Making an ACE Estimate Sensitive to Schedule

2009 ACEIT User Conference

Tecolote Research, Inc.

Abstract

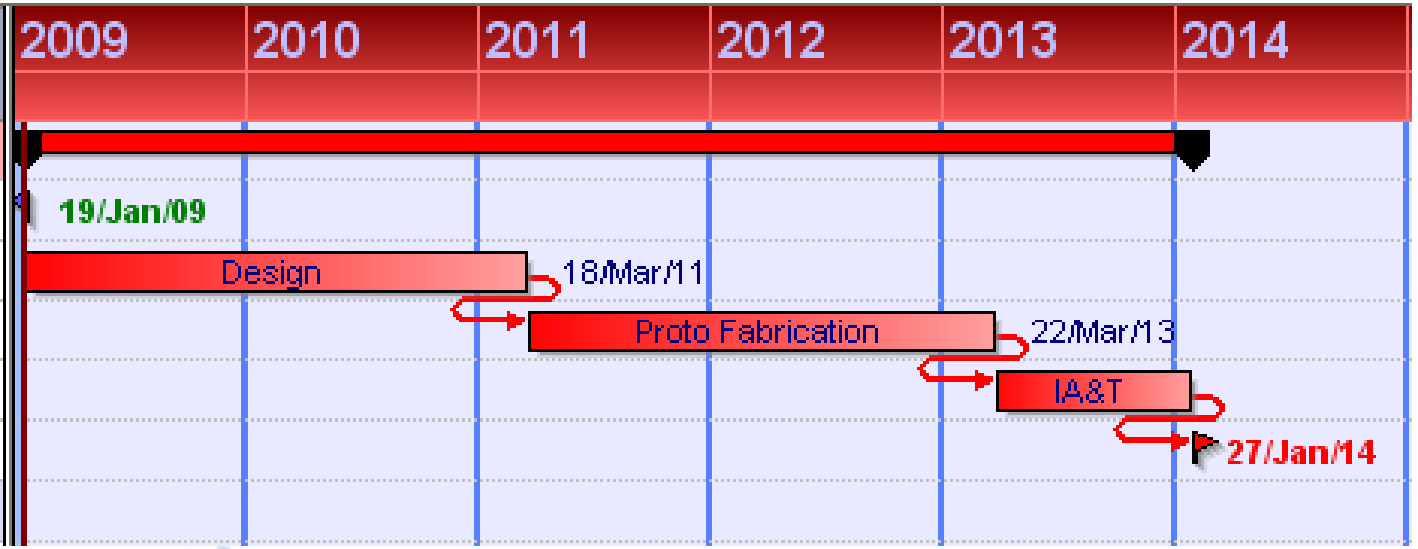
Integrating Cost estimates with the program schedule is becoming increasingly important. This presentation demonstrates techniques and methodologies you can use to make your estimate sensitive to schedule durations and to assess impact on changes to the schedule. Techniques demonstrated include: creating methodologies based on duration, using DECs to calculate duration change impacts, and writing advanced functions to handle penalties/impacts associated with re-phasing of costs or schedule expansion/compression

- **About the Author: Darren Elliott**

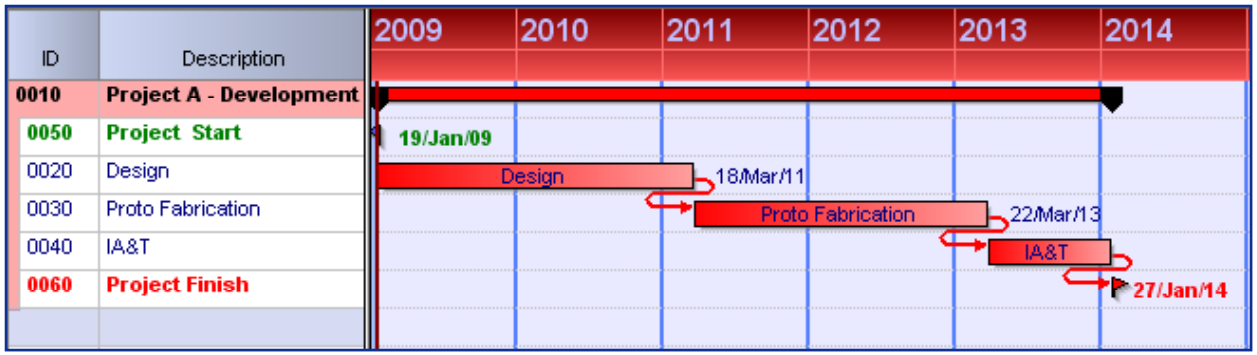
  Darren Elliott has over 18 years of experience in program management consulting and risk analysis. Since 1992 he has been an ACEIT Trainer. He currently is responsible for all ACEIT product support, customer requirements, ACEIT training, ACEIT Sales operations, and consulting support to the NASA Constellation program.

Estimating Directly to a Schedule - What If?

ID	Description
0010	**Project A - Development**
0050	**Project Start**
0020	Design
0030	Proto Fabrication
0040	IA&T
0060	**Project Finish**



ACE Enables Making an Estimate Sensitive to Schedule

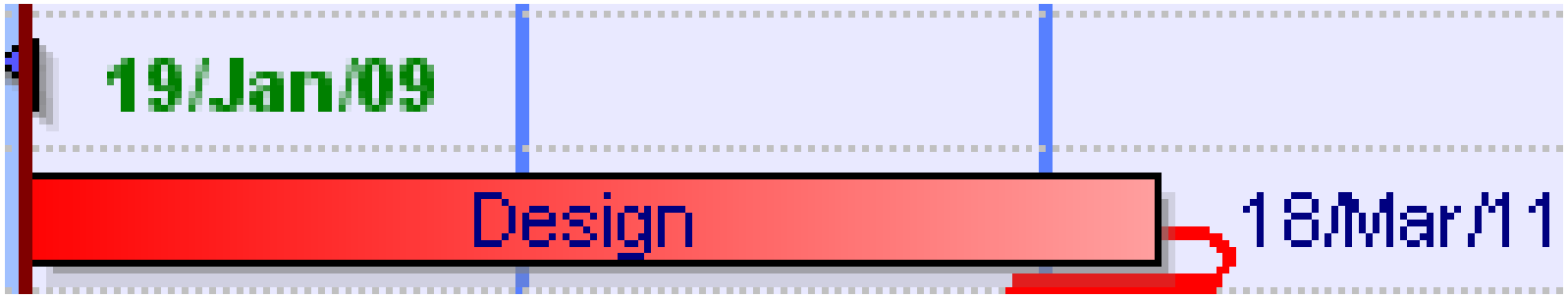


WBS/CES Description	Approp	Unique ID	Cost and Duration	Phasing Method	Equation / Throughput	Fiscal Year	Units	Start Date	Finish Date
*Project A - Development Estimate		*Estimate							
Project A - Development			**$ 53.408 ***						
Design	3600	Design_$	$ 22.841 *	BE	2306 *wt ^ 0.7	2004	$K	Dsn_Start	DateAdd(aStartDate,0,Dsn_Duration,0)
Protoytpe Fabrication			$ 8.028 *						
Proto Material	3600	Fab_Mat$	$ 1.228 *	TS	1.2	2008	$M	DateAdd(Design_$.aFinishDate,0,0,1)	DateAdd(aStartDate,0,0,1)
Fabrication Staffing	3600	Fab_Man$	$ 6.800 *	TS	6.8	2009	$M	DateAdd(Design_$.aFinishDate,0,0,1)	DateAdd(aStartDate,0,Fab_Duration,1)
IA&T	3600	IA&T_$	$ 1.855 *	TS	(IA&T_MoHeads * IA&T_MoBurn) * IA&T_Duration			DateAdd(Fab_Man$.aFinishDate,0,0,1)	DateAdd(aStartDate,0,IA&T_Duration,1)
Systems Eng/Proj Mgmt	3600	SEPM_$	$ 20.684 *	TS	((SE_MoHeads * SE_MoBurn) + (PM_MoHeads * PM_MoBurn)) *			Min(Design_$.aStartDate, Fab_Mat$.aStartDate, Fab_Man$.aStartDate, IA&T_$.aStartDate)	Max(Design_$.aFinishDate, Fab_Mat$.aFinishDate, Fab_Man$.aFinishDate, IA&T_$.aFinishDate)

Key Modeling Needs

- Calculate Dates Based on Duration Inputs
- Enter Date Logic
- Estimate Costs Based on Inputs
- Phase and Inflate Costs Over the Duration
- Obtain Annual Phased Values
- Input and Calculate Uncertainty

Phasing an Estimate Over Duration

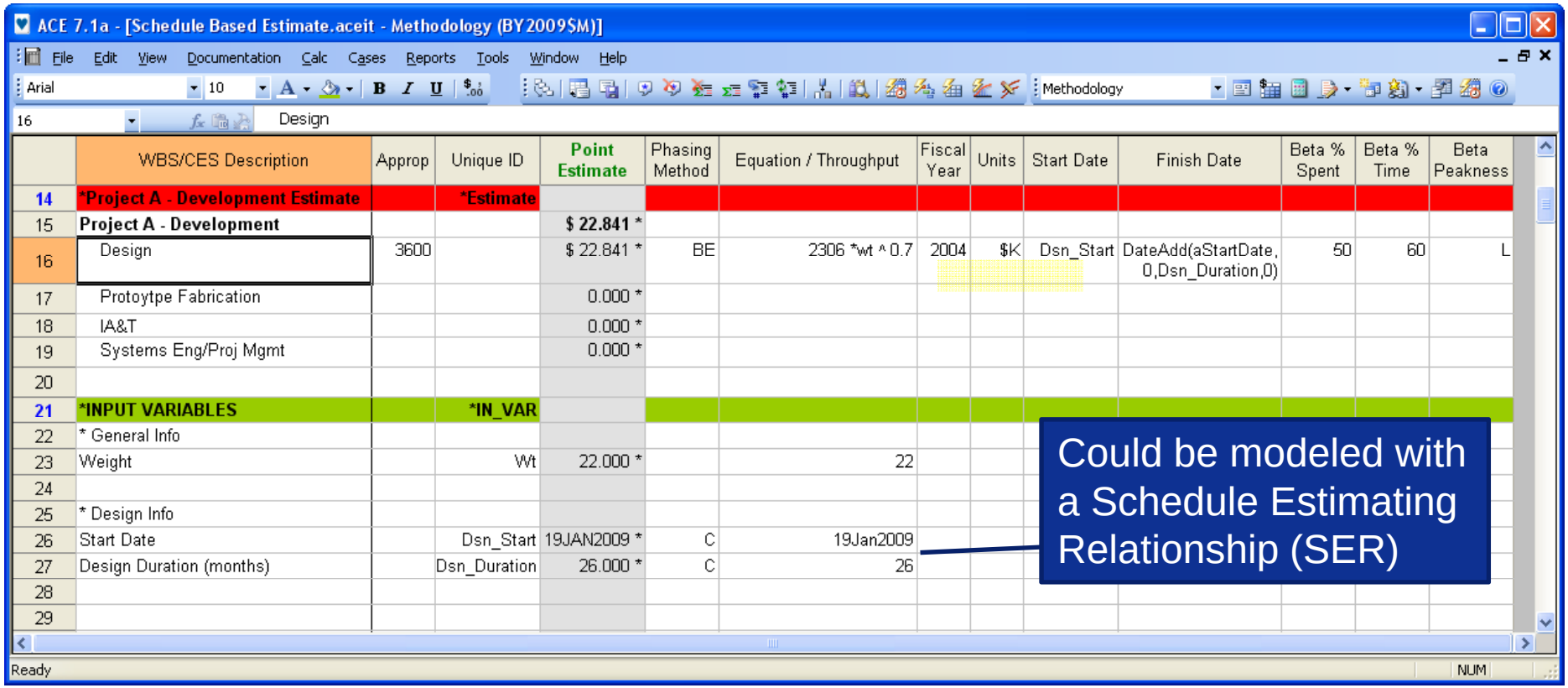


- **Total Cost is Calculated by an Equation**
  - Design = 2306 * Wt ^ 0.7 (BY2004$K)

- **Cost needs to be Spread over Duration with Beta Curve**

Duration: Key in Enabling Schedule Modeling

- **Estimation and Phasing are Standard Items in ACE**
- **Date Columns Can Reference Variables**
- **DateAdd() Function Allows Date Calculations**
  - Finish Dates can be modeled with durations
- **Date Columns Can Reference Other Columns**

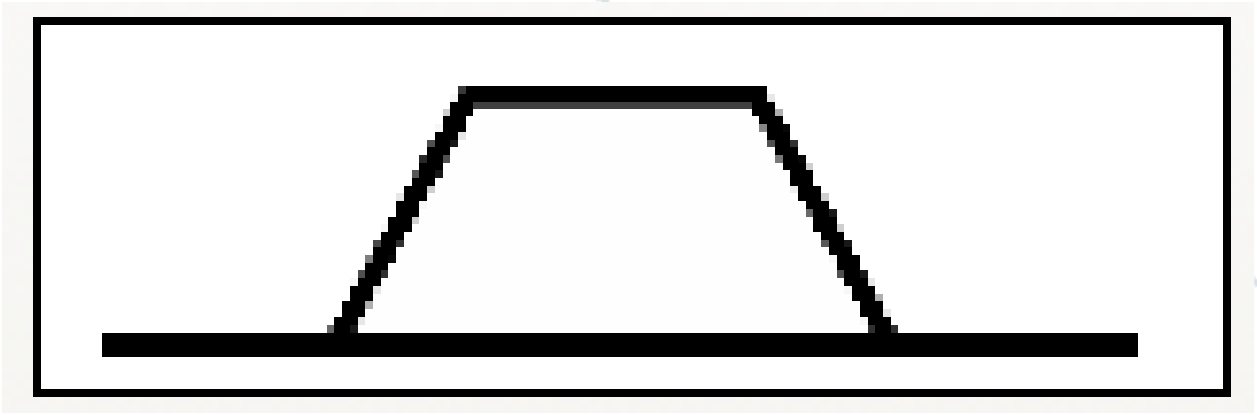


	WBS/CES Description	Approp	Unique ID	Point Estimate	Phasing Method	Equation / Throughput	Fiscal Year	Units	Start Date	Finish Date	Beta % Spent	Beta % Time	Beta Peakness
14	*Project A - Development Estimate		*Estimate										
15	Project A - Development			$ 22.841 *									
16	Design	3600		$ 22.841 *	BE	2306 *wt ^ 0.7	2004	$K	Dsn_Start	DateAdd(aStartDate, 0,Dsn_Duration,0)	50	60	L
17	Protoytpe Fabrication			0.000 *									
18	IA&T			0.000 *									
19	Systems Eng/Proj Mgmt			0.000 *									
20													
21	*INPUT VARIABLES		*IN_VAR										
22	* General Info												
23	Weight		Wt	22.000 *		22							
24													
25	* Design Info												
26	Start Date		Dsn_Start	19JAN2009 *	C	19Jan2009							
27	Design Duration (months)		Dsn_Duration	26.000 *	C	26							
28													
29													

Could be modeled with a Schedule Estimating Relationship (SER)

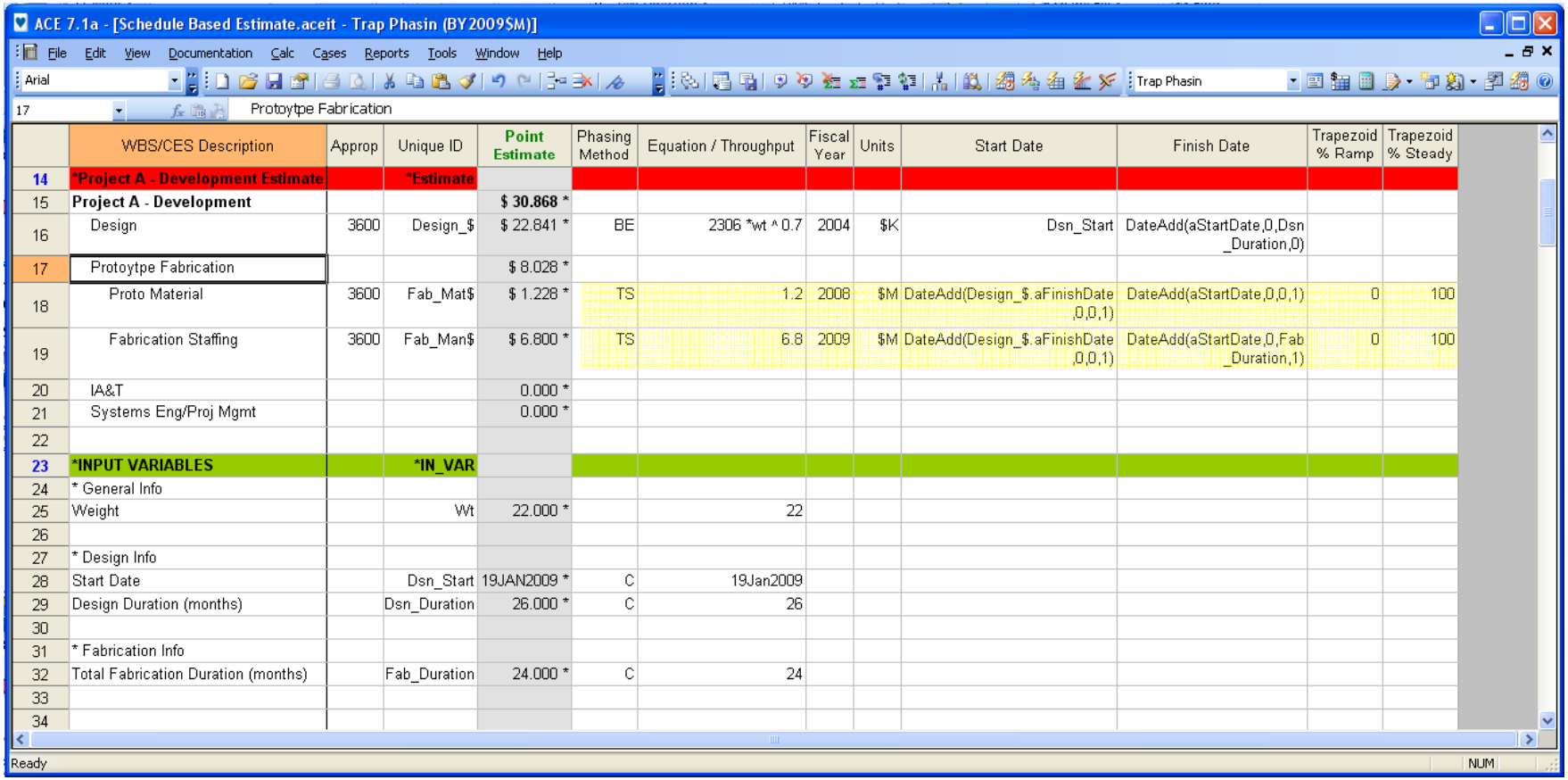
Expanding Schedule to Accommodate Cost Elements

- **Fabrication requires Material and Manpower**
  - Material Purchased Upfront
  - Total Manpower Cost phased as LOE over entire Duration



Child Elements: Key for Multiple Cost Loading

- **Indentured WBS Allows Costs to be Summed**
- **TS Phasing Method Allows for LOE Phasing and Purchases**
- **DateAdd() Function and DEC Referencing via Row.Col Notation Allow for Linking Schedules**



	WBS/CES Description	Approp	Unique ID	Point Estimate	Phasing Method	Equation / Throughput	Fiscal Year	Units	Start Date	Finish Date	Trapezoid % Ramp	Trapezoid % Steady
14	*Project A - Development Estimate		*Estimate									
15	Project A - Development			$ 30.868 *								
16	Design	3600	Design_$	$ 22.841 *	BE	2306 *wt ^ 0.7	2004	$K	Dsn_Start	DateAdd(aStartDate,0,Dsn_Duration,0)		
17	Protoytpe Fabrication			$ 8.028 *								
18	Proto Material	3600	Fab_Mat$	$ 1.228 *	TS	1.2	2008	$M	DateAdd(Design_$.aFinishDate,0,0,1)	DateAdd(aStartDate,0,0,1)	0	100
19	Fabrication Staffing	3600	Fab_Man$	$ 6.800 *	TS	6.8	2009	$M	DateAdd(Design_$.aFinishDate,0,0,1)	DateAdd(aStartDate,0,Fab_Duration,1)	0	100
20	IA&T			0.000 *								
21	Systems Eng/Proj Mgmt			0.000 *								
22												
23	*INPUT VARIABLES		*IN_VAR									
24	* General Info											
25	Weight		Wt	22.000 *		22						
26												
27	* Design Info											
28	Start Date		Dsn_Start	19JAN2009 *	C	19Jan2009						
29	Design Duration (months)		Dsn_Duration	26.000 *	C	26						
30												
31	* Fabrication Info											
32	Total Fabrication Duration (months)		Fab_Duration	24.000 *	C	24						
33												
34												

Applying Burn Rates to Schedule Activities

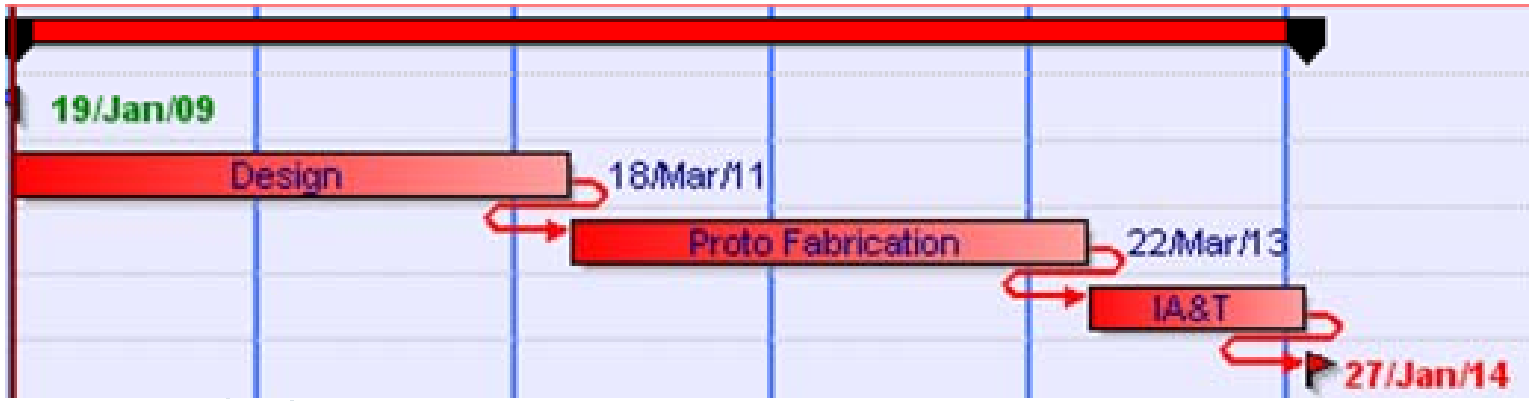
- **Integration Requires Five Heads Per Month**
  - Cost Per Month Can be Calculated Based on Avg Burn Rate
    - Month Cost = 5 * AvgBurnRate_Month
  - Total Cost Can be Calculated by Multiplying Monthly Cost by Duration
    - Total Cost = MonthCost * Duration
  - Total IA&T Cost is Phased as LOE Over Entire Duration

Phase Total Calculated Cost: Key for Burn Rates

- **Both Cost and Schedule are Affected by Duration**
- **TS Phasing Method Allows for LOE Phasing and Purchases**

WBS/CES Description	Approp	Unique ID	Point Estimate	Phasing Method	Equation / Throughput	Fiscal Year	Units	Start Date	Finish Date	Trapezoid % Ramp	Trapezoid % Steady
*Project A - Development Es		*Estimate									
Project A - Development			$ 32.723 *								
Design	3600	Design_$	$ 22.841 *	BE	2306 *wt ^ 0.7	2004	$K	Dsn_Start	DateAdd(aStartDate,0,Dsn_Duration,0)		
Protoytpe Fabrication			$ 8.028 *								
Proto Material	3600	Fab_Mat$	$ 1.228 *	TS	1.2	2008	$M	DateAdd(Design_$.aFinishDate,0,0,1)	DateAdd(aStartDate,0,0,1)	0	100
Fabrication Staffing	3600	Fab_Man$	$ 6.800 *	TS	6.8	2009	$M	DateAdd(Design_$.aFinishDate,0,0,1)	DateAdd(aStartDate,0,Fab_Duration,1)	0	100
IA&T	3600		1.855 *	TS	(IA&T_MoHeads * IA&T_MoBurn) * IA&T_Duration			DateAdd(Fab_Man$.aFinishDate,0,0,1)	DateAdd(aStartDate,0,IA&T_Duration,1)	0	100
Systems Eng/Proj Mgmt			0.000 *								
*INPUT VARIABLES		*IN_VAR									
* IA&T Info											
Total IA&T Duration (months)		IA&T_Duration	10.000 *	C	10						
IA&T MonthlyBurnRate per He	3600	IA&T_MoBurn	$ 0.026 *	C	26.5	2009	$K				
IA&T Avg Heads per Month		IA&T_MoHeads	7.000 *	C	7						

What About Costs for the Entire Schedule?



- **System Engineering and Program Management are LOE Throughout Entire Effort**
  - Both are Manpower Based Estimates
    - Sys Eng Monthly Heads = 12
    - Project Management Monthly Heads = 6

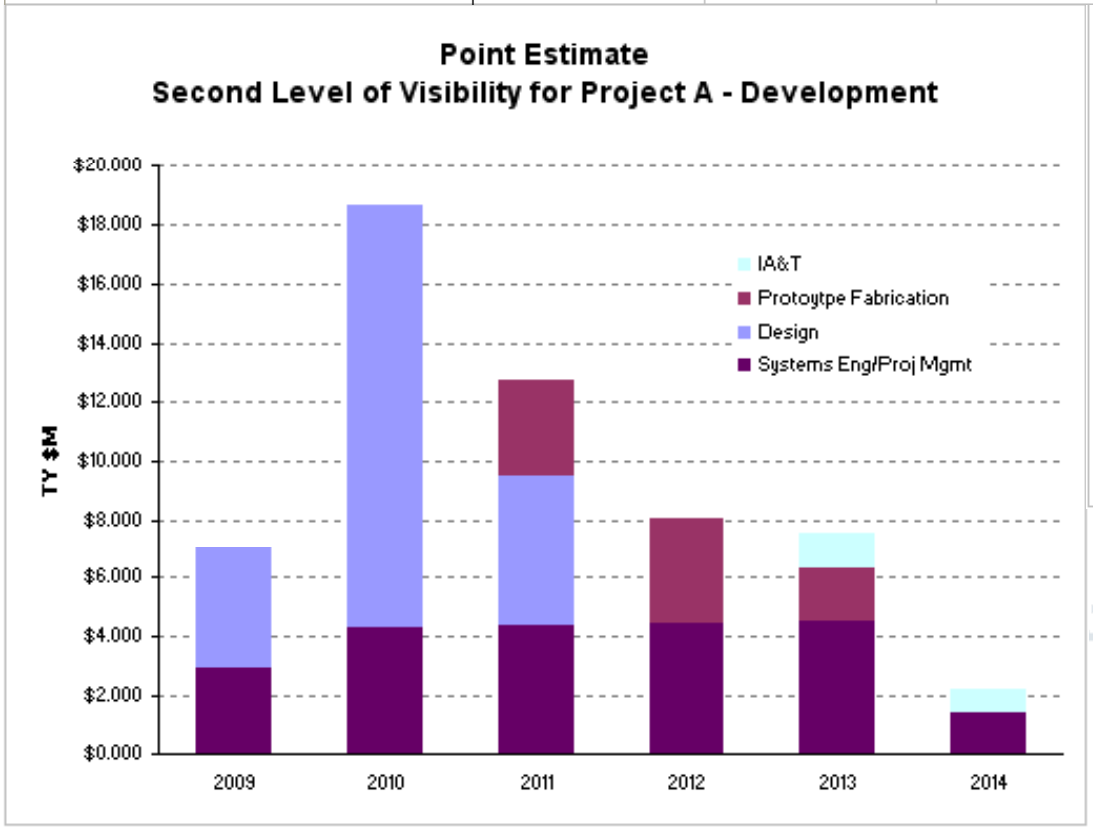
Determining Total Date Range

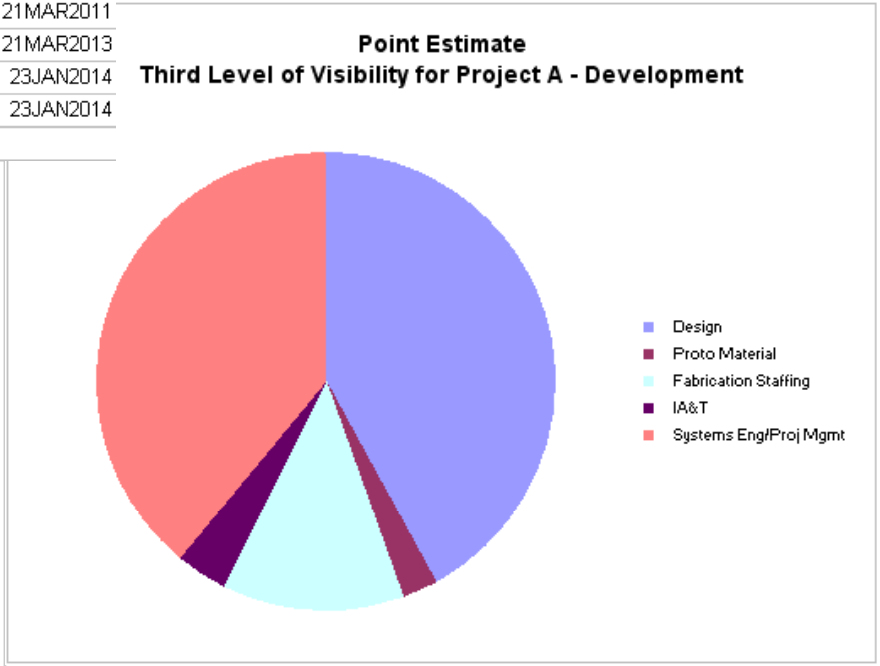
- Min() Function Used to Calculate Earliest Start Date
- Max() Function Used to Calculate Latest Finish Date
- DateMonthDiff() Used to Calculate Duration

WBS/CES Description	Approp	Unique ID	Point Estimate	Phasing Method	Equation / Throughput	Fiscal Year	Units	Start Date	Finish Date	Trapezoid % Ramp	Trapezoid % Steady
*Project A - Development Es		*Estimate									
Project A - Development			$ 49.956 *								
Design	3600	Design_$	$ 22.841 *	BE	2306 *wt ^ 0.7	2004	$K	Dsn_Start	DateAdd(aStartDate,0,Dsn_Duration,0)		
Protoytpe Fabrication			$ 8.028 *								
Proto Material	3600	Fab_Mat$	$ 1.228 *	TS	1.2	2008	$M	DateAdd(Design_$.aFinishDate,0,0,1)	DateAdd(aStartDate,0,0,1)	0	100
Fabrication Staffing	3600	Fab_Man$	$ 6.800 *	TS	6.8	2009	$M	DateAdd(Design_$.aFinishDate,0,0,1)	DateAdd(aStartDate,0,Fab_Duration,1)	0	100
IA&T	3600	IA&T_$	$ 1.855 *	TS	(IA&T_MoHeads * IA&T_MoBurn) * IA&T_Duration			DateAdd(Fab_Man$.aFinishDate,0,0,1)	DateAdd(aStartDate,0,IA&T_Duration,1)	0	100
Systems Eng/Proj Mgmt	3600	SEPM_$	$ 17.233 *	TS	((SE_MoHeads * SE_MoBurn) + (PM_MoHeads * PM_MoBurn)) * SEPM_Duration			Min(Design_$.aStartDate, Fab_Mat$.aStartDate, Fab_Man$.aStartDate, IA&T_$.aStartDate)	Max(Design_$.aStartDate, Fab_Mat$.aStartDate, Fab_Man$.aStartDate, IA&T_$.aStartDate)	0	100
*INPUT VARIABLES		*IN_VAR									
* SE/PM Info											
Total SE/PM Duration (months		SEPM_Duration	50.097 *	C	DateMonthDiff(SEPM_$.aStartDate, SEPM_$.aFinishDate)						
SE MonthlyBurnRate per Head	3600	SE_MoBurn	$ 0.029 *	C	28.5	2009	$K				
SE Avg Heads per Month		SE_MoHeads	8.000 *	C	8						
PM MonthlyBurnRate per Hea	3600	PM_MoBurn	$ 0.029 *	C	29	2009	$K				
PM Avg Heads per Month		PM_MoHeads	4.000 *	C	4						

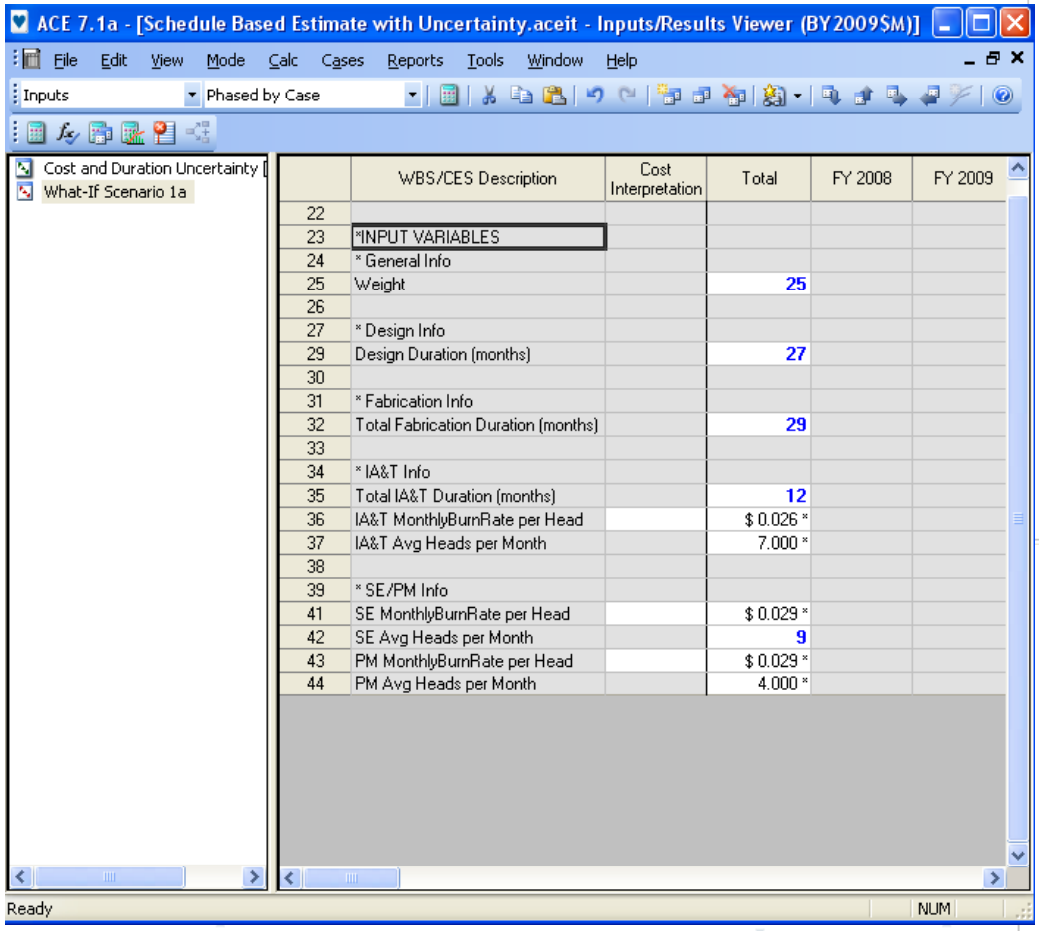
End Result is a Cost Model Tied to a Schedule

WBS/CES Description	Total	Result: Start Date	Result: Finish Date
Project A - Development	$ 53.408		
Design	$ 22.841	19JAN2009	19MAR2011
Protoytpe Fabrication	$ 8.028		
Proto Material	$ 1.228	20MAR2011	21MAR2011
Fabrication Staffing	$ 6.800	20MAR2011	21MAR2013
IA&T	$ 1.855	22MAR2013	23JAN2014
Systems Eng/Proj Mgmt	$ 20.684	19JAN2009	23JAN2014

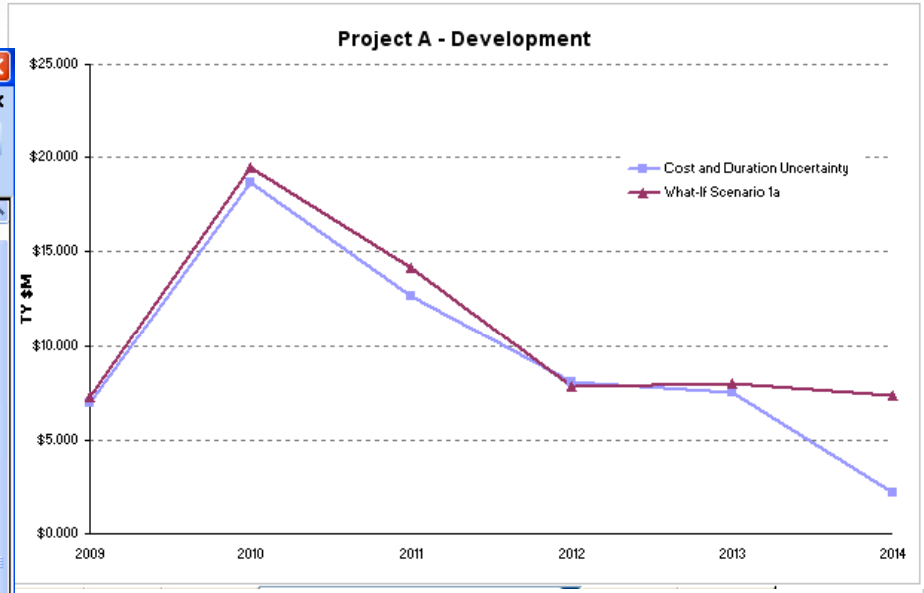


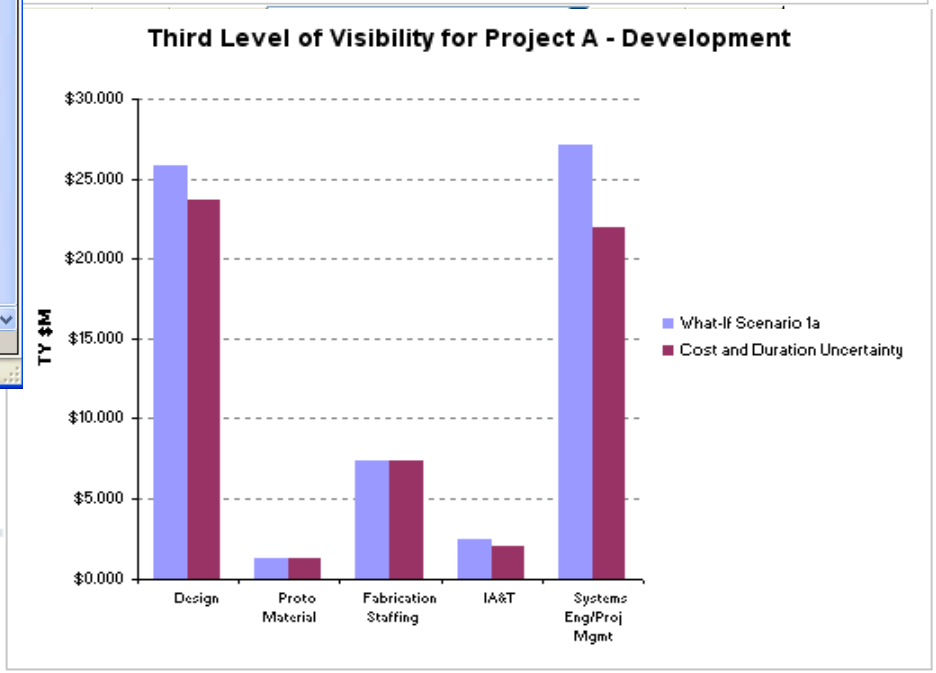


Sensitivities can be Conducted

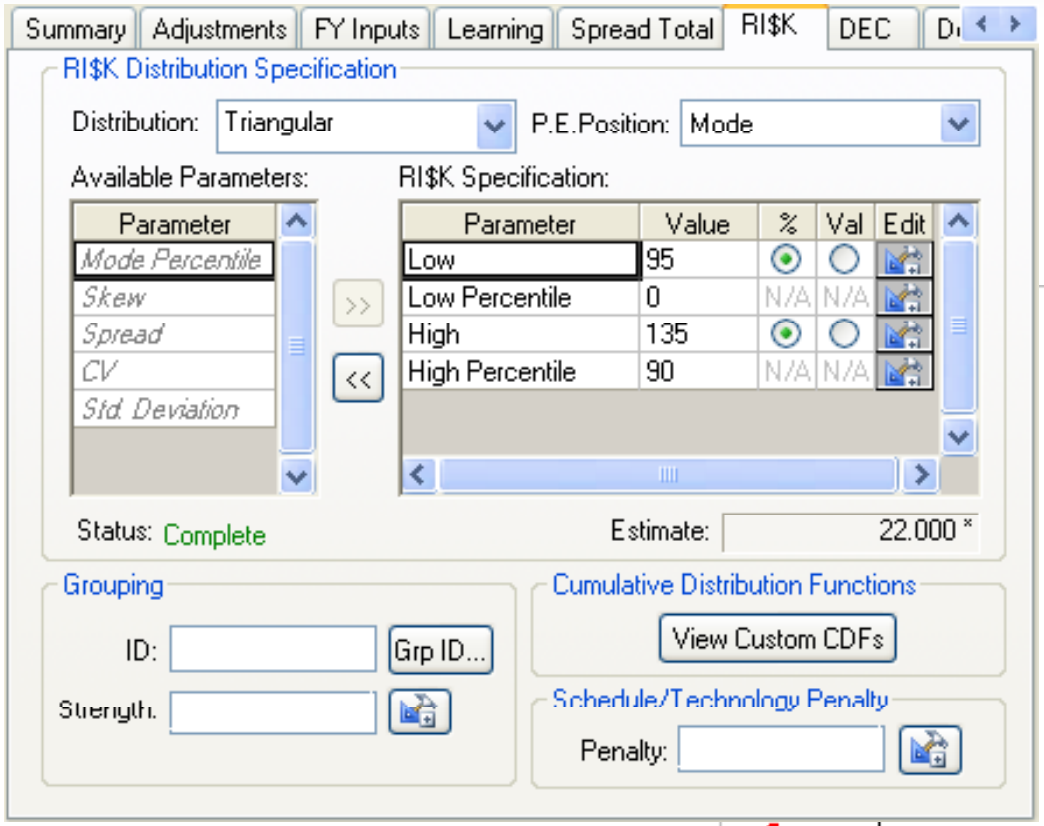


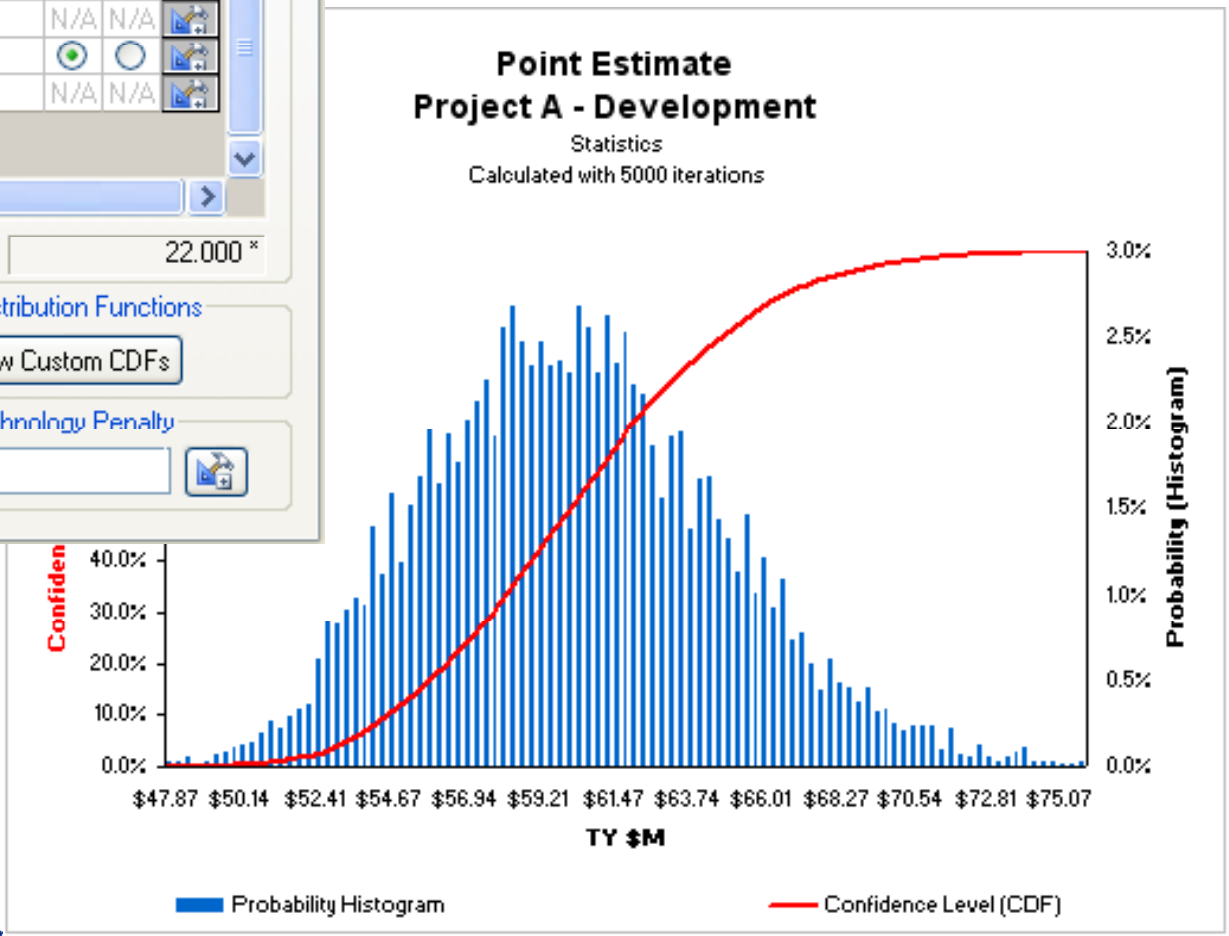
	WBS/CES Description	Cost Interpretation	Total	FY 2008	FY 2009
22					
23	*INPUT VARIABLES				
24	* General Info				
25	Weight		25		
26					
27	* Design Info				
29	Design Duration (months)		27		
30					
31	* Fabrication Info				
32	Total Fabrication Duration (months)		29		
33					
34	* IA&T Info				
35	Total IA&T Duration (months)		12		
36	IA&T MonthlyBurnRate per Head		$ 0.026 *		
37	IA&T Avg Heads per Month		7.000 *		
38					
39	* SE/PM Info				
41	SE MonthlyBurnRate per Head		$ 0.029 *		
42	SE Avg Heads per Month		9		
43	PM MonthlyBurnRate per Head		$ 0.029 *		
44	PM Avg Heads per Month		4.000 *		



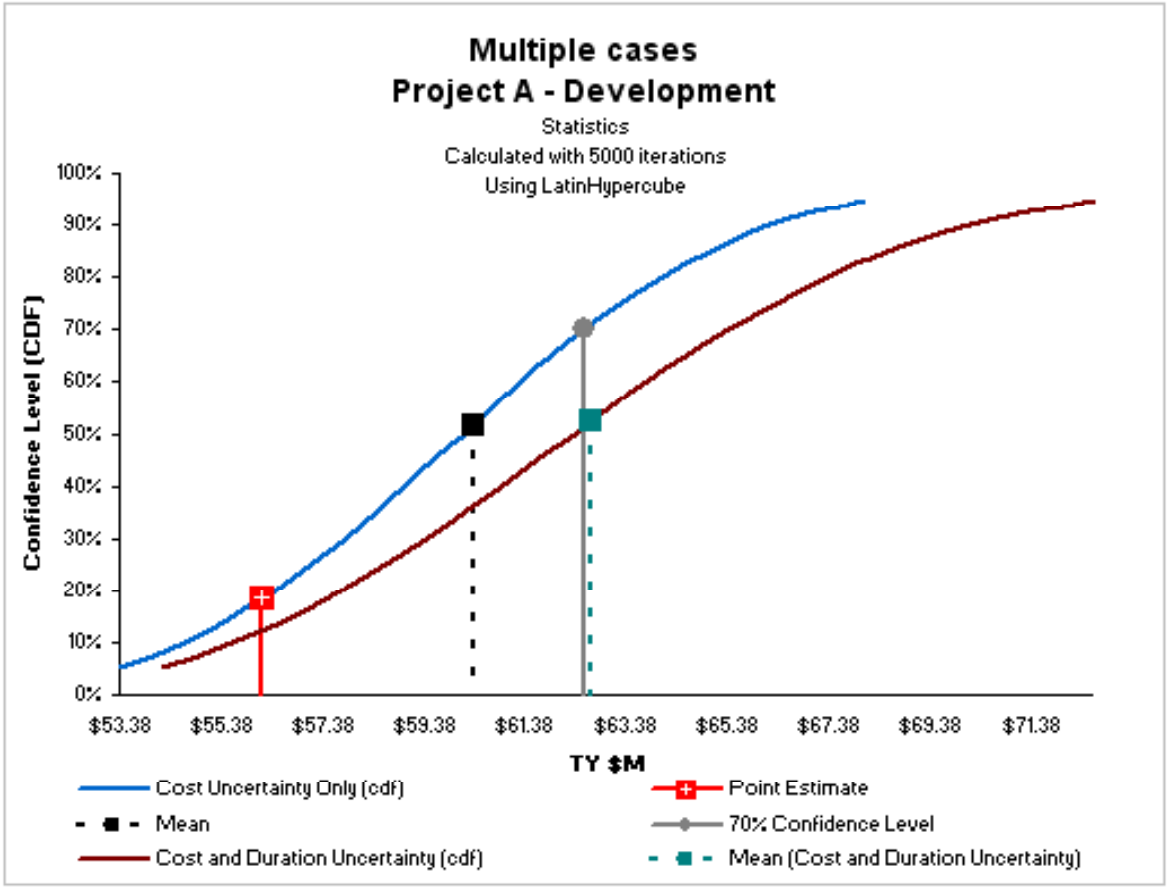


Uncertainty can be Modeled for Cost





Incorporating Duration Uncertainty Changes Results



Key Enablers

Key Enablers

- **ACE Standard Functionality for Equations and Phasing**
- **ACE Advanced Functionality for Date Calculations, Logic, and Uncertainty Analysis**
  - Trapezoid Phasing
  - DECs
  - RI$K
- **ACE Functions**
  - DateAdd()
  - Min()
  - Max()
  - DateMonthDiff()

DateAdd()

DATE ADD function

Purpose:

This function returns the Julian date of a specified date after adding the specified number of years, months and days.

Syntax:

DateAdd (Date, Year [, Month [,Day]])

Date

This argument is the date to be changed. The proper syntax is in the ACE DDMMMYYYY format (e.g., 01OCT2004) and can be either entered directly into the function, specified as an Excel Julian date, or referenced as a variable.

Year

This argument is used to reference the number of years to add or subtract from the given date. This function allows you to enter positive or negative integer numbers to either add or subtract years. Fractional years will be truncated. This argument can be either entered directly into the function or referenced as a variable.

[Month]

This is an optional argument used to reference the number of months to add or subtract from the given date. This function allows you to enter positive or negative integer numbers to either add or subtract months. Fractional years will be truncated. This argument can be either specified as an equation, a value, or a variable. If no month is specified, the function defaults to 0.

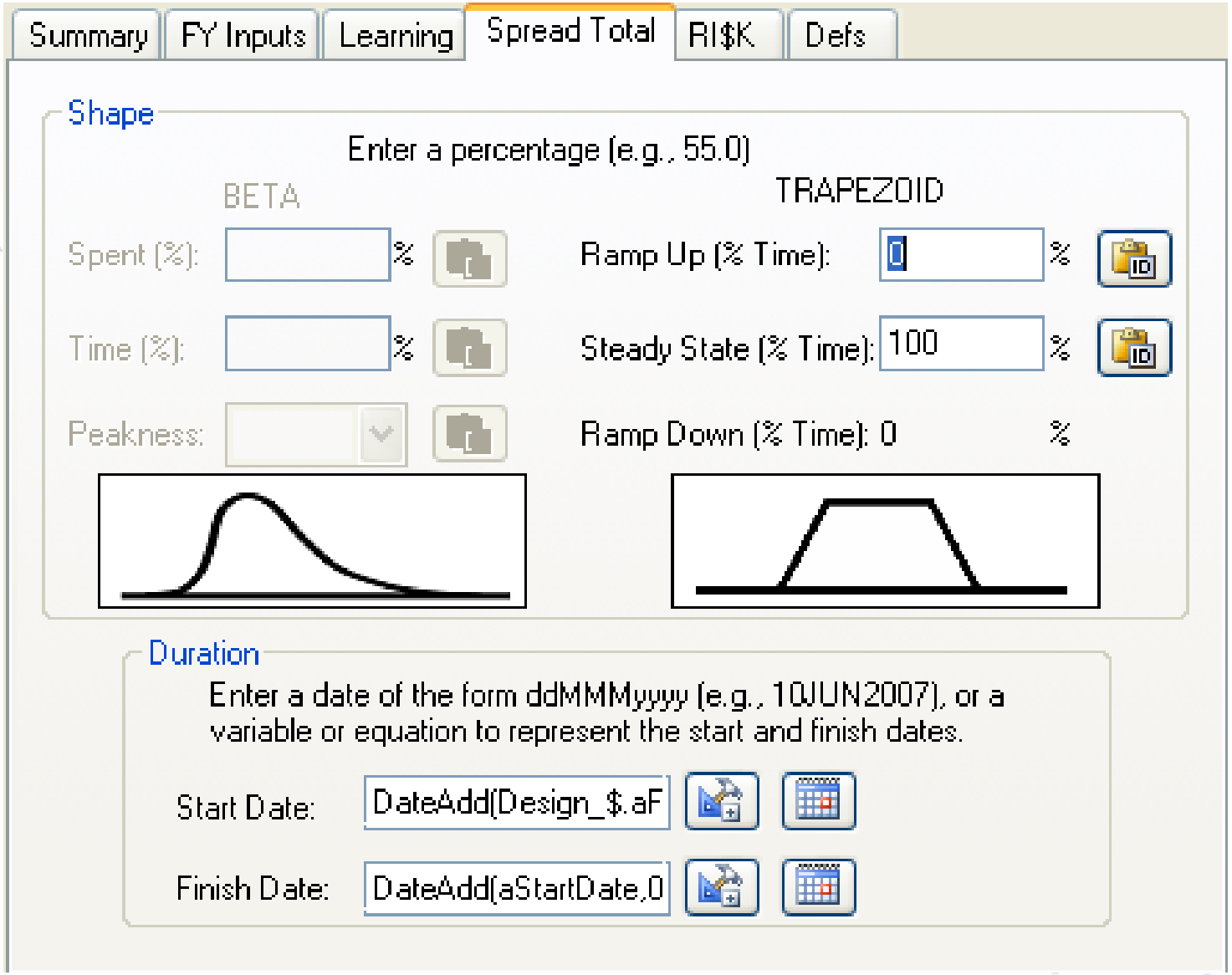
[Day]

This is an optional argument used to reference the number of days to add or subtract from the given date. This function allows you to enter positive or negative integer numbers to either add or subtract days. Fractional years will be truncated. This argument can be either specified as an equation, a value, or a variable. If no day is specified, the function defaults to 0.

Remarks:

1. This function can be used in conjunction with the DATEOF(), DATEDAY(), DATEMN(), and DATEYR() functions to create a new date adjusted for the given number of days, months and years.
2. The Year, Month and Day arguments can be specified as negative or positive values.
3. ACE adjusts for the last day of the month so if you specify a date as 30Jun2004 and add 1 month, the resulting date will be 31Jul2004.
4. This function can be used within other functions as part of an expression.
5. All dates must be specified between January 1, 1910 and December 31, 2999.

Trapezoid Phasing



Dynamic Equation Columns (DECs)

DECs are user-defined columns that are most commonly used for intermediate inputs or calculations on a row. They are a way to make your session wider (i.e., more columns) instead of longer (i.e., more rows). You can add a DEC by clicking on **Edit > Add DEC** from the ACE main menu, or by clicking the Add New DEC icon () on the Session Construction toolbar.

There are four types of DECs available in ACE:

1. Normal - Column holds non-cost data and/or equations. Select this when the variable you are entering is not a cost. This means that ACE doesn't need to inflate/deflate the value or change its units in any way before calculating.
2. Cost - Column holds cost data and/or equations. Select this when the variable you are entering is a cost. This means that ACE needs to inflate/deflate the value to the base year of the estimate and adjust the units before calculating. The base year and units of the cost entered are assumed to match the fiscal year and units entered on the line for the equation. If they are different, you will need to add the parameter in the usual way in the Input Variables section of the workscreen.
3. Comment - Column holds comments and text that is not evaluated. Select this when you do not want ACE to do anything with this information except store it in the column. Data stored here will not be used in any ACE calculations for the row.
4. Date - Column holds dates of the form ddMMMyyyy. Select this when that the variable you are entering is a date. This means that when ACE calculates, the value will remain in date format and not be changed to a Julian date.

Select the "Sum up results of children into their parents for this column" check box if you want the traditional ACE hierarchy to be in effect, i.e., the children sum to their parents. If you do not wish to see a total at the parent level, remove the check from this box. This checkbox is disabled if the DEC type is either a Date or a Comment.

You can quickly see what type of DEC column you have created by noting the character that separates the column unique ID from the column description. There are six types summarized below.

SYMBOL	MEANING
+	Summing Normal DEC
!	Non-Summing Normal DEC
$	Summing Cost DEC
!$	Non-Summing Cost DEC
*	Comment DEC
Date	Date DEC

Once you have created a DEC, you need to know how to reference the data in that DEC. You can reference data in the DEC on the row where it's defined, or on another row. To reference the DEC data on the current row, simply type the DEC name in the Equation/Throughput column (e.g., DECID). To reference the data on a different row, you must ensure that the row of the DEC data you wish to reference contains a Unique ID. You can then reference the DEC data using dot notation (e.g., UniqueID.DECID).

Min()

MINimum

Purpose:

This function returns the minimum value from a list of values.

Syntax:

Min (x, y, ... **)**

x, y, ...

This argument a series of two or more numbers, variable names, or valid expressions separated by commas.

Remarks:

1. This function can be used within other functions as part of an expression.
2. This function can be used to evaluate the result of complex functions.

Example:

1. **MIN**(10,80) = 10
2. **MIN**(10,80,110) = 10
3. **MIN**(-1,-5,-10) = -10
4. **MIN**(0.6*a,0.2*b) = 6, for a=10, b=100

Max()

MAXimum

Purpose:

This function returns the maximum value from a list of values.

Syntax:

Max (x, y, ... **)**

x, y, ...

This argument is a series of two or more numbers, variable names, or valid expressions separated by commas.

Remarks:

1. This function can be used within other functions as part of an expression.
2. This function can be used to evaluate the result of complex functions.

Example:

1. **MAX**(10,80) = 80
2. **MAX**(10,80,110) = 110
3. **MAX**(-1,-5,-10) = -1
4. **MAX**(0.6*a,0.2*b) = 20, for a=10, b=100

DateMonthDiff

DATE Month Difference function

Purpose:

This function returns the number of months between the two dates specified.

Syntax:

DateMonthDiff (*FromDate, ToDate*)

FromDate

This argument is the first day of the date range. The proper syntax is in the ACE DDMMMYYYY format (e.g., 01OCT2004) and can be either entered directly into the function, specified as an Excel Julian date , or referenced as a variable.

ToDate

This argument is the last day of the date range. The proper syntax is in the ACE DDMMMYYYY format (e.g., 01OCT2004) and can be either entered directly into the function, specified as an Excel Julian date , or referenced as a variable.

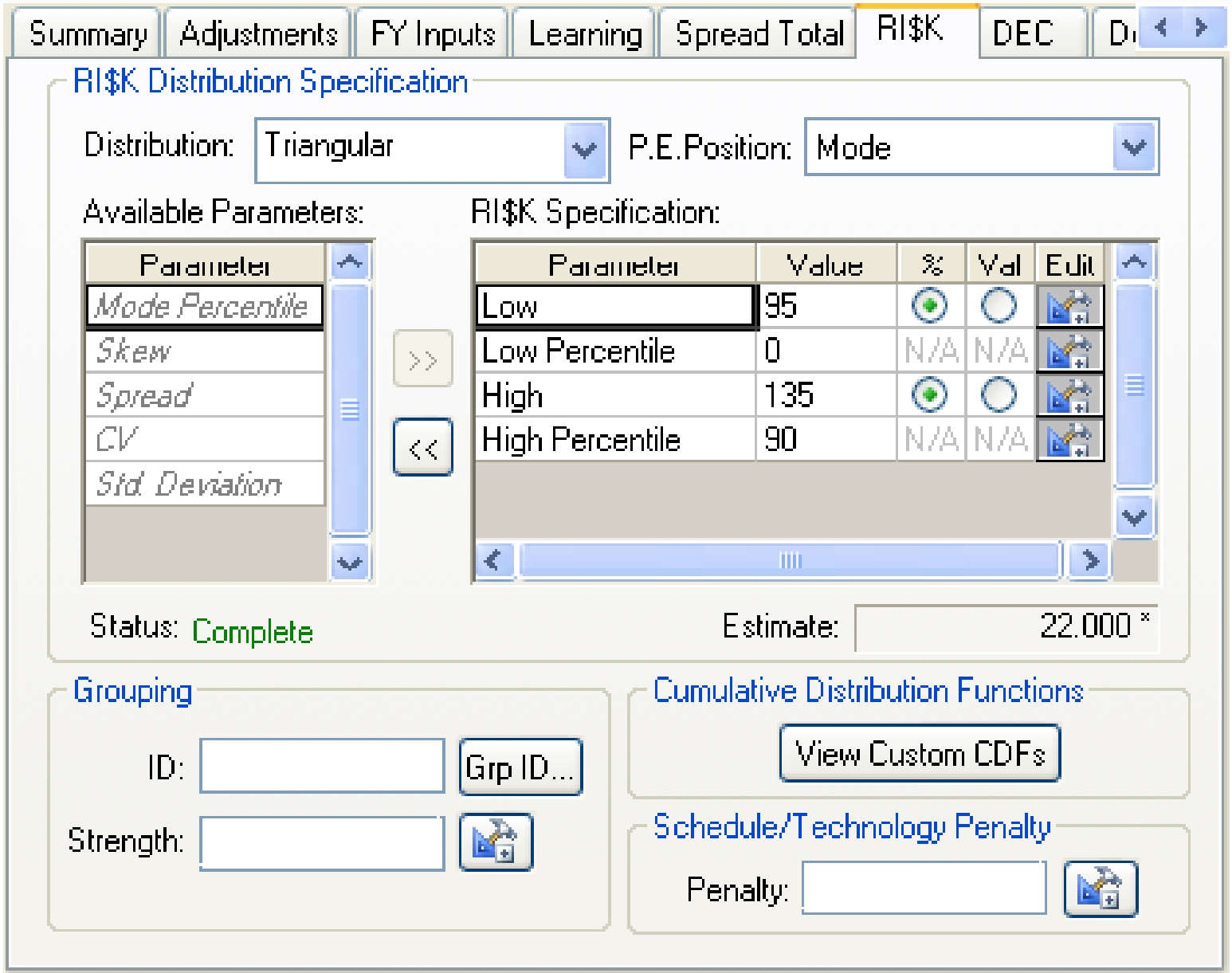
Remarks:

1. This function can be used with years instead of dates and ACE will use the first day of the year.
2. This function can be used within other functions as part of an expression.
3. All dates must be specified between January 1, 1910 and December 31, 2999.

Example:

1. DateMonthDiff(01OCT2004,30Sep2007) returns "35.967" as the number of months between the 2 dates.
2. DateMonthDiff(25Dec2010, 30Sep2007) returns "-38.808" as the number of months between the 2 dates.

Uncertainty Analysis



Summary

- Use ACE to make an Estimate Sensitivity to Schedule
- Calculate Dates Based on Duration Inputs
- Enter and Calculate Date Logic
- Estimate Costs Based on Inputs
- Phase and Inflate Costs Over the Duration
- Obtain Annual Phased Values
- Input and Calculate Uncertainty

WBS/CES Description	Approp	Unique ID	Cost and Duration	Phasing Method	Equation / Throughput	Fiscal Year	Units	Start Date	Finish Date
*Project A - Development Estimate		*Estimate							
Project A - Development			$ 53.408 *						
Design	3600	Design_$	$ 22.841 *	BE	2306 *wt ^ 0.7	2004	$K	Dsn_Start	DateAdd(aStartDate,0,Dsn_Duration,0)
Protoytpe Fabrication			$ 8.028 *						
Proto Material	3600	Fab_Mat$	$ 1.228 *	TS	1.2	2008	$M	DateAdd(Design_$.aFinishDate,0,0,1)	DateAdd(aStartDate,0,0,1)
Fabrication Staffing	3600	Fab_Man$	$ 6.800 *	TS	6.8	2009	$M	DateAdd(Design_$.aFinishDate,0,0,1)	DateAdd(aStartDate,0,Fab_Duration,1)
IA&T	3600	IA&T_$	$ 1.855 *	TS	(IA&T_MoHeads * IA&T_MoBurn) * IA&T_Duration			DateAdd(Fab_Man$.aFinishDate,0,0,1)	DateAdd(aStartDate,0,IA&T_Duration,1)
Systems Eng/Proj Mgmt	3600	SEPM_$	$ 20.684 *	TS	((SE_MoHeads * SE_MoBurn) + (PM_MoHeads * PM_MoBurn)) *			Min(Design_$.aStartDate, Fab_Mat$.aStartDate, Fab_Man$.aStartDate, IA&T_$.aStartDate)	Max(Design_$.aFinishDate, Fab_Mat$.aFinishDate, Fab_Man$.aFinishDate, IA&T_$.aFinishDate)

The End

Copyright © Tecolote Research, Inc. January 2009