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Since 1973

Assessing Impact of Funding Constraints to Cost and Schedule

ISPA/SCEA Conference – June 2011

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Contents

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- Modeling Concept
- Model in Action
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- Summary

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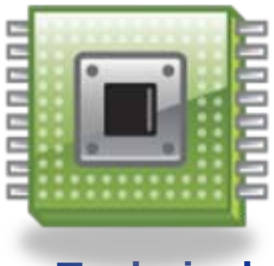
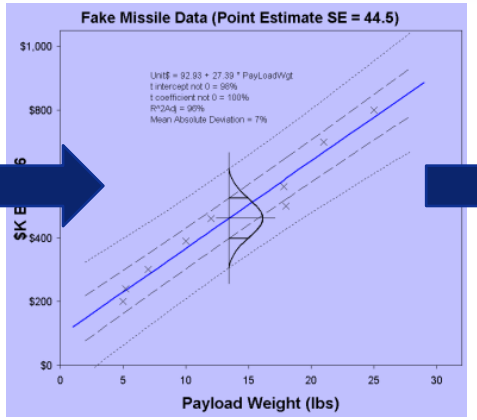
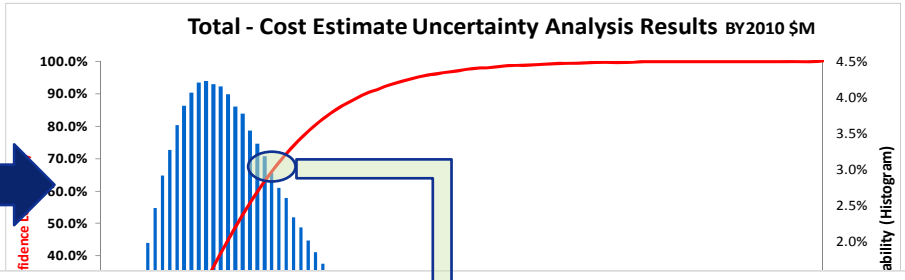
Current Techniques to Align Cost and Schedule via Uncertainty Analysis

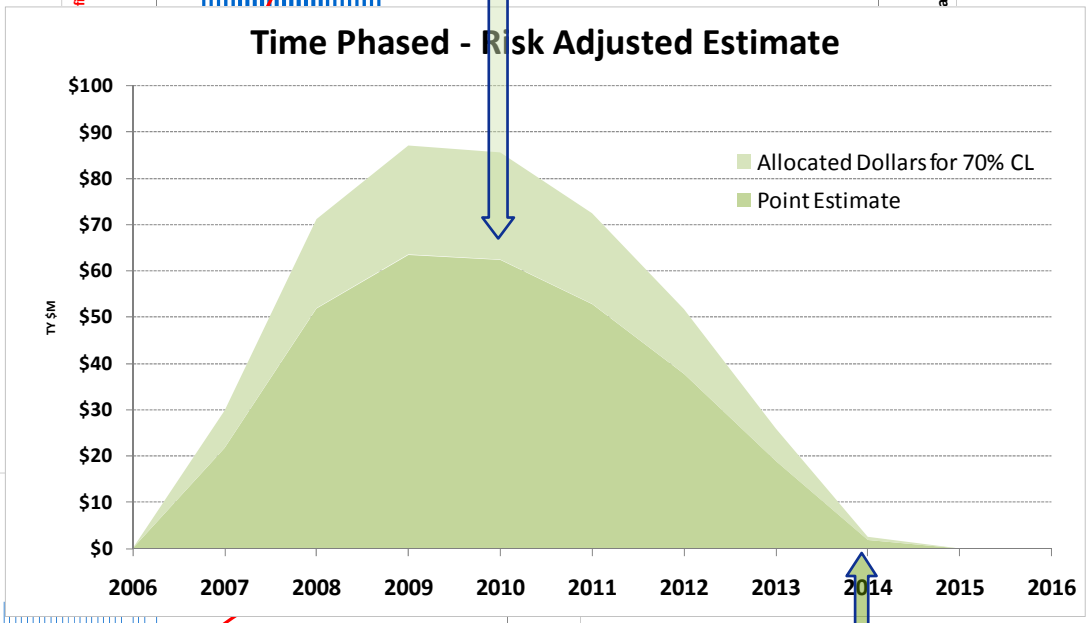


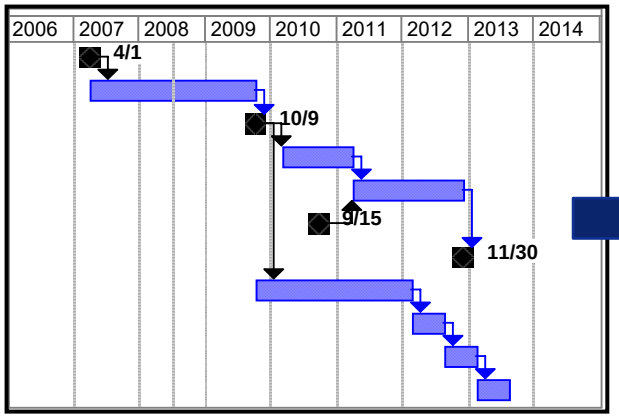
Technical Parameters



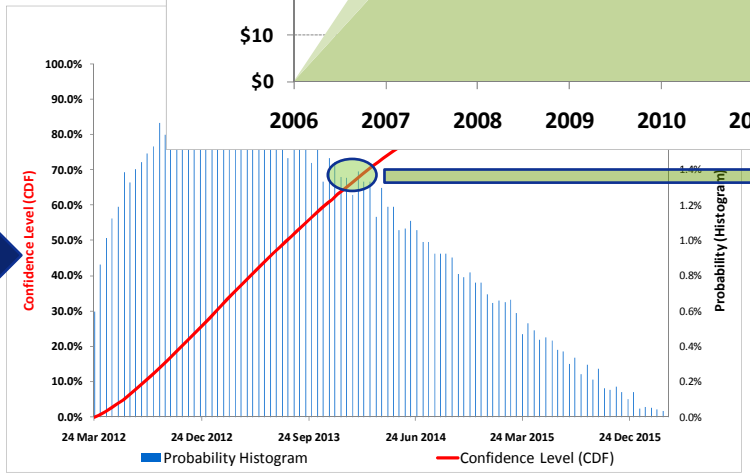
CERs





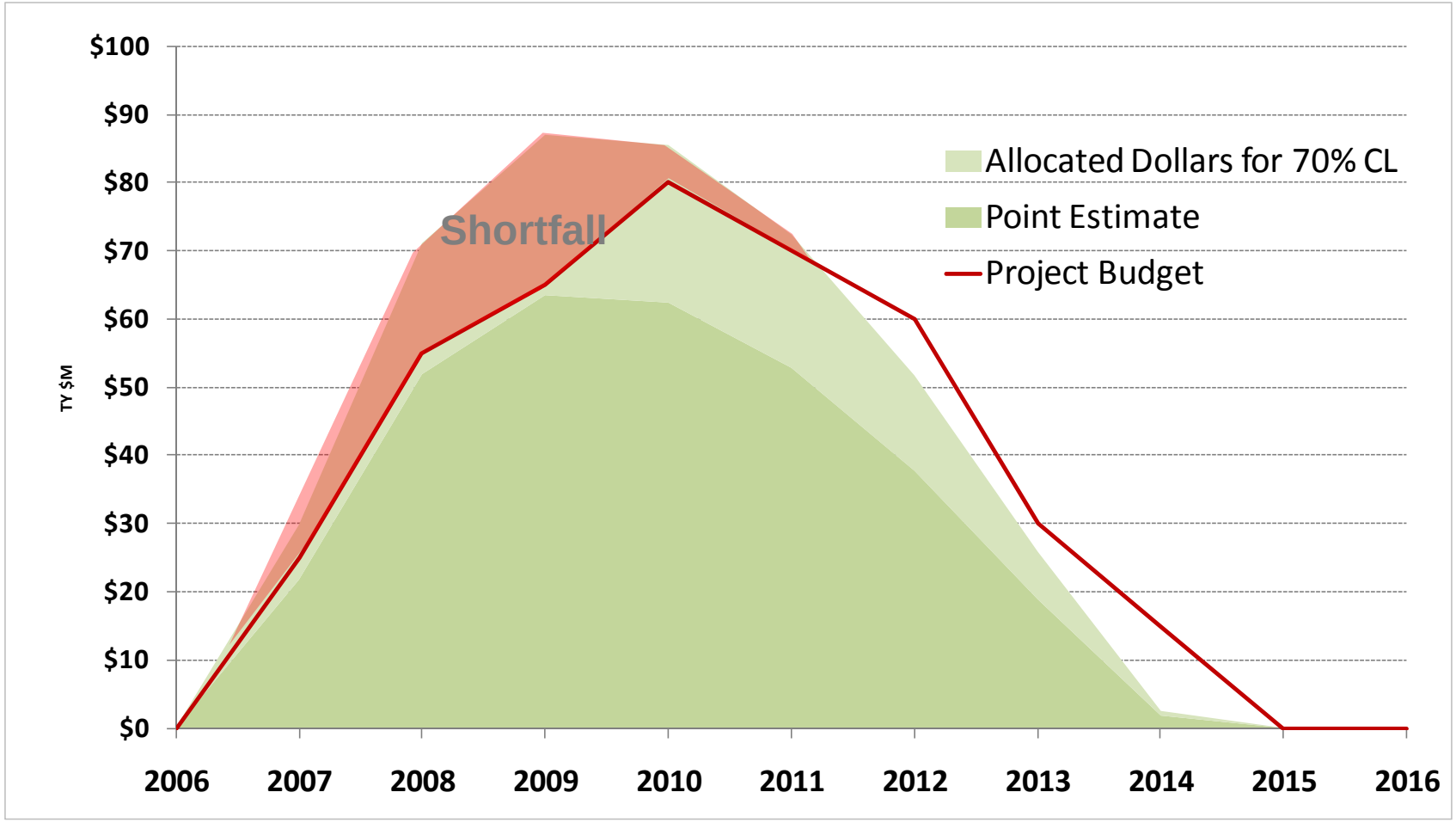


Schedule



Schedule Uncertainty Analysis

However, Budget Profiles Rarely Match Risk-Adjusted Time-Phased Estimates



- **Annual budget sufficient to cover estimated point estimate effort**
- **Shortfall in funding 70% effort for years 2007-2011**

How Does Shortfall Impact Project?

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Lack of Budget Availability Stretches the Schedule

"If the budget goes down, then everything squirts to the right"
Gen. Charles Bolden, NASA Administrator 2/6/10

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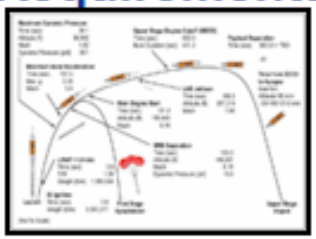
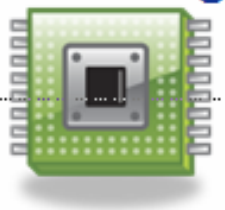
Our Reality is an Integrated System; Where Budget Availability is a Major Input

Requirements

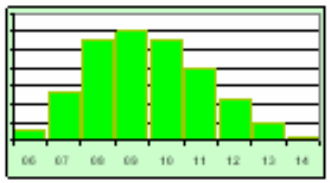


Technology



Resources

Budget



Effort

Work to be done

(i.e. estimated touch labor + material cost)

Productivity

Availability

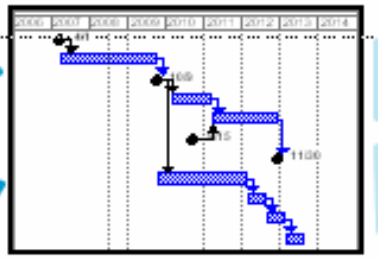
Capacity to do work

LOE

Managing the work

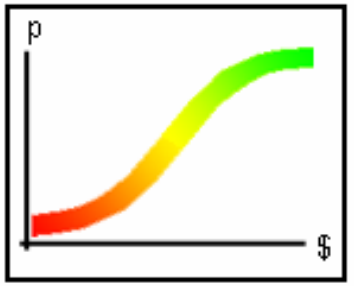
Schedule

A plan to do work

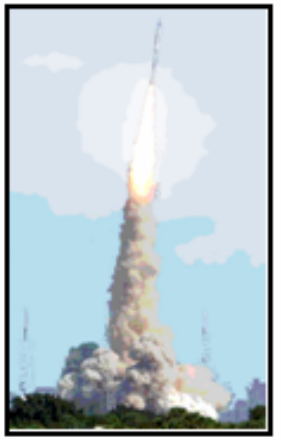


External Events

Total Project Cost (w/ LOE)



Project Completion Date



= Source of Uncertainty

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Embracing the Reality that Duration is Driven by Effort and Availability

- **Schedules are a plan on how to execute the work**
  - Indicates time-phased flow and relationship of work activities
  - At most lower levels of detail, they are effectively notional
- **Schedule durations are driven by cost requirements and budget availability**
  - A certain amount of effort is inherent in meeting requirements
  - Availability of resources to perform inherent effort determines duration
  - Budget is an input that determines relationship between cost and schedule
- **Effort risk (i.e. cost risk) drives duration uncertainty**
- **All budgets are constrained once laid in**
  - External commitments/limitations
  - Internal planning/staffing/training inertia
  - Organizational boundaries

The Model Concept

The Concept

- **Tecolote Developed a ROM-level analysis technique for NASA to gauge the impact of budget availability on a project's target cost confidence level**
- **The Technique requires:**
  - Risk adjusted, time-phased cost estimate
  - Annual budget information
  - User input on how to address multiple items (e.g., penalties, etc)
- **The General Approach**
  - Compare estimated effort (i.e., point estimate, risk adjusted time phased results, or annual risk iteration results) to available budget
  - Identify and track budget shortfalls
  - Rollover unfunded effort, with associated inflation and productivity penalties, to future years
  - Apply logic to use available budget to fund rollover effort

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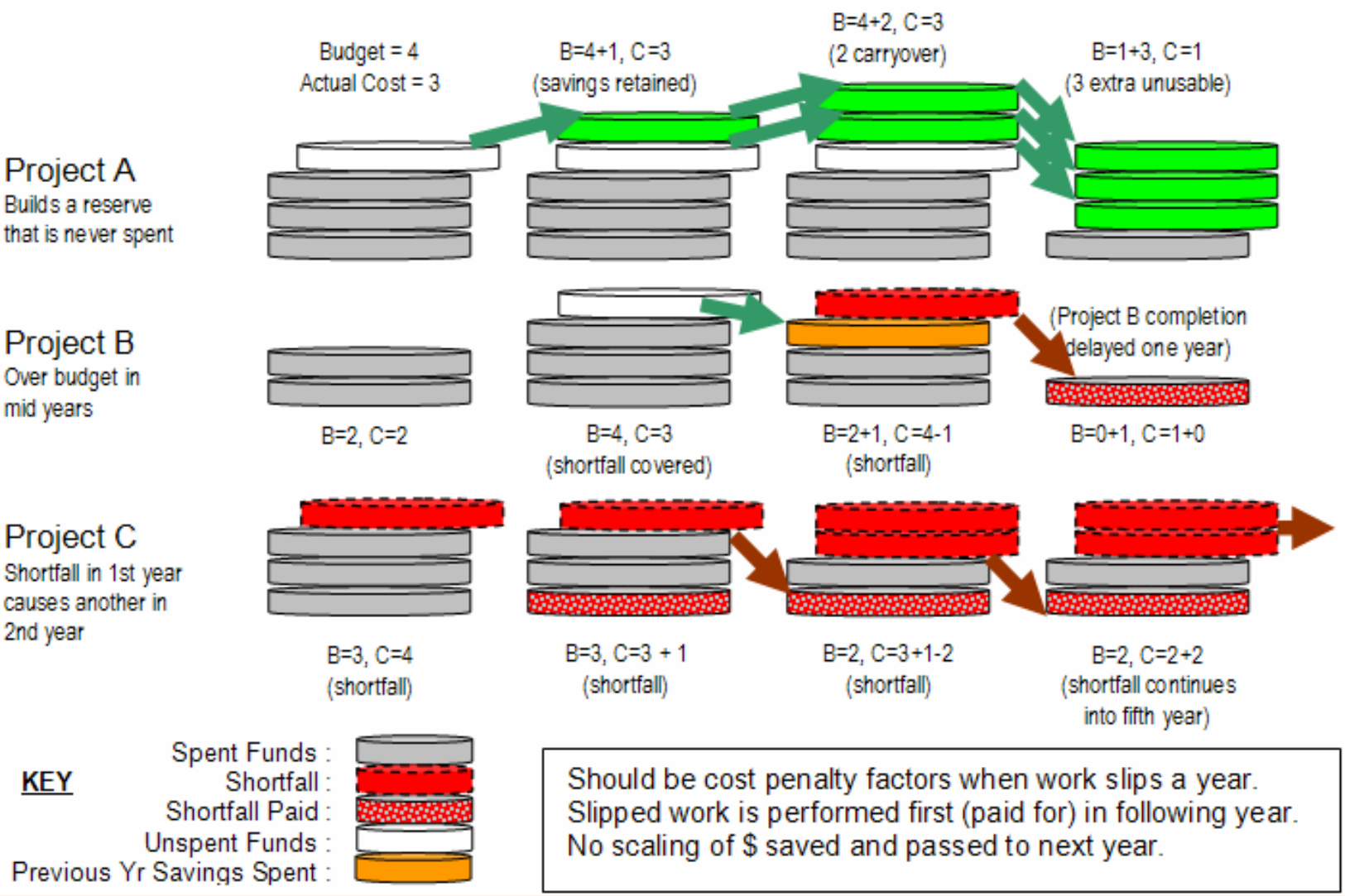
General Approach for Three Different Scenarios



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Modeling Approach – A Simple View of the Calculations for a Time-Phased Risk Adjusted Estimate

		FY 2008	FY 2009	FY 2010	FY 2014	FY 2015	FY 2016
Penalty			1.1295	1.1300	1.1300	1.1294	1.1294
	Total	FY 2008	FY 2009	FY 2010	FY 2014	FY 2015	FY 2016
Budget	$3,856	$95	$411	$475	$543	$558	
	Total	FY 2008	FY 2009	FY 2010	FY 2014	FY 2015	FY 2016
70% RY Estimate	$3,870	$125	$515	$628	$494	$395	
1. Rollover			$30	$139	$375	$375	$261
2. Rollover * Penalty			$34	$157	$424	$424	$295
3. Est + Rolling Rollover		$125	$549	$785	$918	$819	$295
4. Cost Of Budget	$281	-$30	-$104	-$153	$49	$163	$295
5. New Estimate	$4,151	$95	$411	$475	$543	$558	$295

Calculation details:

1. New Estimate prior year – Budget prior year
2. Rollover * Penalty (which is uncertain)
3. 70% TY Estimate + Rollover * Penalty
4. Budget – New Estimate
5. Budget + Last Year of rollover

- Rollover * Penalty in 2016 is not the cost of this budget profile.
- The total "cost" of the Budget profile captures the fact that the estimate was already $17 higher than the budget.

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User Inputs and Controls

- **The user has the ability to:**
  - Select type of analysis to conduct
    - Point estimate
    - Risk-adjusted (e.g., 70%) cost estimate
    - Dynamic assessment of confidence level results
  - Specify budget scenarios
    - Extend budget at peak
    - Infuse/Reduce funds in specific year
  - Allow budget carryover
  - Incorporate penalties for rollover effort:
    - Inflation considerations
    - Productivity loss

Set Estimate Confidence Level	70				
Select Estimate to Compare to Budget:					
Point Estimate TY$ Total @ Target Confidence Level	1				
Include Inflation	1				
	Low	Mode	High		
Productivity Penalty Factor (15%, Mode, 85%)	1.00	**1.10**	1.25	<-- make them	
	Total	**2008**	**2009**	**2010**	**201**
Budget in TY$	**$3,856**	$95	$411	$475	$5
Original Budget TY$	**$3,856**	$95	$411	$475	$5
Budget Injection TY$	**$0**				

- **Advanced Considerations**
  - Incorporating fixed costs (LOE) into consideration
  - Conducting portfolio analysis
- **Outputs**
  - Initial phasing result for Target CL
  - Constrained phasing result
  - Additional years of funding required

The Model in Action
"Illustrative Case"

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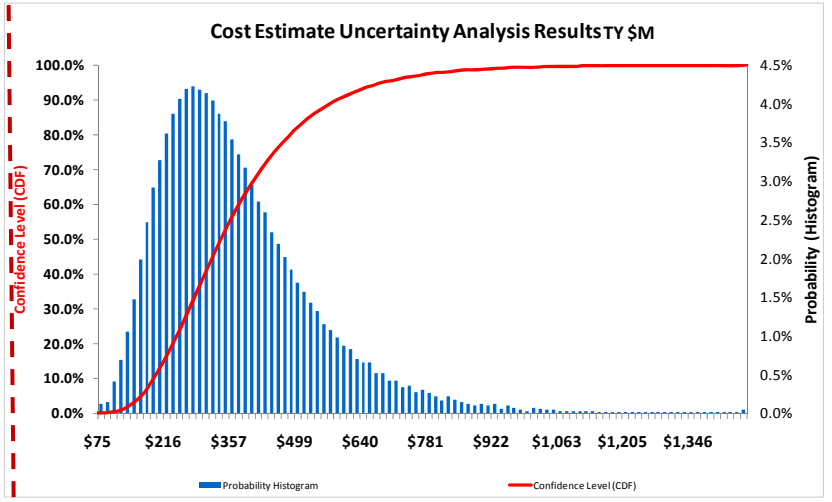
Example Case – 70% Effort Exceeds Available Budget

Phased budget and point estimate

TY$M	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	*Total*
Budget	$25	$55	$65	$80	$70	$60	$30	$15	***$400***
Cost	$21.8	$51.9	$63.6	$62.4	$52.9	$37.8	$18.9	$1.8	***$311***

Cost risk analysis data (TY$M)

Point Estimate	Confidence Level	Mean	Standard Deviation	CV
$311	42%	$372	$168	0.45



Cost estimate @ 70% confidence level

TY$M	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	*Total*
70% CLE	$29.8	$71.2	$87.1	$85.6	$72.4	$51.7	$25.9	$2.5	***$426***

Budget Shortfall to Fund 70% CLE

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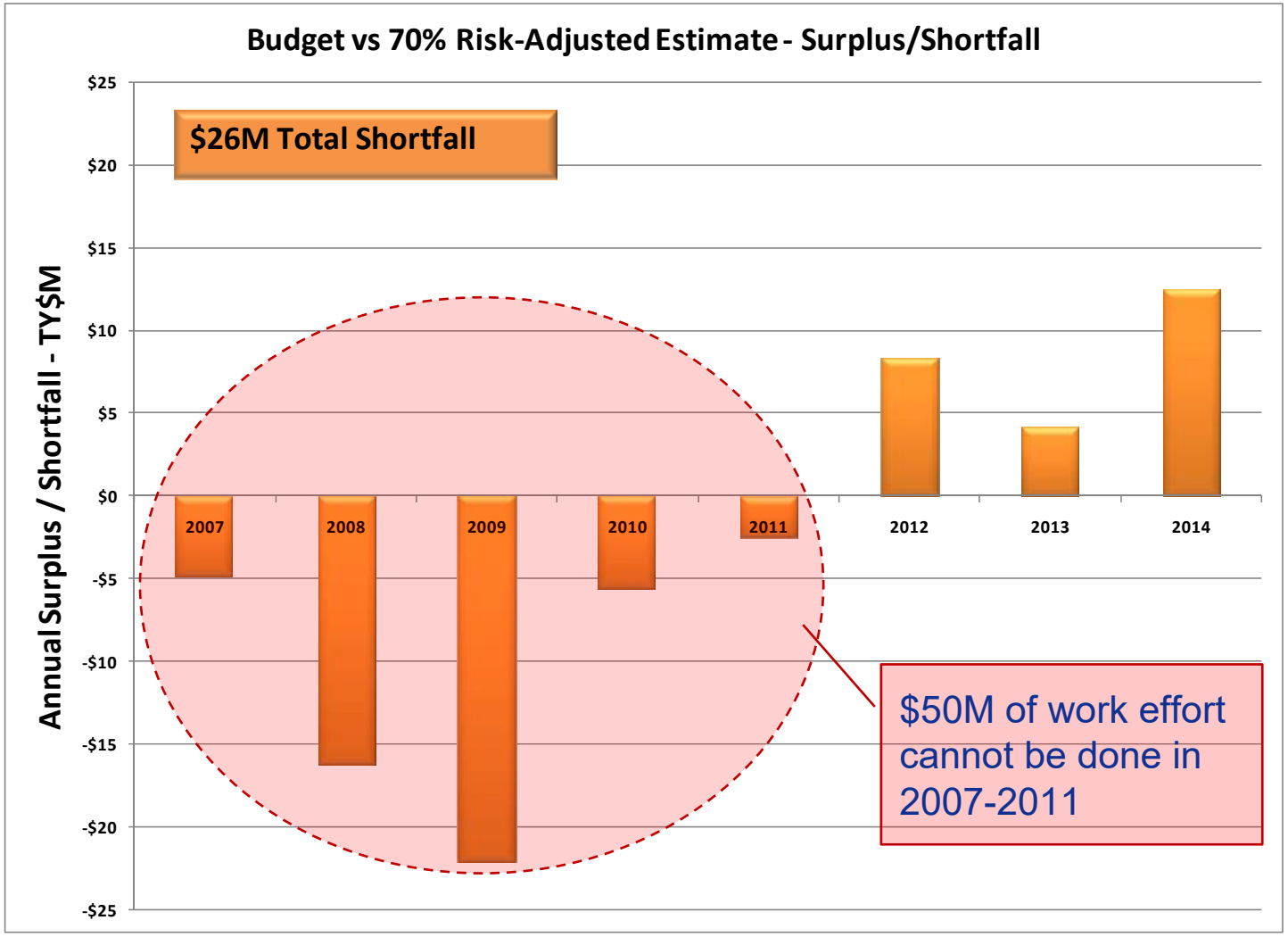
Understanding the Shortfall – Work Slips to the Right



- **Total Budget inadequate to fund 70% CLE**
- **Large shortfall in early years, if funds cannot be obtained, effort will slip into future periods**
  - 2007 work slips to 2008
  - and so on…
- **Extended work carries penalties**
  - Inflation
  - Productivity

What are Possible Budget Scenarios?

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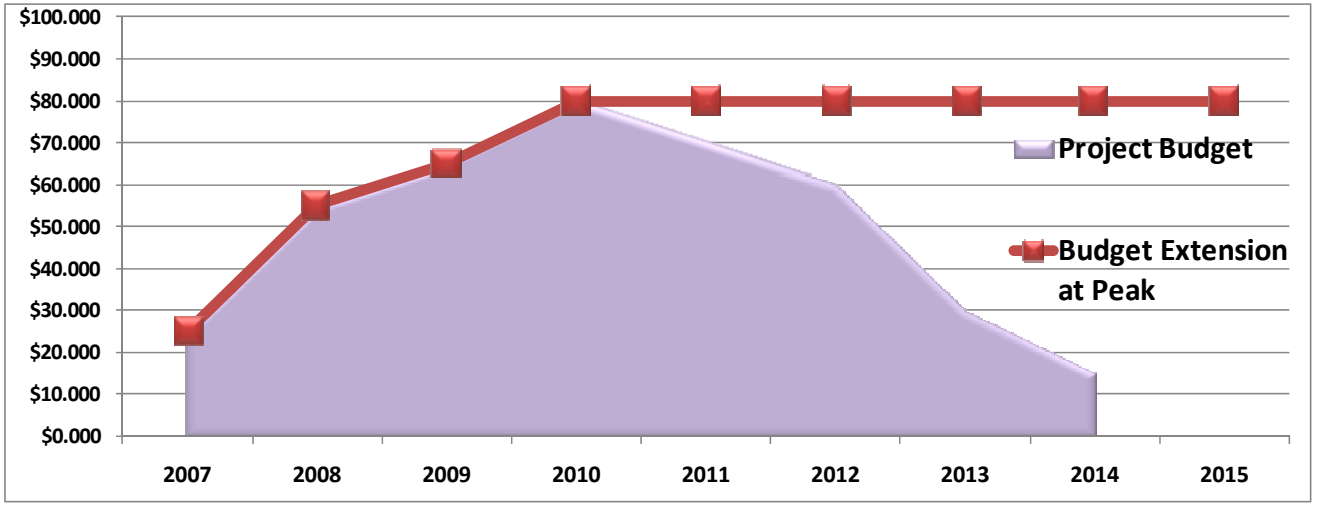
Identifying Budget Scenarios

Budget Scenario Considerations

- Need to be realistic
  - Near-term funds are difficult to obtain
  - Annual increase must match capability to ramp up staffing levels and should track to required work
  - Should not have extreme changes year-to-year
  - Difficult to increase beyond peak spending year
- Cannot upset overall portfolio needs

Potential Options

- Identify infusion of funds into specific years
- Extend funding beyond peak funding year at or near peak value



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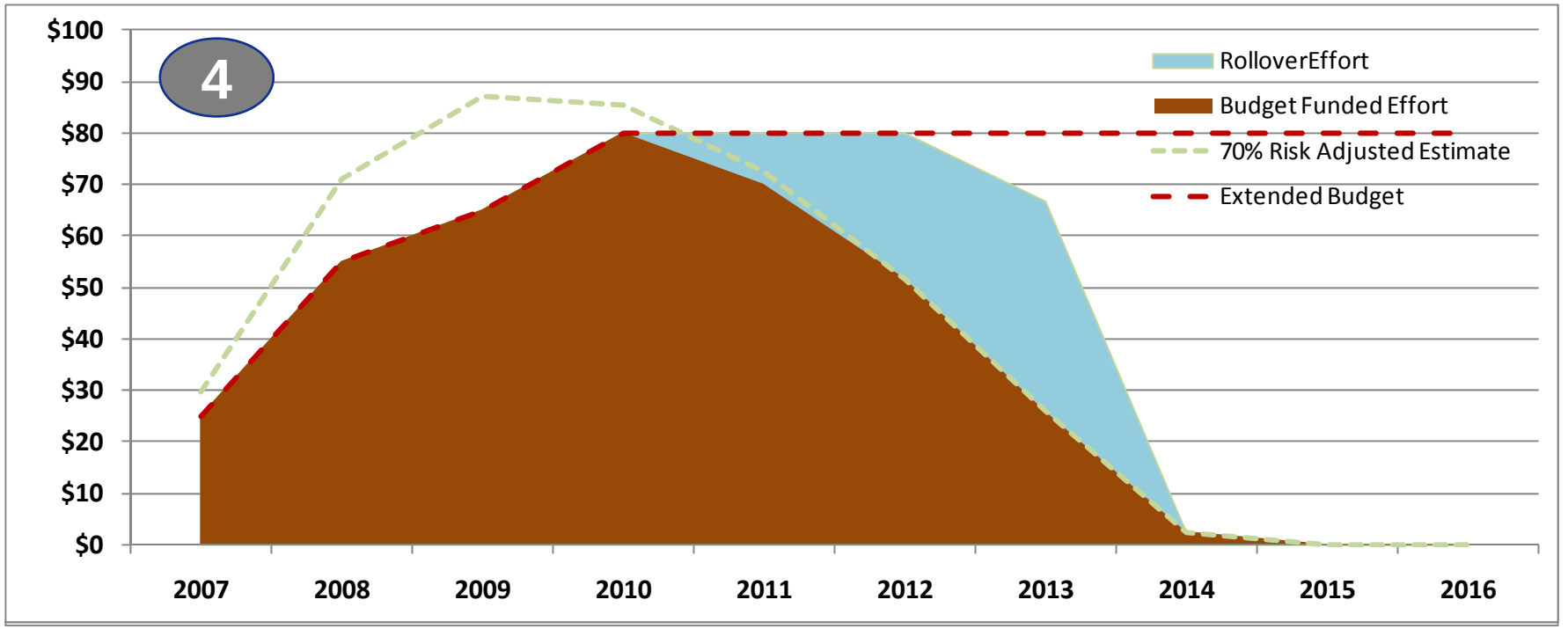
Example Case Results – Effort Rollover Fits Under Budget Constraint



1. **Initial Conditions indicate budget inadequate to fund 70% CLE**
2. **Project funded to budget value**
3. **Budget scenario created to extend budget at peak value and 70% time-phased estimate funded to extended budget values**
4. **Impact of rollover effort funded in out-years**

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Observations

- **Model is simple to run and generates intuitive results**
- **Scenarios with early shortfalls generate additional costs to satisfy 70% CLE**
  - Example case 70% CLE = $426M
  - Budget Constrained 70% CLE = $454M
  - Approximately a $28M penalty cost for the non-optimum budget
- **There are unlimited combinations of budget injections that can mitigate the cost of the original budget profile.**
- **The earlier the budget is adjusted, the more impact the injection will have**
- **The model provides ROM-level results and cannot tell you what has moved, but gives indication of magnitude of impact**

Model Pedigree

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Background of Model Development

- **Early FY Funding Shortfall Impact on Overall Project Confidence Level methodology was initially developed to quantify the impact of early year budget shortfalls on a risk adjusted estimate in ACE**
  - Original development sponsored by NASA HQ Cost Research Division
  - Presented by Alfred Smith and Melissa Cyrulik at the NASA Cost Symposium, April 2009
- **Algorithm enhanced in 2010 to support incorporation of Time Dependent (LOE) cost behavior**
- **Recent development to evolve methodology for portfolio application, run-time during iteration calculation, and inter-project dependencies (e.g., payload and spacecraft)**

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Model Housed in Both Excel and ACEIT

ACE 7.2 - [FSCL Skeleton v11.aceit - Methodology (BY2010$M)]

File Edit View Documentation Calc Cases Reports Tools Window Help

FSCL Skeleton v...logy (BY2010$M)

	WBS/CES Description	Approp	Unique ID	Point Estimate	Phasing Method	Equation / Throughput	Fiscal Year	Units	Start Date	Finish Date	RI$K Specification
15	* Early FY Funding Shortfall Impact on Overall Project Confidence		*FSCL								
16	** User Settings		*Settings								
17	Set Target Confidence Level		FSCL_TargetCL	70 *	C	70					
18											
19	Include Inflation (1=Yes, 2=No)		FSCL_ChooseInflation	1 *	C	1					
20											
21	Penalty Factor Moving $ to Next FY in Addition to Inflation		CL_ProductivityPenFact	1.1 *	C	1.1					Form=Triangular,
22	Penalty Factor Low Value		ProductivityPenFactLow	1.1 *	C	1.1					
23	Penalty Factor High Value		ProductivityPenFactHigh	1.1 *	C	1.1					
24											
25	Allow Shifting of Budget (0 = No , 1 = Yes)		Toggle_ShiftBudget	0.000 *	C	0					
26	Extend Budget from Peak (0 = No, 1 = Yes)		Toggle_ExtendBudget	1.000 *	C	1					
27	Cost Confidence Level (0 = PE, 1 = Target CL)		Toggle_TargetCL	1.000 *	C	1					
28	** Data Preparation		*DataPrep								
29	Total Budget TY$		TotBudgetTY$	$ 3.149 *							
30	Budget TY$			$ 3.149 *	F	Budget$_Input * BYtoTY(R&D, FYBY, FYYR)					
31	Budget Injection TY$ (Enter additional budget as TY$M in Yearly Phas			$ 0.000 *	IS	[Input Throughput]					
32	Total Costs TY$		TotalCosts_TY$	$ 3.536 (13%) *	F	Total_Est$_Input * BYtoTY(R&D, FYBY, FYYR)					
33											
34	FSCL Budget		FSCL_Budget	$ 6.697 *	F	If(And(Toggle_ExtendBudget, FYYR >					
35	FSCL Cost		FSCL_Cost	$ 4.298 *	F	If(Toggle_TargetCL ,					
36	** FSCL Calculations		*FSCLCalc								
37	Delta Between Cost and Budget TY$		AvailDeltaToBudget_TY$	*	F	[If(And(Not(Toggle_ShiftBudget) ,					
38											
39	Rollover Costs for Penalty Factor			*	F	FYCVal(FYYR - 1) -				Not(	
40	Inflation By Year Penalty Factor		CL_Pen_InflationByYear	*	F	If(FYCVal(@FSCL_CumRollOver$, FYYR - 1) >			FYCFirstYr(@F	Not(	
41	Shifting Costs Penalty Factor		FSCL_Pen_FactByYear	*	F	If(FYCVal(@FSCL_CumRollOver$, FYYR - 1) >			FYCFirstYr(@F	Not(	
42	Combined Adjustment		FSCL_Pen_CombAdj	*	F	FSCL_Pen_InflationByYear *			FYCFirstYr(@F	Not(	
43	Cumulative Rollover		FSCL_CumRollOver$	*	F	If(Toggle_ShiftBudget , (FYCVal(FYYR - 1) -				Not(	
44											
45	Phased Results for Extended or Constraint Budget TY$		PhaseBudgetConst_TY$	$ 4.666 *							
46	Total Phased Costs TY$			4.666 *							
47	Phased results to the Peak Year			$ 2.097 *	F	If(Toggle_ExtendBudget , FSCL_Budget , Min(				FYCMaxYr(@F	Form=PointEstimate,
48	Phased results beyond Peak Year			$ 1.258 *	F	If(And(FYYR > FYCMaxYr(@FSCL_Budget) ,					Form=PointEstimate,
49	Phased Rollover Effort Beyond Last Year of Costs		PhaseRolloverEffort_TY$	$ 1.310 *	F	If(FSCL_CumRollOver$ < 0 , 0 , If(			FYCLastYr(@F		Form=PointEstimate,
50	* Inputs/Outputs		*InputsOutputs								
51	*Input Model										
52	Budget in BY$	R&D	Budget$_Input	$ 2.782 *	TY	[Cost Throughput]		$M			
53	Cost Estimate in BY$	R&D	Total_Est$_Input	$ 3.120 (13%) *	BE	3.12	2010	$M	01oct2010	30sep2018	Form=LogNormal,
54											

WBS/CES | Yearly Phasing | Methodology | RI$K All Columns | All Columns

Ready NUM

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Summary

- **Environment**
  - Budget Profiles Rarely Match Risk-Adjusted Time-Phased Estimates
  - Lack of Budget Availability Stretches the Schedule
  - Our Reality is an Integrated System—Where Budget Availability is a Major Input
- **New Understanding – Time is a Function of Effort and Availability**
- **ROM-level analysis technique for NASA to gauge the impact of budget availability on a project's target cost confidence level**
- **User controls type of analysis to conduct, specify budget scenarios, allow budget carryover, and incorporate penalties for rollover effort**
- **Rollover concept is simple to implement and communicate**
  - Provides bridge between project formulation/planning and execution areas – bringing utility to the Program Manager
  - Can be done in Excel and ACEIT models

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References & Further Reading

- **Alfred Smith, Melissa Cyrulik, "Early FY Funding Shortfall Impact on Overall Project Confidence Level (FSCL)", Tecolote Research, Inc., 23 January 2009**
- **Bob Bitten, "Perspectives on NASA Mission Cost and Schedule Performance Trends", Future In-Space Operations (FISO) Colloquium, The Aerospace Corporation, 02 July 2008**
- **Peter Frederic, "Budget-Constrained Joint Confidence Level Sample Cases", Tecolote Research, Inc., 02 September 2010**
- **Debra Emmons, Marcus Lobbia, Torrey Radcliffe, Robert Bitten, "Affordability Assessments to Support Strategic Planning and Decisions at NASA", The Aerospace Corporation, 07 March 2010**

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