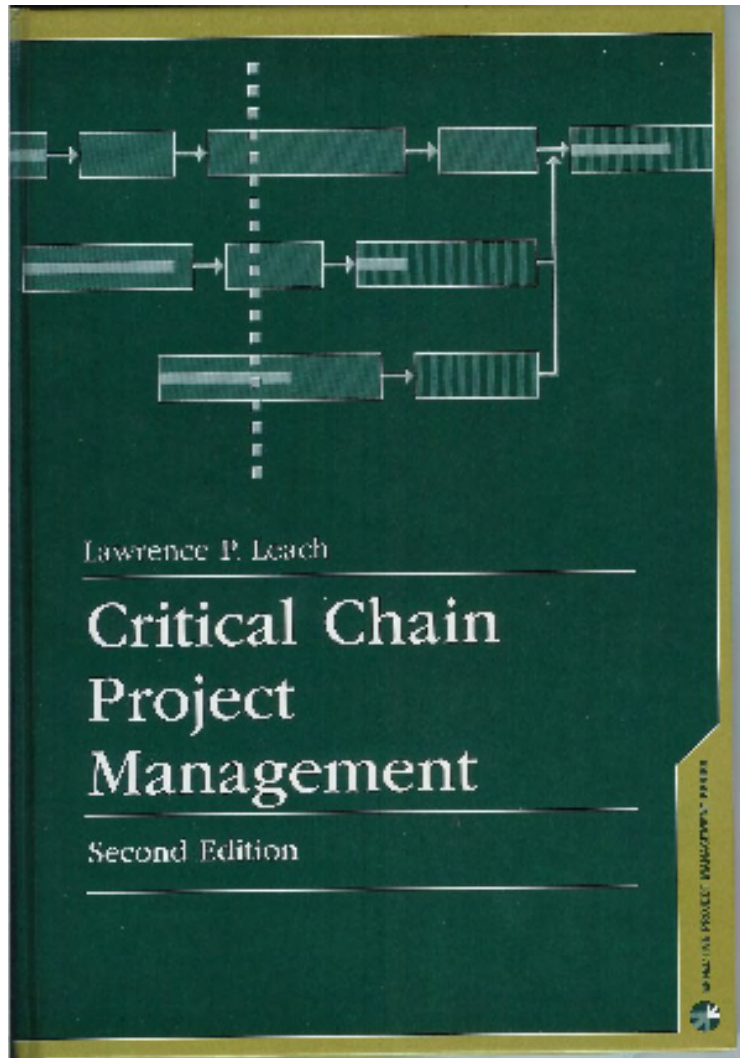
# Uncertainty Management

Type	Example	Management Method
<b>Variation</b> (Also known as common-cause variation)	All causes of variation within the output of processes in statistical control (most conventional project tasks).	Buffers and action thresholds (e.g. control charts).
<b>Environmental Uncertainty</b> (Also known as special-cause variation)	Natural events, new regulations, external-driven changes in project requirements, accidents.	Deterministic project risk management: Identify, Quantify, Monitor, Prevent and Mitigate.
<b>Design Uncertainty</b>	Assumptions in initial plans, R&D findings, new theories, or discoveries.	Progressive elaboration. Robust decision making. Project baseline changes.

## Combining EV and CCPM Measures Enables More Effective Project Control

- Buffers enable realistic planning for schedule and cost variation.
- Schedule buffer improves schedule control:
  - Simplified status (remaining duration).
  - Focus on schedule critical tasks.
  - Correct trends.
  - Forward looking.
  - Action oriented (fever chart).
- Cost buffer improves cost control:
  - Uses EV measurements.
  - Action oriented (fever chart).

# For Further Information



Leach, Lawrence P.

*Critical Chain Project Management,  
Second Edition*

Artech House, Boston, 2004

Available from Artech House,  
Amazon.com, and other major online  
book sellers.

[Lawrence\\_leach@hotmail.com](mailto:Lawrence_leach@hotmail.com)

Tel: 208-345-1136