The Case for Contingency Reserve

L-3 STRATIS

MANAGEMENT SOLUTIONS OFFICE

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A Target, but no Confidence Level

COST PERFORMANCE REPORT
FORMAT 1 - WORK BREAKDOWN STRUCTURE

DOLLARS IN Thousands

Page 1 of 3

1. CONTRACTOR	2. CONTRACT		3. PROGRAM	4. REPORT PERIOD
a. NAME US LHC Accelerator Project Office	a. NAME US LHC		a. NAME US LHC Accelerator Project	a. FROM *(YYMMDD)* 990201
b. LOCATION *(Address and ZIP Code)* P.O. Box 500 MS 343 Batavia, IL 60510	b. NUMBER 1			b. TO *(YYMMDD)* 990228
	c. TYPE FPI	d. SHARE RATIO 100/0 100/0	b. PHASE *(X one)* x RDT&E x PRODUCTION	

5. CONTRACT DATA

a. QUANTITY	b. NEGOTIATED COST	c. EST. COST AUTH UNPRICED WORK	d. TARGET PROFIT/ FEE	e. TARGET PRICE	f. ESTIMATED PRICE	g. CONTRACT CEILING	h. ESTIMATED CONTRACT CEILING
0/0/0	89,417.8	0.0	0.0 / 0.0%	89,417.8	89,417.8	110,000.0	110,000.0

6. ESTIMATED COST AT COMPLETION

	MANAGEMENT ESTIMATE AT COMPLETION (1)	CONTRACT BUDGET BASE (2)	VARIANCE (3)
a. BEST CASE	89,417.8		
b. WORST CASE	89,417.8		
c. MOST LIKELY	89,417.8	89,417.8	0.0

7. AUTHORIZED CONTRACTOR REPRESENTATIVE

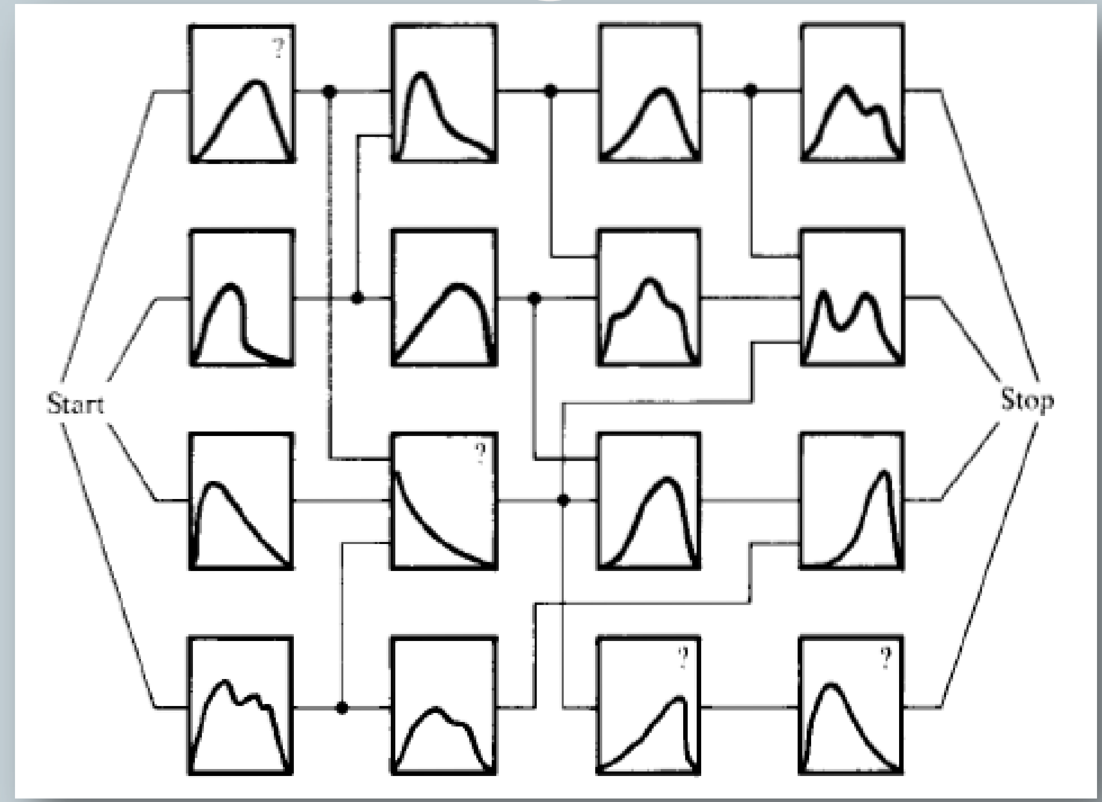
a. NAME *(Last, First, Middle Initial)*	b. TITLE
Jim Strait	US LHC Project Manager
c. SIGNATURE	d. DATE SIGNED *(YYMMDD)* 990323

8. PERFORMANCE DATA

ITEM		CURRENT PERIOD					CUMULATIVE TO DATE					REPROGRAMMING ADJUSTMENTS		AT COMPLETION		
		BUDGETED COST		ACTUAL	VARIANCE		BUDGETED COST		ACTUAL	VARIANCE						
		WORK SCHEDULED	WORK PERFORMED	COST WORK PERFORMED	SCHEDULE	COST	WORK SCHEDULED	WORK PERFORMED	COST WORK PERFORMED	SCHEDULE	COST	COST VARIANCE	BUDGET	BUDGETED	ESTIMATED	VARIANCE
(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
a. WORK BREAKDOWN STRUCTURE ELEMENT																
1.1 - Interaction Regions	2	621.5	307.8	664.0	-313.7	-356.2	11,283.0	8,792.9	10,064.7	-2,490.1	-1,271.8			35,919.7	34,701.4	1,218.3
1.1.1 - Quadrupoles	3	439.5	228.5	535.2	-211.0	-306.7	7,983.0	6,777.6	7,761.3	-1,205.4	-983.7			21,904.7	21,682.9	221.8
1.1.1.1 - Tooling	4	109.6	21.3	36.3	-88.2	-15.0	1,070.8	917.8	1,018.4	-153.1	-100.6			1,606.4	1,554.0	52.4
1.1.1.2 - Cold Mass	4	17.3	21.8	240.4	4.5	-218.6	1,436.1	1,380.4	2,431.0	-55.8	-1,050.6			4,056.2	5,051.1	-994.9
1.1.1.3 - Cryostat	4	3.8	0.0	6.1	-3.8	-6.1	123.8	105.9	486.7	-17.9	-380.9			3,298.4	3,661.3	-362.9
1.1.1.4 - Magnet Testing	4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]

Sources of uncertainty in the project baseline…

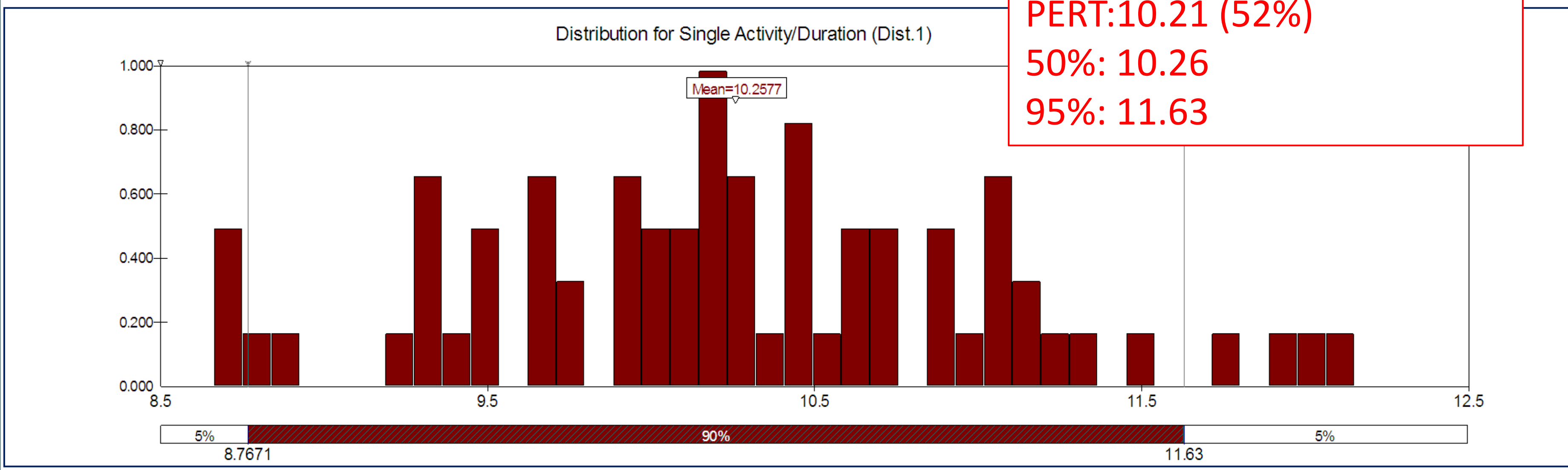
Activity Durations are Uncertain



The underlying statistics of each task and their arrangement in a schedule network define the probability of the project completing by a given date. The probabilities are not additive and must be simulated.

Uncertainty – Single Activity

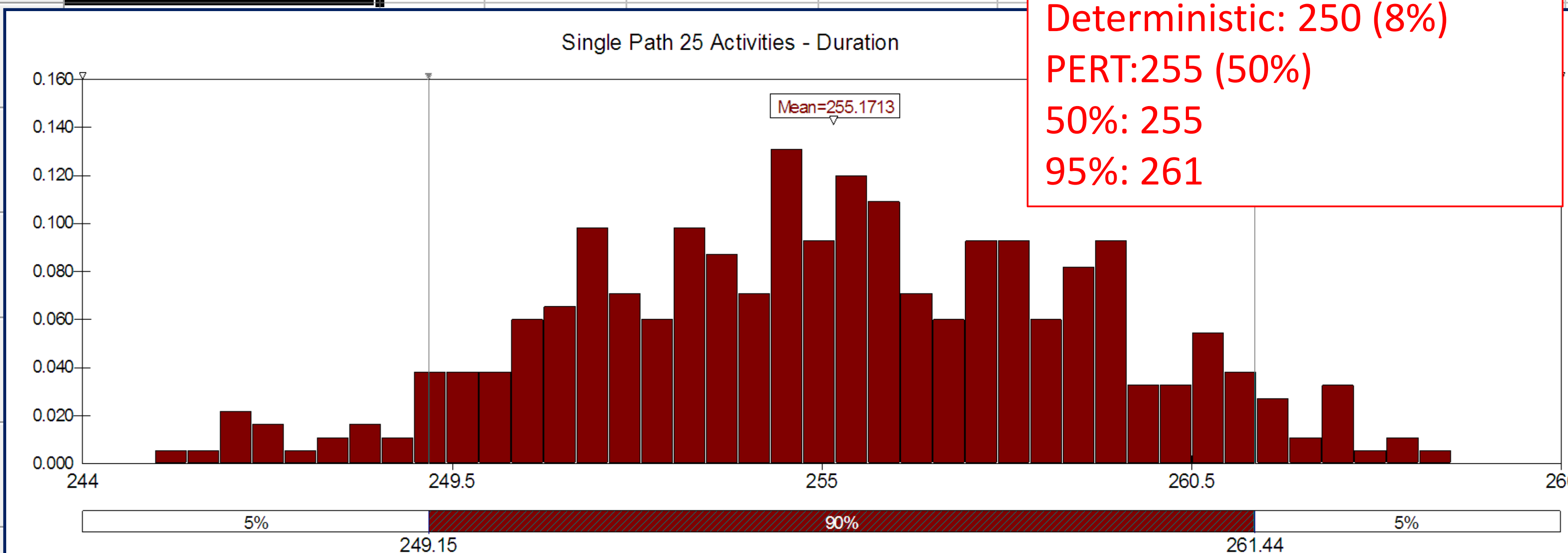
	Name	Work	Duration	Start	Finish	Uncertainty	Min Duration	Most likely Duration	Max Duration	PERT
1	Single Activity	80 hrs	10 days	5/30/12	6/12/12	High	8.33	10	12.92	10.21



Deterministic: 10 (38%)
PERT:10.21 (52%)
50%: 10.26
95%: 11.63

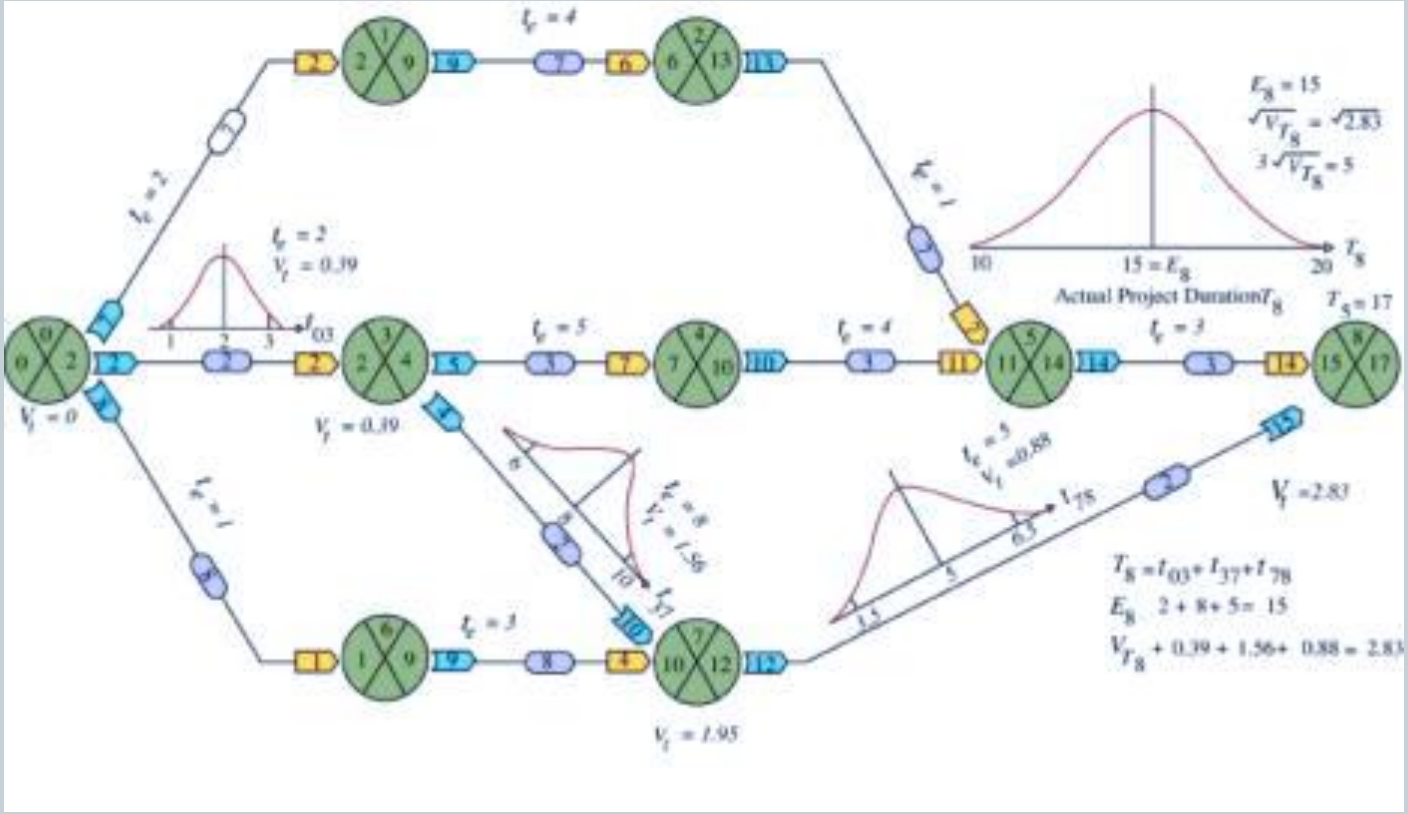
Uncertainty – Single Path

	Name	Work	Duration	Start	Finish	Uncertainty	Min Duration	Most likely Duration	Max Duration	PE
1	**Single Chain 25 Activities**	**########**	**250 days**	**5/30/12**	**5/14/13**					**25**
2	Activity 1	80 hrs	10 days	5/30/12	6/12/12	High	8.33	10	12.92	10
9	Activity 8	80 hrs	10 days	9/5/12	9/18/12	High	8.33	10	12.92	10



Deterministic: 250 (8%)
PERT:255 (50%)
50%: 255
95%: 261

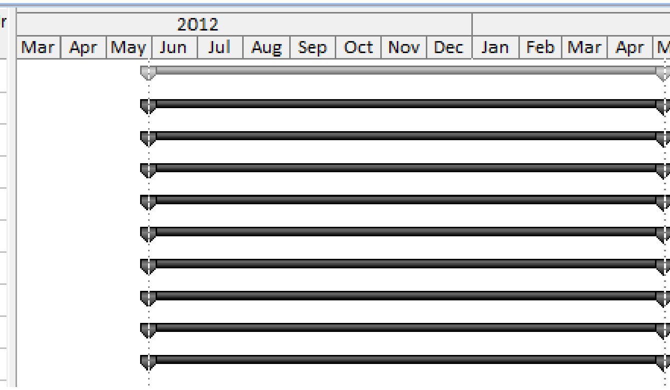
Merge Path Bias adds Uncertainty

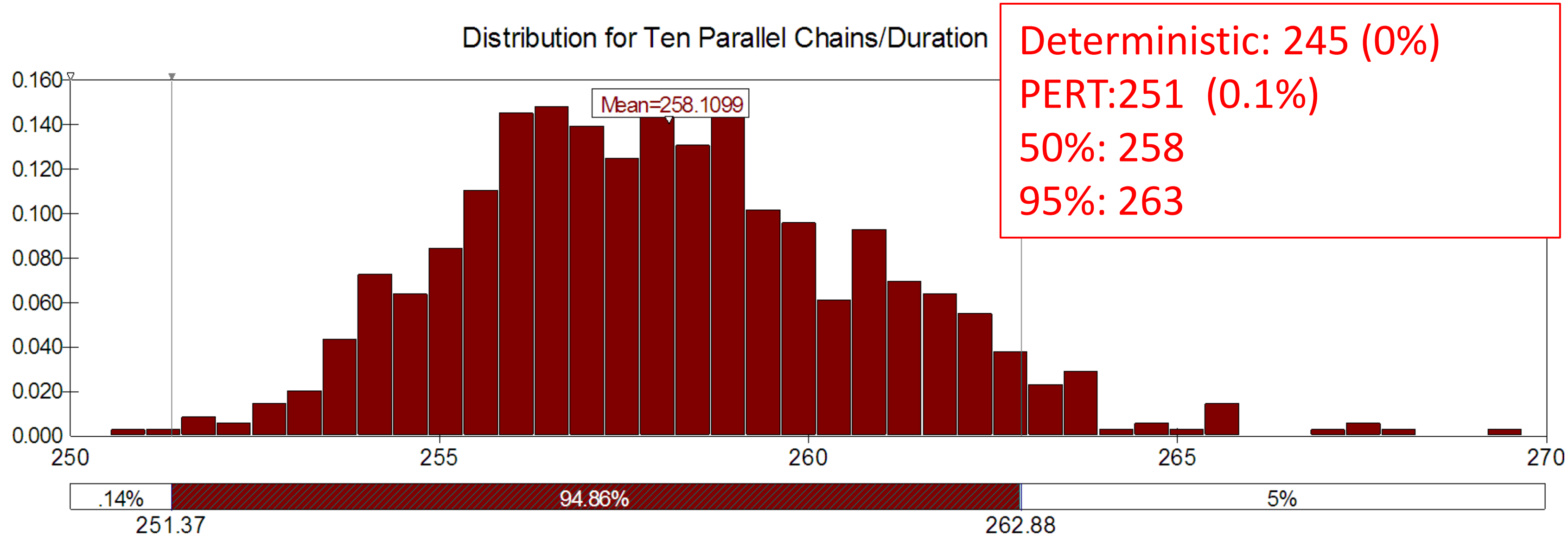


Most projects have parallel paths. “Merge Bias” creates extra risks at the points where these paths converge, extending the project completion date.

Uncertainty – Merging Paths

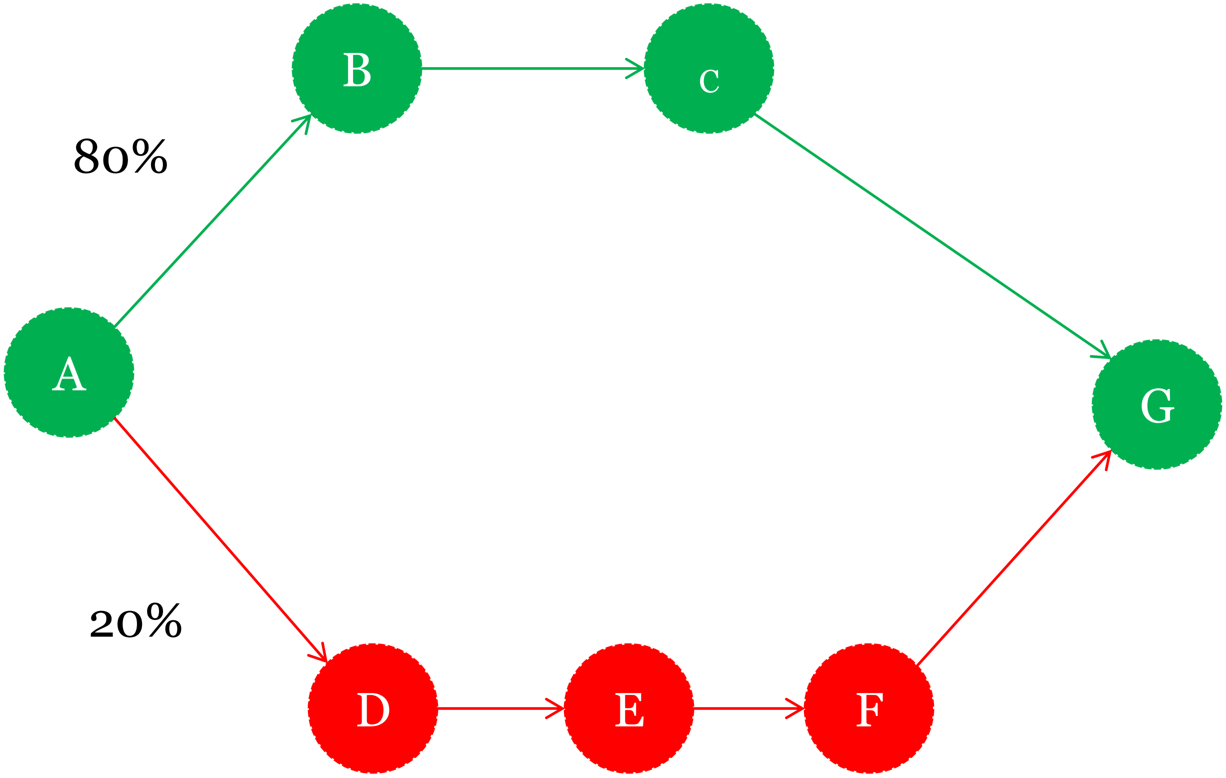
	Name	Work	Duration	Start	Finish	PERT	Ur
0	**Ten Parallel Chains**	**19,632 hrs**	**245.4 days**	**5/30/12**	**5/8/13**	**250.61**	
1	Chain 1 - 25 Activities	1,963.2 hrs	245.4 days	5/30/12	5/8/13	250.61	
27	Chain 2 - 25 Activities	1,963.2 hrs	245.4 days	5/30/12	5/8/13	250.61	
53	Chain 3 - 25 Activities	1,963.2 hrs	245.4 days	5/30/12	5/8/13	250.61	
79	Chain 4 - 25 Activities	1,963.2 hrs	245.4 days	5/30/12	5/8/13	250.61	
105	Chain 5 - 25 Activities	1,963.2 hrs	245.4 days	5/30/12	5/8/13	250.61	
131	Chain 6 - 25 Activities	1,963.2 hrs	245.4 days	5/30/12	5/8/13	250.61	
157	Chain 7 - 25 Activities	1,963.2 hrs	245.4 days	5/30/12	5/8/13	250.61	
183	Chain 8 - 25 Activities	1,963.2 hrs	245.4 days	5/30/12	5/8/13	250.61	
209	Chain 9 - 25 Activities	1,963.2 hrs	245.4 days	5/30/12	5/8/13	250.61	



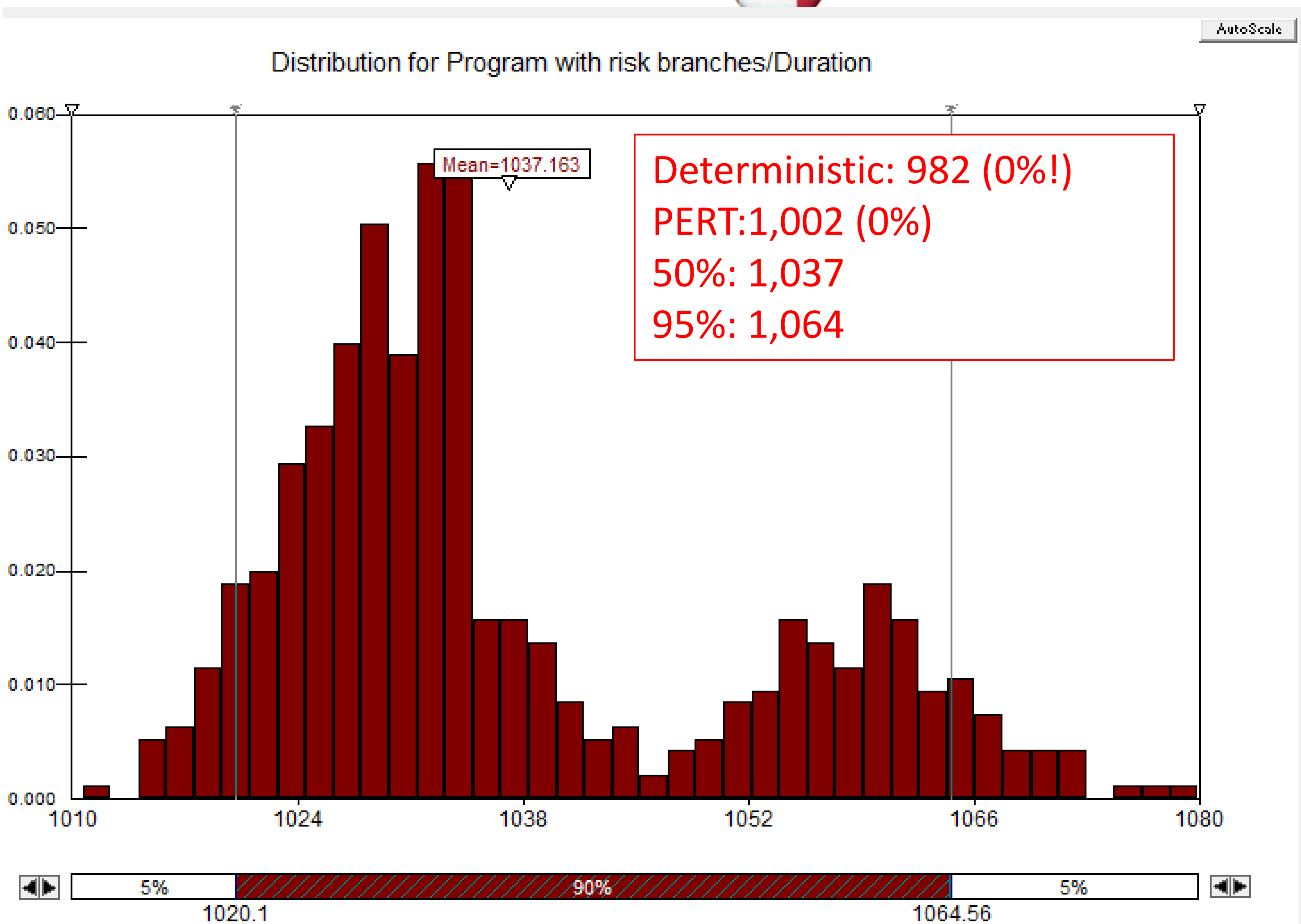


Deterministic: 245 (0%)
PERT:251 (0.1%)
50%: 258
95%: 263

Risks add More Uncertainty



Uncertainty - Program with Risks



Name	Program with
	Task 0
Minimum	1010.67
Mean	1037.163
Maximum	1079.87
Std Dev	14.54105
Variance	211.4421
Skewness	0.8514701
Kurtosis	2.630817
Mode	1031.26
Left X	1020.1
Left P	5%
Right X	1064.56
Right P	95%
Diff. X	44.46008
Diff. P	90%
5th Perc.	1020.1
95th Perc.	1064.56
#Errors	0
Filter Min	
Filter Max	
#Filtered	0

Critical Path? What Critical Path?

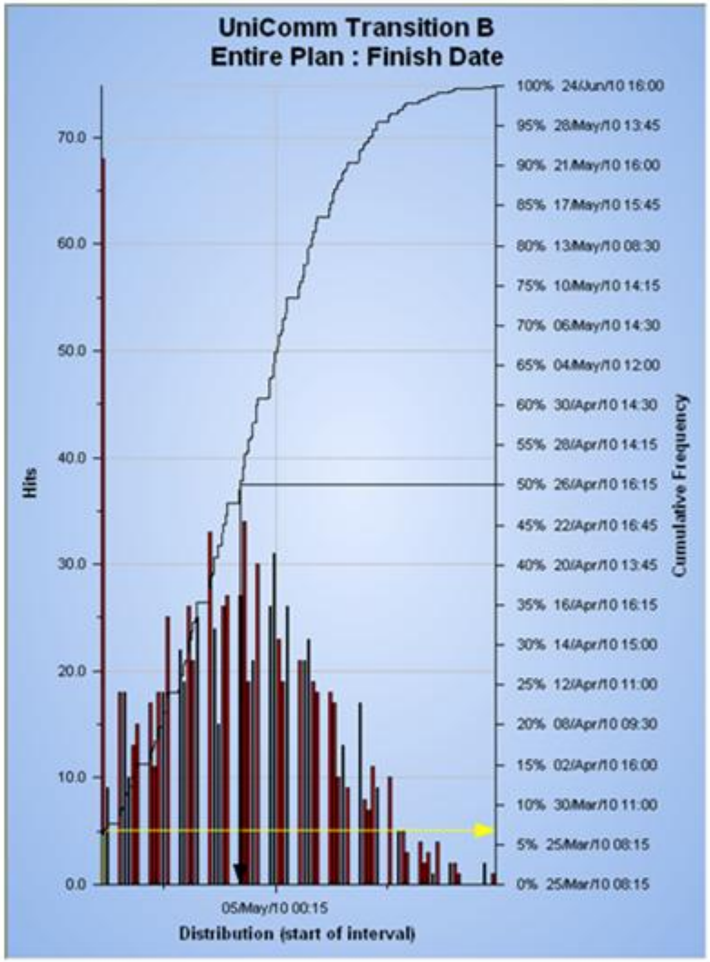
- The critical path is not static, it changes constantly
- It is highly dependent on the stochastic behaviors of the task completion times that emerge from the underlying probability distributions
- It is also dependent on the dynamics of the interactions of the network nodes

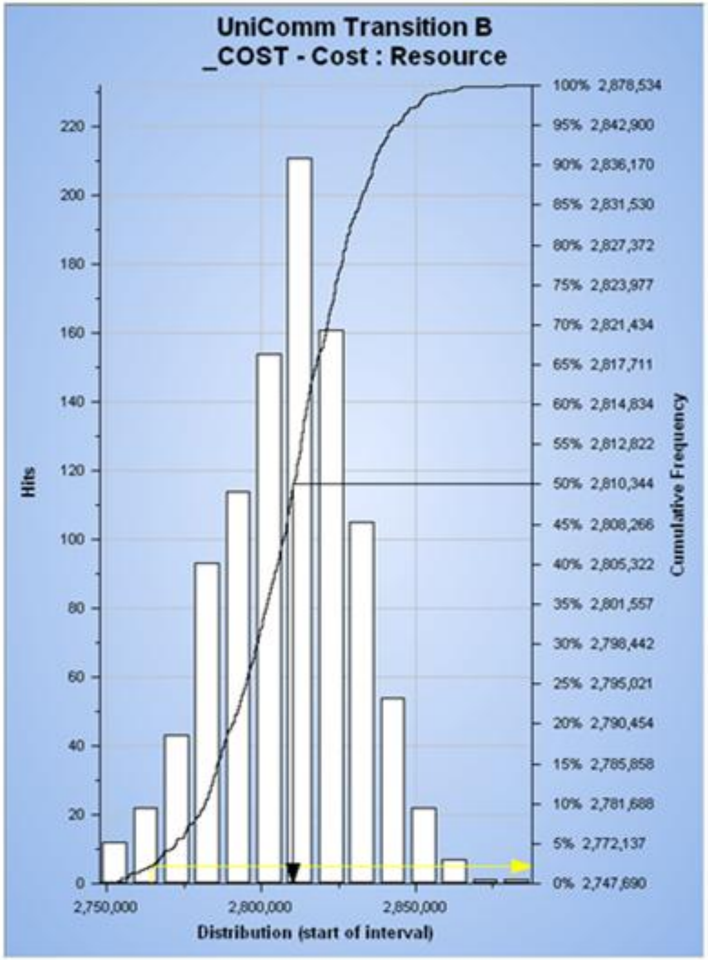
Critical path is frequently meaningless at the program/contract level. Monte Carlo simulations provide a much more useful view of the likely duration and remaining uncertainty.

Establishing Cost and Schedule Buffers

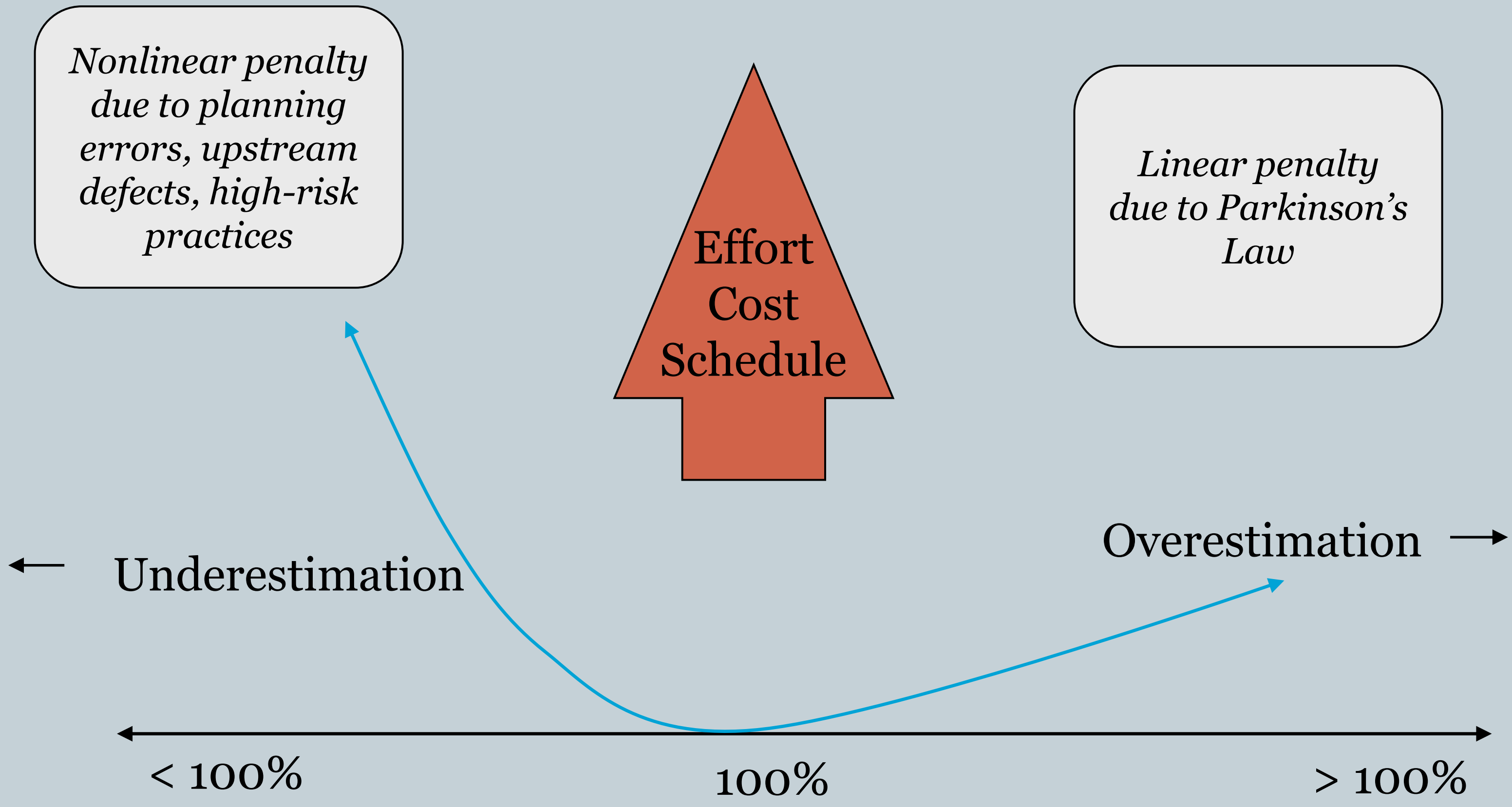
BUFFERS PROTECT THE PROJECT COST AND SCHEDULE TARGETS.

Monte Carlo Simulations Establish Confidence Levels

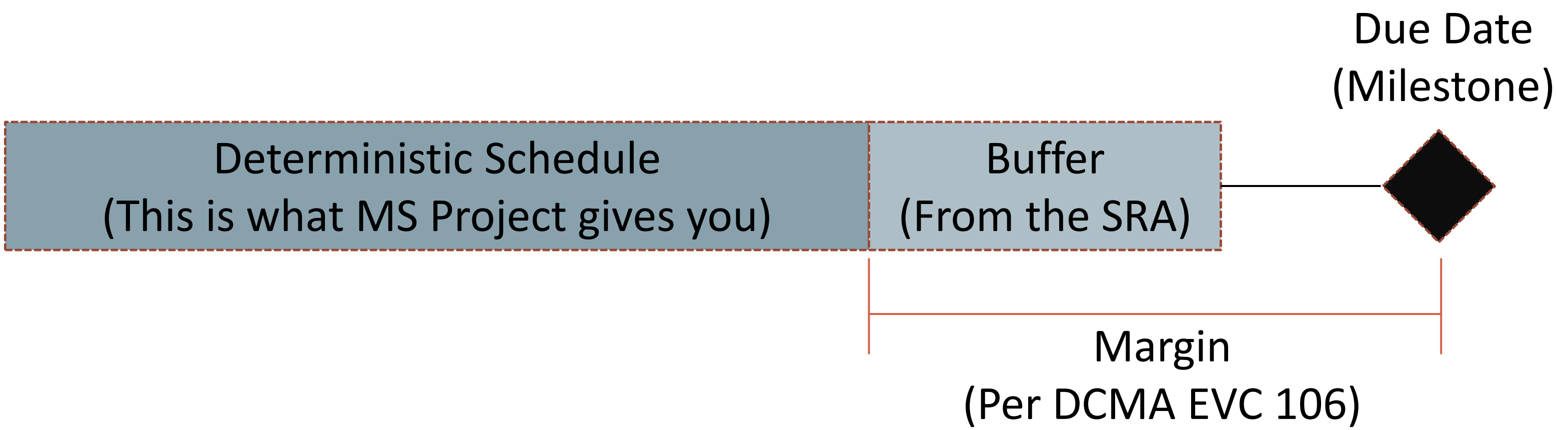




Poor Estimates Lead to Poor Results

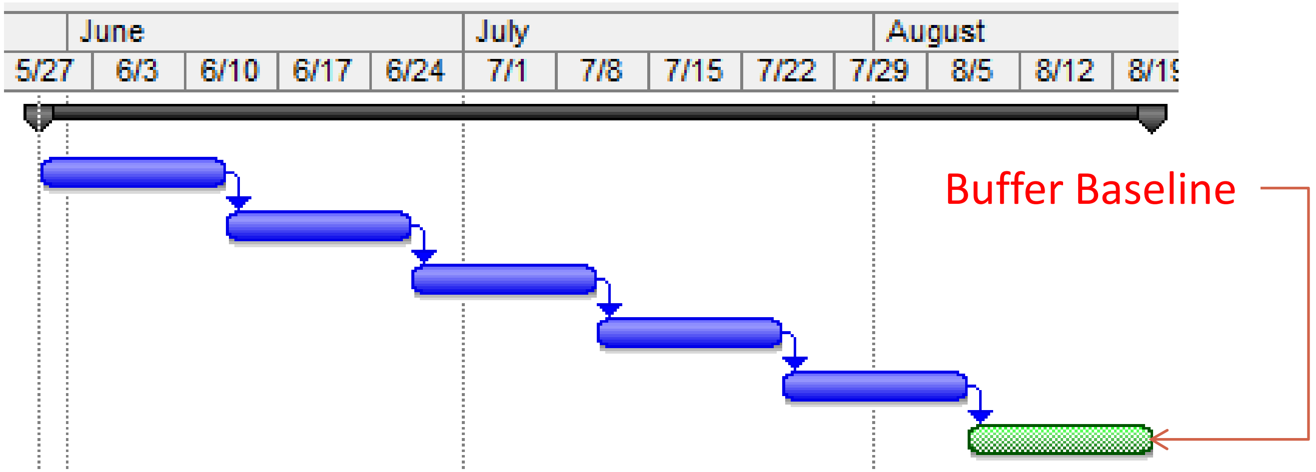


Review of Schedule Terms



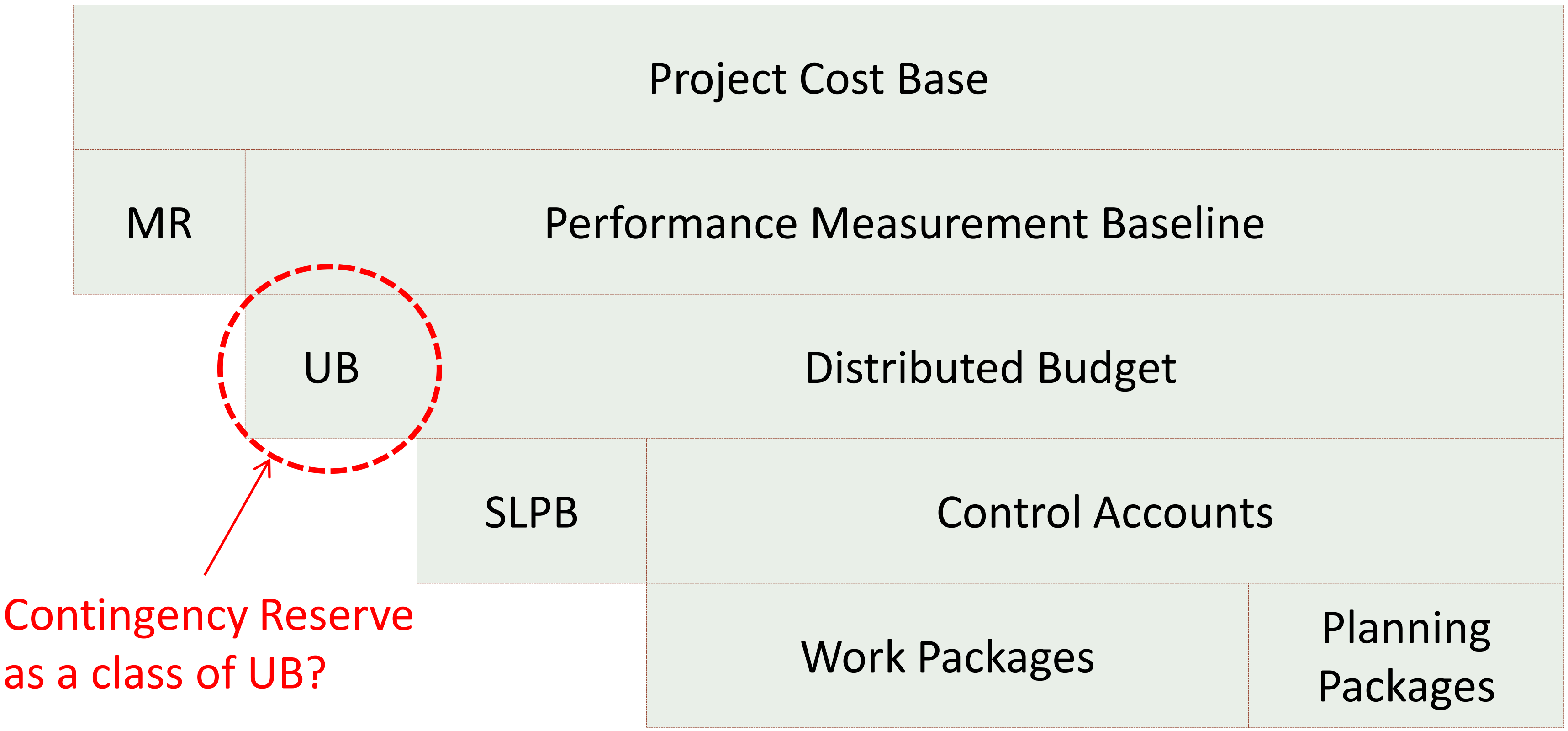
1. Schedule Margin is the difference between our deterministic schedule date and the customer due date (aka No Later Then date).
2. Schedule Buffer is the amount of additional time required to achieve a given confidence level. **<u>Schedule Buffer can only be determined through simulation</u>**, most commonly by Monte Carlo analysis.

Determining Buffer in the Schedule



The blue activities are in the deterministic schedule. Simulation modeling shows that there is zero chance of accomplishing the project within this time period. The green buffer is added to increase likelihood of success to an acceptable confidence level, such as 90%. Note that the size of the buffer can only be determined through simulation modeling; it cannot be calculated directly!

Contingency Reserve in the Budget



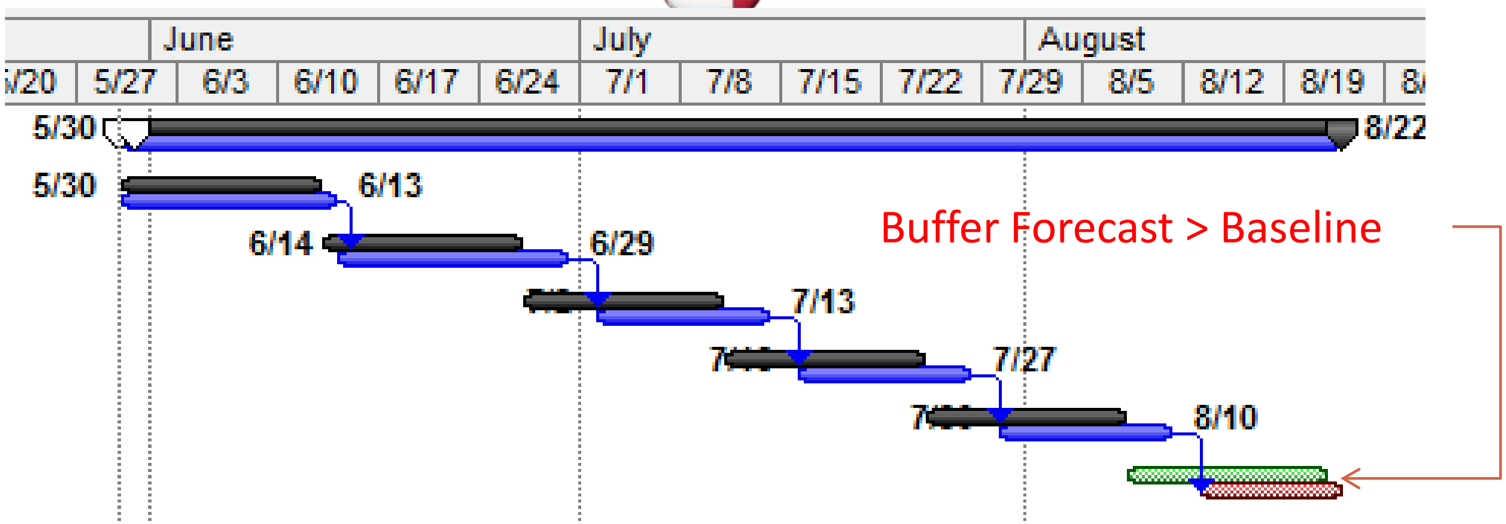
MR = Management Reserve; UB = Undistributed Budget; SLPP = Summary Level Planning Packages

Cost and schedule buffers represent the difference between the base point estimate and the estimate required to achieve the desired confidence level. They cannot be allocated to individual baseline elements because they represent the pooled uncertainty of the entire project.

Using Schedule Buffer and Contingency Reserve in Program Execution

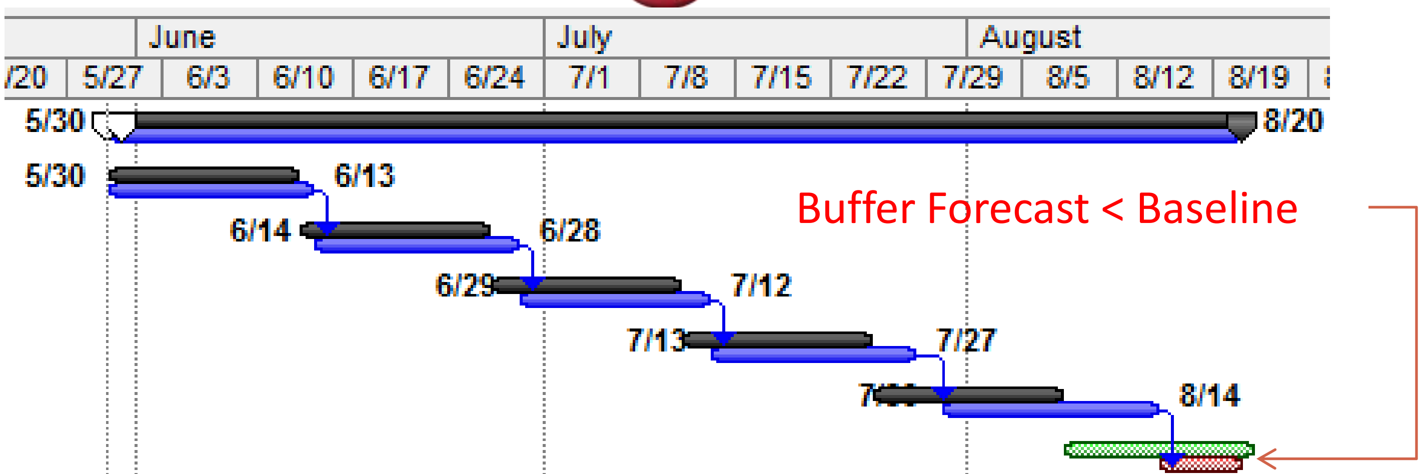
ADJUSTING EVM METRICS AND SCHEDULES TO ACCOUNT FOR THE EXISTENCE OF RESERVE IN THE BASELINE

First Post-Award SRA – Buffer Exceeded



We run the SRA again every quarter. Each new SRA takes into account the fact that some activities are completed (no uncertainty), and that the uncertainty about future activities and risks has changed. Typically, we know more as we go along, and are less uncertain. The diagram shows that our forecast tasks (in blue) are slipping relative to the original plan (in black). However, the forecast buffer (red) is smaller than the original buffer because of the reduced uncertainty. Still, we are behind because we see the end of the forecast with the red buffer is past the original finish date as shown by the green buffer.

Second Post-Award SRA – Buffer Intact



We are farther along now, and are starting to significantly reduce uncertainty about the project as we get through PDR and toward CDR. Our forecast activities (blue) are still finishing later than our baseline (black), but the project is now forecast to finish early because of the reduced need for buffer to get to the target confidence level.

If we did not have the buffer, we would be viewed as being late. This is a false variance that will trigger a host of negative behaviors, reducing productivity and decreasing trust with the customer.

What about the budget?

Sample Performance Report

Metric	Value
Deterministic BAC (not including Contingency Reserve)	1,050
Contingency Reserve (CR)	150
BCWS	800
BCWP	800
ACWP	900
CV = BCWP - ACWP	-100
CV% = CV/BCWP	-13%
CPI = BCWP/ACWP	0.89

Project simulation reveals that the confidence of achieving the BAC of 1,050 is less than 10%, so a contingency reserve of $150 is added to increase the chance of success to 80%. Red status indicates CPI less than 0.9.

Accounting for Available Contingency Reserve

Planned Completion Percentage= BCWS/BAC = 800/1050 = 76%

Using this ratio we determine how much of the contingency reserve is available at this point in time to account for known uncertainty:

Available CR = CR x Planned Completion Percentage = 150 x 76% = 114

Available CR represents the amount of variance predicted by the simulation model at our target confidence level at this point during the project. By comparing this number to the Cost Variance we get Reserve Margin:

Reserve Margin = Available CR + CV = 114 -100 = 14

A positive Reserve Margin indicates that variances are within the expected level predicted by the Monte Carlo simulation for the desired confidence level. A negative Reserve Margin would indicate that the Cost Variance is exceeding the ability of the Contingency Reserve to protect the cost baseline.

This approach also supports a simple metric to determine contingency reserve erosion:

Reserve Erosion Index (REI) = (Available CR - Reserve Margin)/Available CR = (114-14)/100 = .88

Sample Performance Report – With Reserve Metrics

Metric	Value
Deterministic BAC (not including Contingency Reserve)	1,050
Contingency Reserve (CR)	150
BCWS	800
BCWP	800
ACWP	900
CV = BCWP - ACWP	-100
CV% = CV/BCWP	-13%
CPI = BCWP/ACWP	0.89
Available CR = CR * (BCWS/BAC)	114
Reserve Margin = Available CR + CV	14
Reserve Erosion Index = (Available CR – Reserve Margin)/ Available CR	.88

Questions or Comments?

Please direct questions or comments to:

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