



Automated Cost Estimating Integrated Tools

Challenges with Using Spreadsheets for Cost Analysis: ACE versus Spreadsheets Executive Summary

ACEIT version 7.5

May 2017



TECOLOTE
RESEARCH

■ **Would you continue to use this...**



■ **If you had one of these...**



- **Decision makers need estimate information that is accurate, timely and actionable**
 - Spreadsheets have limitations in supporting cost estimating and analysis
 - Takes longer: more steps to build and maintain
 - Prone to inaccuracies
 - Oversimplified solutions due to limitations in spreadsheet mechanics
 - Managing scenarios with multiple What-if drills is difficult and time consuming
 - ACE provides consistency and efficiencies
 - Government developed specifically to support cost estimating and analysis
- **This presentation explores the significant differences between spreadsheets and ACE; it demonstrates why ACE is the standard for many organizations**

ACEIT: Celebrating 30 Years of Cost Estimating Excellence

ACE Compared with Traditional Spreadsheets

- **ACE's design promotes time savings and estimate accuracy**
 - Designed to apply cost estimating techniques with minimal effort
 - Minimizes time associated with spreadsheet structuring
 - Saves time to calculate core cost estimating techniques
- **Open architecture in spreadsheets creates major challenges**
 - **Takes longer** to set up; must create estimate structure, mechanics and methods
 - **Errors** can easily go undetected
 - **Limited standardization** presents difficulties in transferring estimates/models to other analysts for review, revision and follow-on effort
 - File link issues between estimate, documentation and reporting

A trained ACE user can build an estimate in a fraction of the time required to do the same effort in a spreadsheet

- **Approach to supporting cost estimates and analysis**
 - Bring **structure** and **consistency** to the process
 - **Focuses on estimate methodology** rather than spreadsheet mechanics
 - Incorporate **approved processes** to perform repetitive functions
 - Eliminates many sources of errors found in spreadsheets
 - **Promote efficiency**; standardized methodology, auditing, documentation/reporting

- **ACEIT is designed for and by cost analysts**
 - Available to government, support contractors and commercial users
 - Training delivered by experienced cost analysts and ACEIT users

Approach for Spreadsheet and ACE Comparison

- Easiest way to understand differences between spreadsheets and ACE is to visualize a side by side example
- This exploration is broken into sections to compare different aspects of the key characteristics of cost estimates
 - Section 1: Basic Estimate Structure
 - Section 2: Basic Estimate Calculations
 - Section 3: Complex Estimating Problems
 - Section 4: Adding WBS Elements to the Estimate
 - Section 5: What if Drills
 - *The imbedded uncertainty analytics in ACE are a known benefit: they are not highlighted in this presentation*

**This presentation shows items from a detailed example available on
www.aceit.com**

Example for Comparison

Power Generation Plant Example

- Defined WBS
 - RDT&E, Procurement and OS Phases
- Defined Ground Rules and Assumptions
 - Detailed Schedule
 - Plant Engine Quantities
 - 10 development
 - 70 time phased procurement
 - 10 year engine service life
 - Technical Characteristics
 - Material weights
 - Engine specifications
 - Software Definition
 - Software Lines of Code
 - Staffing Levels
- Estimate Documentation
 - What is being estimated
 - Estimating method applied
- Estimate Results and Reporting



POWER GENERATION PLANT	
1	RDT&E
1.1	Prime Mission Product
1.1.1	Hardware (HW)
1.1.1.1	Structure
1.1.1.2	Cables, Conduits, and Connectors (CCC)
1.1.1.3	Engine (with learning)
1.1.2	Software (SW)
1.1.2.1	CSCI1
1.1.2.2	CSCI2
1.1.2.3	CSCI3
1.1.3	Integration and Assembly (I&A)
1.1.3.1	I&A Check-Out
1.1.3.2	HW/SW Integration
1.1.3.3	Tooling and Test Equipment
1.2	SEPM (RDT&E)
1.3	Training
1.4	Data
1.5	System Test and Evaluation (ST&E)
2	Procurement
2.1	Manufacturing
2.1.1	Hardware (HW)
2.1.1.1	Structure
2.1.1.2	Cables, Conduits, and Connectors (CCC)
2.1.1.3	Engine (with learning)
2.1.2	Integration
2.2	SEPM (Procurement)
2.3	Other
3	Operations and Support
3.1	Unit Level Maintenance
3.2	Software Maintenance
3.2.1	Software Maintenance Support
3.2.2	Software Maintenance Upgrade

Comparison Illustrations

- Each major topic area is illustrated in both the spreadsheet and ACE
 - Highlights challenges with spreadsheets and the benefits of ACE

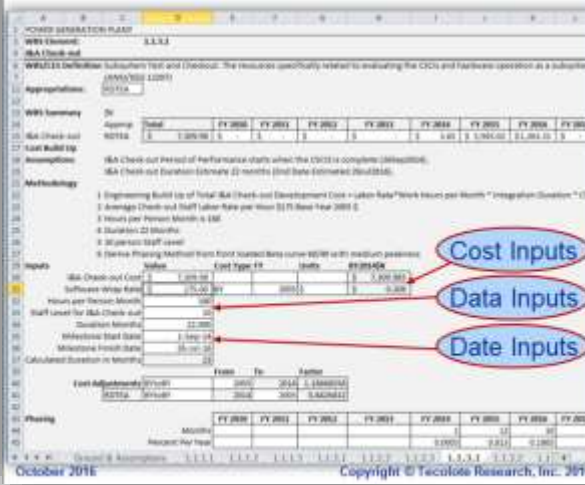
Spreadsheet: Estimate Inputs

Even the most basic estimating methodologies have multiple inputs to generate a time phased cost estimate

- Example: Integration and Assembly Cost
- Inputs include: Labor Rate, Staff Level, Work Hours per Month, Duration, and Start Date

Challenges

- Ensure all inputs are included
- Develop a consistent input approach for others to follow, update or review
- Ensure that inflation is properly and consistently applied
- Track inputs used in multiple estimate methods
- Link inputs with logical relationships: schedules and component-to-total items
- Document inputs and methods
- Manage changes in methods and inputs



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ACE: Estimate Inputs

Each Input is stored on a separate row of the ACE estimate

Each Input must be fully defined with parameters to pass the syntax check

- Example: Cost rows must have Approp, Fiscal Year and Units

WBS/CES Description	Approp	Unique ID	Tech Baseline	Planning Method	Equation / Throughput	Fiscal Year	Units	Start Date	Finish Date
Powerplant System Estimate			Estimate						
Integration and Assembly (IA) Check-Out	RDTEA								
*INPUT VARIABLES			*IN_VAR						
* General Inputs									
Ins per Pers Month		InsPerPersMth		C			180		
* Dates Derived From Durations									
HW Start Date		HWStartDate	01MAR2011	C				01MAR2011	
HW End Date		HWEndDate	01SEP2012	C	DATEADD(HWStartDate, 0, HWDurationMths)				
CSC1 Start Date		CSC1_StartDate	01MAR2011	C	DATEADD(HWEndDate, 0, -E)				
CSC2 Start Date		CSC2_StartDate	01NOV2012	C	DATEADD(CSC1_StartDate, 0, CSC2_Dur)				
CSC3 Start Date		CSC3_StartDate	01AUG2013	C	DATEADD(CSC2_StartDate, 0, CSC3_Dur)				
IA Start Date		IAStartDate	26SEP2014	C	DATEADD(CSC3_StartDate, 0, CSC3_Dur)				
IA End Date		IAEndDate	26JUL2016	C	DATEADD(IAStartDate, 0, HWIntg_Dur)				
* Durations									
HW Integration Duration		HWIntg_Dur	22.0	C			22		
* Annual Staff Levels									
Staff Level HW SW Integration (low E)		StaffLvlHwSwIntg	14.0	C			14		
* Wrap Rates									
IA Wrap Rate	RDTEA	IAWrapRate	\$ 0.200	C			170	2005	

Benefits

- Row definition institutes consistency in input entry: easy to follow, update and review
- Proper inflation factors applied to cost rows from definition parameters: easy to change inputs
- Syntax check reduces errors of omission and error log provides guidance to correct issues

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Section #1

Basic Estimate Structure

- All estimates need basic structure to calculate a credible estimate
- Section 1: Basic Estimate Structure
 - Estimate Layout
 - Work Breakdown Structure (WBS)
 - Estimate WBS set up
 - WBS documentation and definition
 - WBS roll-up calculation
 - Basic Inflation Calculation
 - Inflating source costs to Base Year of the estimate
 - Calculating Estimate Then Year budget results
 - Setting up Ground Rules and Assumptions
 - Base Year of estimate
 - Underlying assumptions in creating the estimate

If the structure is not standardized the estimate quickly becomes unmanageable



Section #1 Estimate Layout

Challenges

- Estimate start focuses on estimate layout
- Work in many worksheets to organize data, calculations, and reports
- Training: new analyst must learn spreadsheet layout before work can begin

Benefits

- Estimate start focuses on WBS definition, input variables, and methodology building
- Single tabbed spreadsheet simplifies audit process: entire estimate visible by scrolling
- Training: ACE trained analysts can pick up new estimates and almost immediately make progress

ACE 7.5 - [Power Plant Demo ACE vs Spreadsheet Oct 2016.aces - Methodology]

WBS/CES Description	Approp	Unique ID	Tech Baseline	Phasing Method	Equation / TI
7 * Powerplant System Estimate			*Estimate		
8 POWER GENERATION PLANT	RDTEA		\$ 510,048,105 *		
9 RDTE&E	RDTEA		\$ 128,286,402 *		
10 Prime Mission Product	RDTEA		\$ 91,142,702 *		
11 Hardware (HW)	RDTEA	HW\$	\$ 31,964,729 *		
12 Structure	RDTEA	StructDev\$	\$ 23,467,610 *	BE	
13 Cables, Conduits, and Connector	RDTEA	CCCDev\$	\$ 2,118,063 *	BE	
14 Engine	RDTEA		\$ 6,379,057 *	BE	
15 Software (SW)	RDTEA	SW\$	\$ 38,710,019 *		
16 CSC11	RDTEA		\$ 10,083,809 *	BE	SWWrapRate\$ *
17 CSC12	RDTEA		\$ 11,504,203 *	BE	SWWrapRate\$ *
18 CSC13	RDTEA		\$ 17,122,007 *	BE	SWWrapRate\$ *
19 Integration and Assembly (I&A)	RDTEA		\$ 20,467,953 *		
20 I&A Check-Out	RDTEA		\$ 7,309,983 *	BE	I&AWrapRate\$ * HrsPerPer
21 HW/SW Integration	RDTEA		\$ 10,233,977 *	BE	I&AWrapRate\$ * HrsPerPer
22 Tooling and Test Equipment	RDTEA		\$ 2,923,993 *	BE	I&AWrapRate\$ * HrsPerPer
23 SEPM (RDT&E)	RDTEA		\$ 32,812,240 *	BE	SEPMWrapRate\$ * Hrs
24 Training	RDTEA		\$ 958,942 *	BE	
25 Data	RDTEA		\$ 706,747 *	BE	D
26 System Test and Evaluation (ST&E)	RDTEA		\$ 2,665,771 *	BE	ST&EWrapRate\$ * Hrs
27					
28 Procurement	OPA		\$ 278,967,433 *		

Section #1 WBS Roll-up

PowerPlant Spreadsheet Model Oct 2016.xlsx - Microsoft Excel

File Home Insert Page Layout Formulas Data Review View

Normal Page Layout Full Screen Workbook Views

OFFSET $=E7+E11+E15$

Results		Base Year 2014					Units \$K	
WBS/Item	* Power Plant System Estimate	Approp	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	
1	POWER GENERATION PLANT		\$ -	\$ 19,428.80	\$ 33,248.65	\$ 23,297.91	\$ 22,539.91	
1	1 RDT&E		\$ -	\$ 19,428.80	\$ 33,248.65	\$ 23,297.91	\$ 22,539.91	
1.1	1.1 Prime Mission Product		\$ -	$=E7+E11+E15$	\$ 24,530.73	\$ 13,574.07	\$ 15,163.21	
1.1.1	1.1.1 Hardware (HW)		\$ -	\$ 17,416.97	\$ 14,547.76	\$ -	\$ -	
1.1.1.1	1.1.1.1 Structure	RDTEA	\$ -	\$ 13,611.21	\$ 9,856.40	\$ -	\$ -	
1.1.1.2	1.1.1.2 Cables, Conduits, and Connectors (CCC)	RDTEA	\$ -	\$ 105.90	\$ 2,012.16	\$ -	\$ -	
1.1.1.3	1.1.1.3 Engine (with learning)	RDTEA	\$ -	\$ 3,699.85	\$ 2,679.20	\$ -	\$ -	
1.1.2	1.1.2 Software (SW)		\$ -	\$ -	\$ 9,982.97	\$ 13,574.07	\$ 15,152.98	
1.1.2.1	1.1.2.1 CSC1	RDTEA	\$ -	\$ -	\$ 9,982.97	\$ 100.84	\$ -	
1.1.2.2	1.1.2.2 CSC12	RDTEA	\$ -	\$ -	\$ -	\$ 11,504.20	\$ -	
1.1.2.3	1.1.2.3 CSC13	RDTEA	\$ -	\$ -	\$ -	\$ 1,969.03	\$ 15,152.98	
1.1.3	1.1.3 Integration and Assembly (I&A)		\$ -	\$ -	\$ -	\$ -	\$ 10.23	
								3.65

Challenges

- Parent sum equations must be defined for the entire WBS
- Difficulty inserting new WBS elements: requires equation modifications
- Some employ VB macros to calculate the WBS
 - Training required to write macros
 - Macros require maintenance

ACE 7.5 - [Power Plant Demo ACE vs Spre

File Home View Construction Functions Results

Documentation Revision Log Traceback Navigator Input/Results Viewer Workscreen

POWER GENERATION PLANT

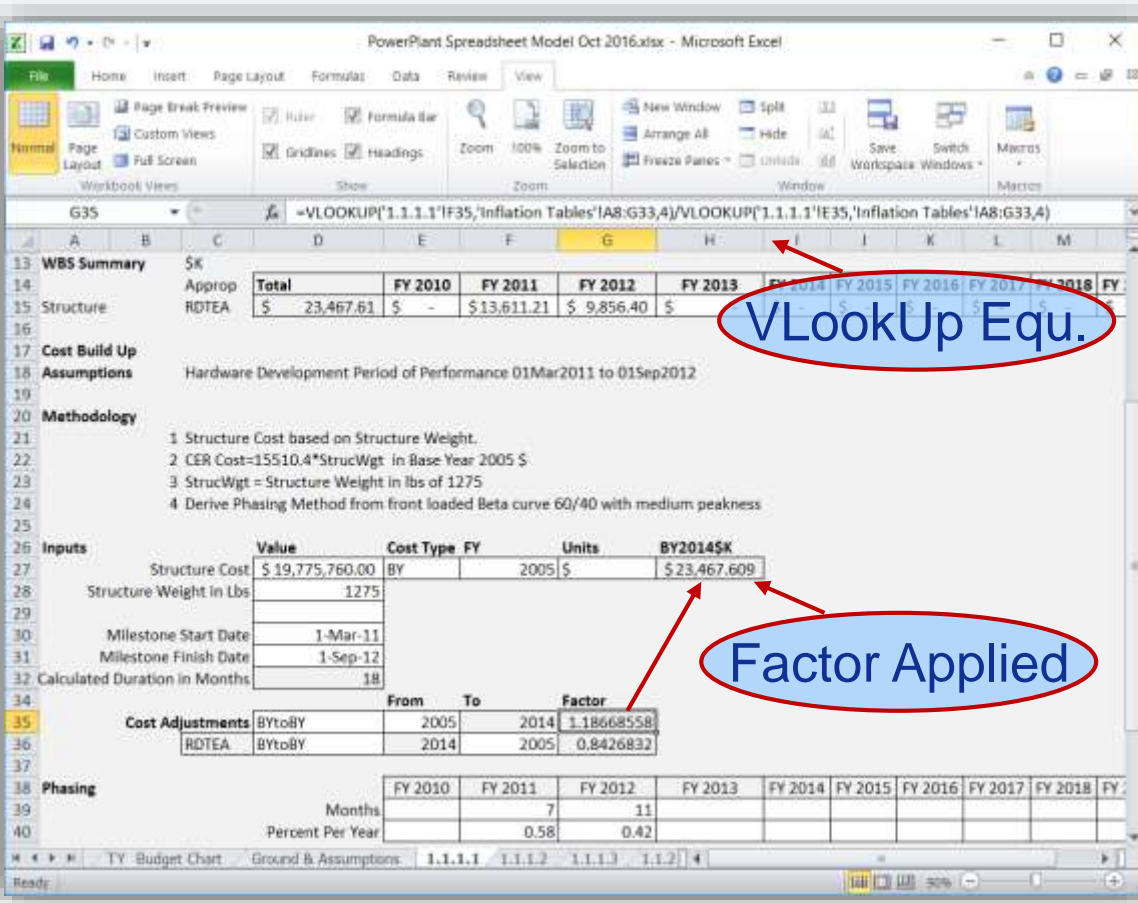
Power Plant ... (BY2014SK)

WBS/CES Description	Approp	Unique ID	Tech Baseline	Phase
* Powerplant System Estimate		*Estimate		
POWER GENERATION PLANT	RDTEA		\$ 510,048.105 *	
RDTE&E	RDTEA		\$ 128,286.402 *	
Prime Mission Product	RDTEA		\$ 91,142.702 *	
Hardware (HW)	RDTEA	HW\$	\$ 31,964.729 *	B
Structure	RDTEA	StructDev\$	\$ 23,467.610 *	B
Cables, Conduits, and Connectors	RDTEA	CCCDev\$	\$ 2,118.083 *	B
Engine	RDTEA		\$ 6,379.057 *	B
Software (SW)	RDTEA	SWS	\$ 38,710.019 *	B
CSC1	RDTEA		\$ 10,083.809 *	B
CSC12	RDTEA		\$ 11,504.203 *	B

Benefits

- No equations at parent rows
- Add, delete or move rows when the WBS/CES changes without re-writing summing equations
- Requires fewer equations
- Eliminates summing errors
- Calculates faster
- Equations focus on estimating methods not spreadsheet mechanics
- Easier to review and audit estimates

Section #1 Inflation Calculation



The screenshot shows a spreadsheet with the following sections:

- WBS Summary:** Total cost of \$23,467,609 for FY 2010.
- Cost Build Up Assumptions:** Hardware Development Period of Performance 01Mar2011 to 01Sep2012.
- Methodology:**
 - Structure Cost based on Structure Weight.
 - CER Cost = 15510.4 * StrucWgt in Base Year 2005 \$.
 - StrucWgt = Structure Weight in lbs of 1275.
 - Derive Phasing Method from front loaded Beta curve 60/40 with medium peakness.
- Inputs:**

Value	Cost Type	FY	Units	BY2014\$K
Structure Cost \$19,775,760.00	BY	2005	\$	\$23,467,609
Structure Weight in Lbs			1275	
- Cost Adjustments:**

	From	To	Factor
RDTEA	2005	2014	1.18668558
RDTEA	2014	2005	0.8426832
- Phasing:**

	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018
Months		7	11						
Percent Per Year		0.58	0.42						

- ## Challenges
- Updating inflation tables: high volume of small equation changes
 - For inflation factor updates, links require updates and repairs
 - Adding Fiscal Years (FYs) or expanding Approps used requires changes throughout the workbook

- ## Benefits
- Inflation consistently applied
 - No equations to incorporate inflation
 - Easy to add new Approp. and FYs to the estimate
 - Easy to update government inflation tables each year

WBS/CES Description	Approp	Unique ID	Tech Baseline	Phasing Method	Equation / Throughput	Fiscal Year	Units
105 * Wrap Rates							
106 I&A Wrap Rate	RDTEA	I&AWrapRate\$	\$ 0.208 *	C	175	2005	\$
107 Software Wrap Rate	RDTEA	SWWrapRate\$	\$ 0.261 *	C	220	2005	\$
108 SEPM Wrap Rate	RDTEA	SEPMWrapRate\$	\$ 0.178 *	C	150	2005	\$
109 ST&E Wrap Rate	RDTEA	ST&EWrapRate\$	\$ 0.231 *	C	195	2005	\$

Basic Estimate Calculations

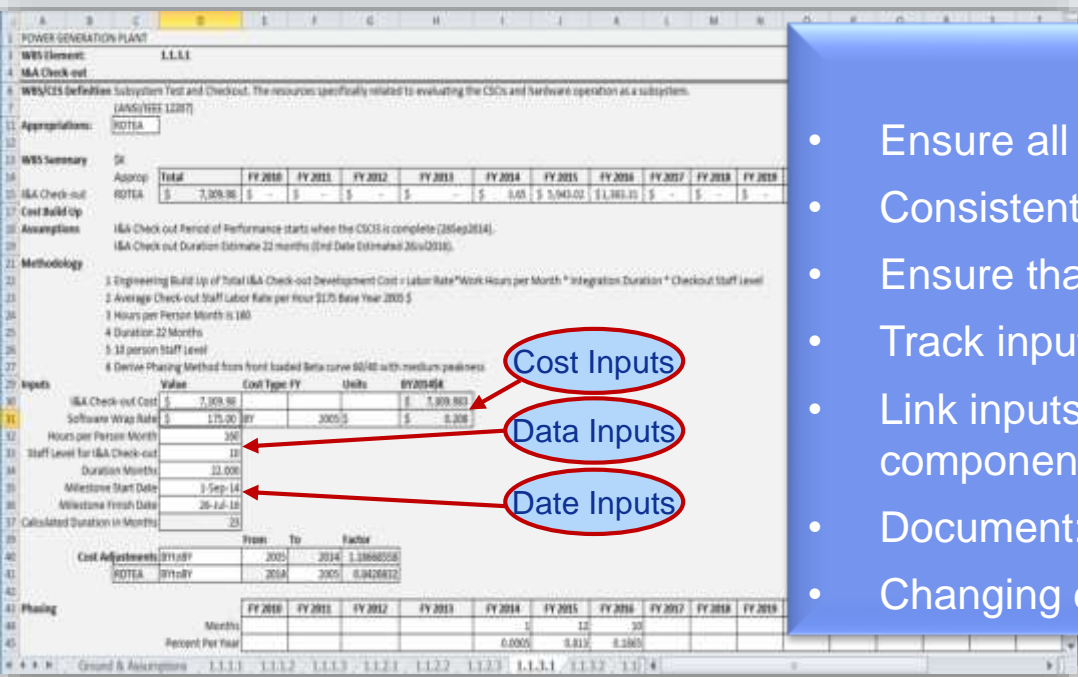
- Each estimate methodology consists of inputs, equations or throughputs
- **Section 2: Basic Estimate Calculations**
 - Estimate Inputs
 - Constant data inputs: non-costs
 - Constant cost inputs
 - Time phased data and costs
 - Schedule inputs: dates and durations
 - Basic Equations
 - Engineering build up equations
 - Factor analogy equations
 - Cost Estimating Relationships (CERs)
 - Time Phased Throughputs
 - Base Year and Then Year throughputs

A consistent approach to inputs, equations and throughputs is necessary for a defensible estimate

Section #2 Estimate Inputs

Challenges

- Ensure all inputs are included
- Consistent input formatting to easily update and review
- Ensure that inflation is properly and consistently applied
- Track inputs used in multiple estimate methods
- Link inputs with logical relationships: link schedules and component-to-total system items
- Document: inputs and methods
- Changing estimating methods and inputs



POWER GENERATION PLANT

WBS Element: L.L.L.L

WBS/CEC Definitions: Subsystem Test and Check-out. The resources specifically related to evaluating the CSCs and hardware operation as a subsystem.

Appropriation: RDTEA

WBS Summary

Asprop	Total	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
I&A Check-out	RDTEA	\$ 7,309,983	\$ -	\$ -	\$ -	\$ -	\$ 0.00	\$ 3,940.00	\$ 1,360.00	\$ -	\$ -

Assumptions

I&A Check-out Period of Performance starts when the CSCs is complete (26Sep2014).

I&A Check-out Duration Estimate 22 months (End Date Estimated 26Jul2016).

Methodology

- 1 Engineering Build Up of Total I&A Check-out Development Cost = Labor Rate * Work Hours per Month * Integration Duration * Checkout Staff Level
- 2 Average Check-out Staff Labor Rate per Hour \$170 Base Year 2005 \$
- 3 Hours per Person Month is 160
- 4 Duration 22 Months
- 5 13 person Staff Level
- 6 Derive Phasing Method from front loaded Beta curve 60/40 with medium peakness

Inputs

Value	Cost Type	FY	Units	FY2010\$
I&A Check-out Cost				\$ 7,309,983
Software Wrap Rate		2005-5		\$ 0.208
Hours per Person Month			160	
Staff Level for I&A Check-out			13	
Duration Months			22.000	
Milestone Start Date			2-Sep-14	
Milestone Finish Date			26-Jul-16	
Calculated Duration in Months			22	

Cost Adjustments

From	To	Factor
RDTEA	RDTEA	0.9426812

Phasing

Month	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Percent Per Year					0.0000	0.0132	0.2865			

Benefits

- Input row definition institutes consistency: easy to follow, update and review
- Automated cost row handling
- Easy to change inputs
- Syntax check reduces errors
- Error log provides guidance to correct issues

WBS/CEC Description	Approp	Unique ID	Tech Baseline	Phasing Method	Equation / Throughput	Fiscal Year	Units	Start Date	Finish Date
* Powerplant System Estimate		* Estimate							
Integration and Assembly (I&A)	RDTEA		\$ 20,467,953 *						
I&A Check-Out	RDTEA		\$ 7,309,983 *	BE	I&AWrapRate\$ * HrsPerPersMth * HwSW_Integ_Dur * StaffLvI&ACheckOut			I&A\$_StartDate	I&A\$_EndDate
* INPUT VARIABLES		* IN_VAR							
* General Inputs									
Hrs per Pers Month		HrsPerPersMth	160.0 *	C			160		
* Dates Derived From Durations									
HW Start Date		HwStartDate	01MAR2011 *	C				01MAR2011	
HW EndDate Date		HwEndDate	01SEP2012 *	C	DATEADD(HwStartDate, 0, HwDurationMths)				
CSCI 1 Start Date		CSCI1_StartDate	01MAR2012 *	C	DATEADD(HwEndDate, 0, -6)				
CSCI 2 Start Date		CSCI2_StartDate	02NOV2012 *	C	DATEADD(CSCI1_StartDate, 0, CSCI1_Dur)				
CSCI 3 Start Date		CSCI3_StartDate	07AUG2013 *	C	DATEADD(CSCI2_StartDate, 0, CSCI2_Dur)				
I&A Start Date		I&A\$_StartDate	26SEP2014 *	C	DATEADD(CSCI3_StartDate, 0, CSCI3_Dur)				
I&A End Date		I&A\$_EndDate	26JUL2016 *	C	DATEADD(I&A\$_StartDate, 0, HwSW_Integ_Dur)				
* Durations									
HW/SW Integration Duration		HwSW_Integ_Dur	22.0 *	C			22		
* Annual Staff Levels									
Staff Level HW SW Integration (Low t		StaffLvHwSwInteg	14.0 *	C			14		
* Wrap Rates									
I&A Wrap Rate	RDTEA	I&AWrapRate\$	\$ 0.208 *	C			175 2005 \$		

Section #2 Schedule Comparison

- Project schedule is a main input for time phasing an estimate
- The total project schedule consists of the combined schedules of the individual elements
- Schedule changes, including slips, are part of estimate what if scenarios and project cost increases
- The basic elements for an activity schedule are:
 - Start date
 - Duration
 - Finish date
- Where possible strive to capture schedule logic (links between elements) to promote what if drills

Caution

- Significant cost changes can come from schedule changes
- Different tools have different approaches to calculating schedule dates
- Excel does not have built-in calendar logic to properly calculate schedule dates and duration

Section #2 Schedule Comparison

- Excel's DAYS360() and Edate() functions produce schedule approximations
- ACE uses a full calendar to calculate schedule logic
 - Calculates End Dates with DateAdd(StartDate, years, months, days, truncate)
- Small deviations in schedule calculations on individual rows build throughout the estimate

	Excel Start Date	Excel Duration	Excel End Date	ACE Start Date	ACE Duration	ACE End Date
CSCI 1	1 Mar 2012	8 months	1 Nov 2012	1 Mar 2012	8 months	2 Nov 2012
CSCI 2	1 Nov 2012	9.2 months	1 Aug 2013	2 Nov 2012	9.2 months	7 Aug 2013
CSCI 3	1 Aug 2013	13.7 months	1 Sep 2014	7 Aug 2013	13.7 months	26 Sep 2014

Excel schedule is 25 days shorter than the ACE calculated schedule

Complex Estimating Problems

- High quality cost estimates require next level techniques to capture the complexities and reporting requirements of government engineering projects
- Section 3: Complex Estimating Problems
 - Some Complex Examples:
 - Learning Curves
 - Schedule Calculations
 - Automating Estimates: Logic and Schedule Functions
 - Schedule Logic
 - Fielded Schedule
 - Upgrade/Refresh

ACE can solve complex estimate problems

Contact our support team and we can show you how

- ACEIT support team at aceit_support@tecolote.com

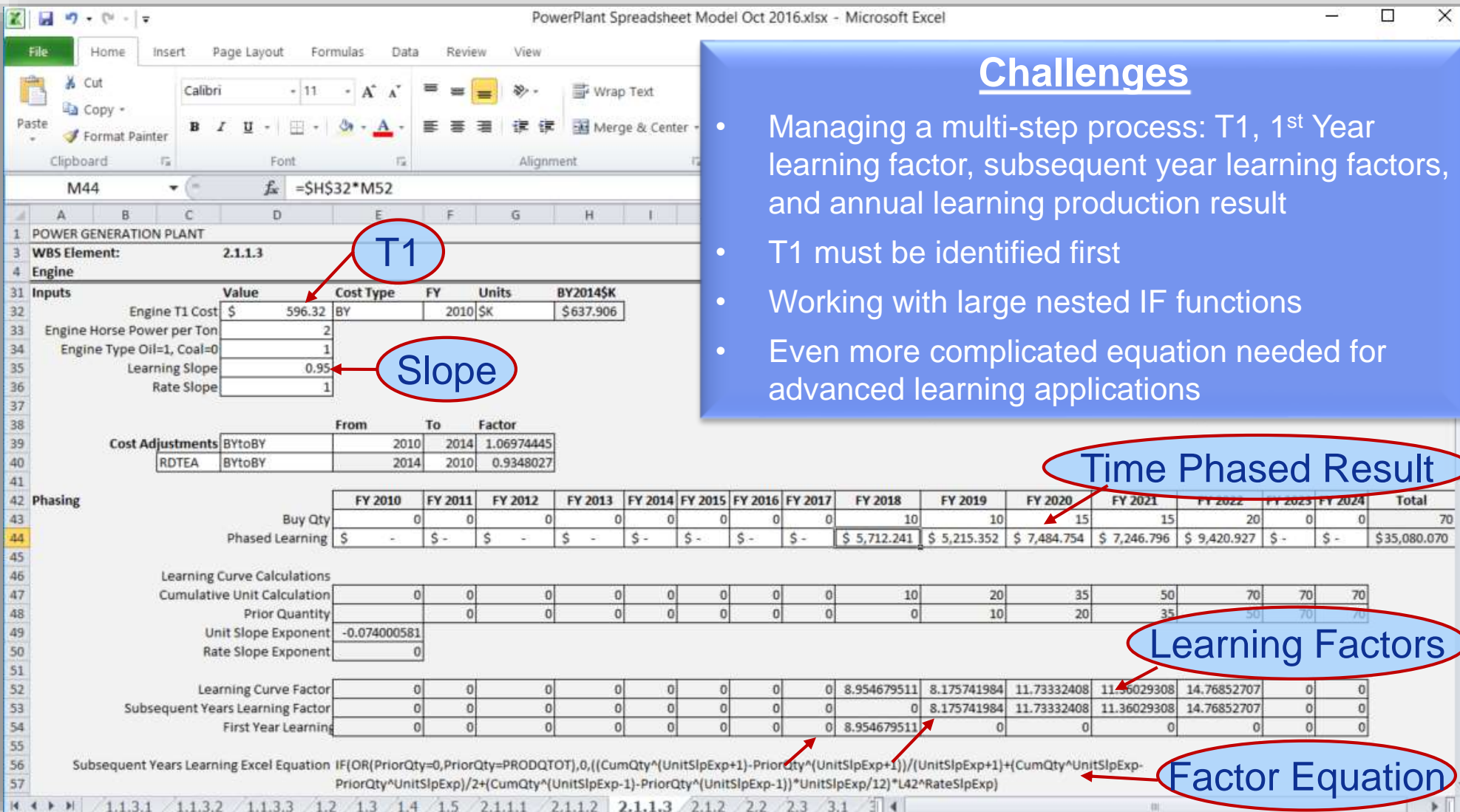
Section #3 Learning Curves

Time phased learning curves are difficult to implement in spreadsheets

- Common approach: calculate annual learning factor to apply to T1 and annual units
 - Factor equation is a large nested IF/then function (see below)

Challenges

- Managing a multi-step process: T1, 1st Year learning factor, subsequent year learning factors, and annual learning production result
- T1 must be identified first
- Working with large nested IF functions
- Even more complicated equation needed for advanced learning applications

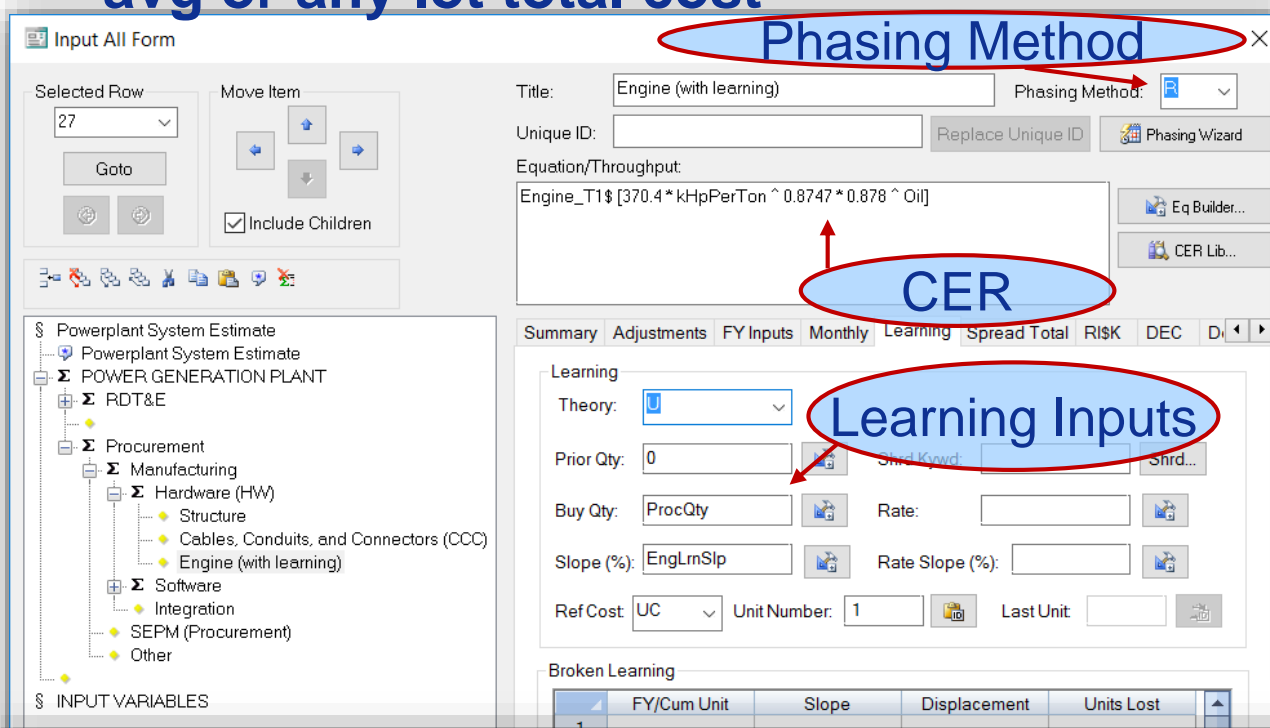


The screenshot shows a detailed spreadsheet model for a power generation plant. Key sections include:

- Inputs:** Engine T1 Cost (\$596.32), Engine Horse Power per Ton (2), Engine Type Oil=1, Coal=0, Learning Slope (0.95), Rate Slope (1).
- Cost Adjustments:** RDTEA adjustment factor of 0.9348027.
- Phasing:** A table showing units and costs from FY 2010 to FY 2024. The 'Phased Learning' row shows a significant cost in FY 2020.
- Learning Curve Calculations:** A table showing cumulative unit calculations, unit slope exponent (-0.074000581), and learning curve factors for each year.
- Factor Equation:** A complex nested IF function at the bottom of the spreadsheet, used to calculate the learning factor for subsequent years based on cumulative quantities and prior quantities.

Section #3 Learning Curves

- Learning curve equations are built into ACE
- T1 automatically calculated from any unit number, any cumulative avg or any lot total cost



Input All Form

Title: Engine (with learning) Phasing Method: [Dropdown]

Equation/Throughput: Engine_T1\$ [370.4 * kWhPerTon ^ 0.8747 * 0.878 ^ Oil]

Learning Theory: [U] Prior Qty: 0 Buy Qty: ProcQty Rate: [] Slope (%): EngLrnSlp Rate Slope (%): [] Ref Cost: UC Unit Number: 1 Last Unit: []

Broken Learning

FY/Cum Unit	Slope	Displacement	Units Lost
1			

Benefits

- No large nested IF functions
- Easy to:
 - Change/compare theories
 - Incorporate prior quantities
 - Set slope as an estimate variable with uncertainty
 - Set up broken learning
 - Share curve on multiple rows



	WBS/CES Description	Total	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023
28	Procurement	\$ 278,967,433		\$ 41,351,779	\$ 40,547,923	\$ 59,657,320	\$ 59,263,907	\$ 78,146,504	
29	Manufacturing	\$ 200,170,659		\$ 29,401,731	\$ 28,830,309	\$ 42,856,448	\$ 42,582,796	\$ 56,499,375	
30	Hardware (HW)	\$ 174,061,443		\$ 25,566,723	\$ 25,069,834	\$ 37,266,477	\$ 37,028,519	\$ 49,129,891	
31	Structure	\$ 127,476,056		\$ 18,210,865	\$ 18,210,865	\$ 27,316,298	\$ 27,316,298	\$ 36,421,730	
32	Cables, Conduits, and Connectors (CCC)	\$ 11,505,317		\$ 1,643,617	\$ 1,643,617	\$ 2,465,425	\$ 2,465,425	\$ 3,287,233	

ACE focuses attention on the learning inputs not the curve mechanics

Section #3 Fielded Schedules

Fielded schedules should be calculated from production quantities

Challenges

- Automating fielding is time consuming and difficult to maintain
- Manually entered fielded quantities becomes the norm

19	Quantities	Total or Annual	Total	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023
20	Development Engine Quantity	Total	10							
21	Procurement Engine Quantity	Annual	70		10	10	15	15	20	
22	Fielded Engine Quantity	Annual		0	0	10	20	35	50	
23	Procurement Engine Fiscal Year: First/Last Finder			No	2018	2019	2020	2021	2022	No
24	OM Engine Fiscal Year: First/Last Finder			No	No	2019	2020	2021	2022	2023
26	Engine Operational Life	Total	10							
27	Lag between Procurement and Fielding	Total	1							

WBS/CES Description	Approp	Unique ID	Tech Baseline	Phasing Method	Equation / Throughput	Fiscal Year	Units
76 * Quantities							
77 Development Quantity		DevQty	10.0 *	C		10	
78 Procurement Quantity		ProcQty	70.0 *	IS	[Input Throughput]		
79 Fielded Quantity		FieldQty	700.000 *	F	OpFieldedUnits(@ProcQty, OpLife, Lag)		
80 Engine Operational Life		OpLife	10.000 *	C		10	
81 Fielding Lag		Lag	1.000 *	C		1	

WBS/CES Description	Total	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025	FY 2026	FY 2027	FY 2028	FY 2029	FY 2030	FY 2031	FY 2032	FY 2033	FY 2034
76 * Quantities																			
77 Development Quantity	10.0																		
78 Procurement Quantity	70.0		10.0	10.0	15.0	15.0	20.0												
79 Fielded Quantity	700.000			10.000	20.000	35.000	50.000	70.000	70.000	70.000	70.000	70.000	70.000	60.000	50.000	35.000	20.000		
80 Engine Operational Life	10.000																		
81 Fielding Lag	1.000																		

OpFieldedUnits(@Qty, OpLife, Lag)

Fielding calculated from:

Production quantity, Operational life and Lag before fielding begins

Benefits

- Functions calculate from simple set of parameters
- Time phased parameters offer even more flexibility
- The parameters can also be variables for What ifs

Section #4 Adding WBS Elements to the Estimate

- **Estimates evolve over the life cycle of a program**
 - Projects become more defined and more detailed estimate are required
 - Adding WBS elements to an estimate is common and necessary

- **Adding a WBS element to a spreadsheet**
 - Requires many steps
 - Requires repeated entry of the same information on multiple worksheets

- **ACE is designed to easily make changes to the WBS**


Section #4 Highlights

■ Spreadsheet steps outlined

- Example adds software site activation and upgrade to the estimate

Spreadsheet: Adding WBS Methods

- Next 5 slides detail the steps to add the WBS elements in the spreadsheet
- Steps to implement Software Procurement Estimate in a Spreadsheet
 - Insert three rows in the Procurement WBS on the WBS Cost Summary BY\$K worksheet
 - Procurement Software parent row and two children for Site Activation and Upgrade
 - Adjust WBS numbers: Proc. Integration changes to 2.1.3 and 2.1.2 is now Software
 - Rename the integration 2.1.2 worksheet to 2.1.3
 - Make a copy of the integration worksheet and rename it 2.1.2 for Software estimate




New WBS Elements

70

Spreadsheet: Adding WBS Methods (Cont.)

- Steps to implement Software Procurement Estimate in a Spreadsheet (Cont.)
 - Move to the new 2.1.2 worksheet to define the methods for Software Activation and Upgrade
 - Edit the WBS element and definition information: short cut employed using one worksheet to capture both Site Activation and Upgrade elements (most WBS worksheets in the workbook are for single elements)
 - Edit cost assumptions and methodology description




WBS Definition

Method Description

71

Spreadsheet: Adding WBS Methods (Cont.)

- Steps to implement Software Procurement Estimate in a spreadsheet (Cont.)
 - Stay on the 2.1.2 worksheet
 - Edit the method inputs
 - Link Total Software Development Costing Input section Link to WBS Cost Summary BY\$K worksheet
 - Set up factor values for activation and upgrade
 - Set up Site Years for activation and Upgrade Costs
 - Use IF statements for which years are procurement units
 - Use the SUM function to determine the sum of years from the Annual Procurement (Digital Buy) Quantities
 - Build the Pricing Equations
 - Develop an equation to calculate the Total Year equals the sum year for activation and then calculate the total the total software development cost
 - Equation multiplies BY\$K digitizing (TY\$K) from activating to number
 - Equation BY Value (BY\$K) times the sum of years
 - Apply similar equation for Upgrade WBS Element
 - Link results into WBS Summary section which is linked to WBS Cost Summary BY\$K worksheet




Method Inputs

Pricing Equations

72

Spreadsheet: Adding WBS Methods (Cont.)

- Steps to implement Software Procurement Estimate in a Spreadsheet (Cont.)
 - On the WBS Cost Summary BY\$K Worksheet
 - For Site Activation and Upgrade elements
 - Link results from the 2.1.2 worksheet WBS Summary section to the WBS Cost Summary BY\$K worksheet
 - Update all parent sub total element equations
 - Incorporate Site Activation and Upgrade into Proc. Software and Proc. Software into Manufacturing sub totals: large WBSs require updates to multiple WBS levels




BY Results

Sum WBS

73

Spreadsheet: Adding WBS Methods (Cont.)

- Steps to implement Software Procurement Estimate in a spreadsheet (Cont.)
 - On the WBS Cost Summary TY\$K Worksheet
 - Insert three new rows for the software elements
 - Fill down the equations
 - Equations take the BY results from the WBS Cost Summary BY\$K worksheet and convert to TY results by applying weighted TY inflation factors
 - On the Budget POM TY\$K
 - Insert three new rows for the software elements
 - Fill down the equations to pull results from the WBS Cost Summary TY\$K



TY Results


TY Inflation Factors

POM/RAP Results

74

Spreadsheet: Adding WBS Methods (Cont.)

- Summary of steps to add new WBS methods to a spreadsheet
 - Add WBS elements: Insert new WBS methods to a spreadsheet
 - Develop estimating methods: Create new WBS worksheets to calculate individual methods
 - Use existing WBS worksheet format as a guide where possible
 - Set up all inputs and develop new equations
 - Produce BY result: Map results into the WBS Cost Summary BY\$K worksheet
 - Produce TY result: Incorporate BY results into WBS Cost Summary TY\$K worksheet
 - Update all individual reports: update links in Summary Charts, Budget POM TY\$K and any other custom estimate reports or charts



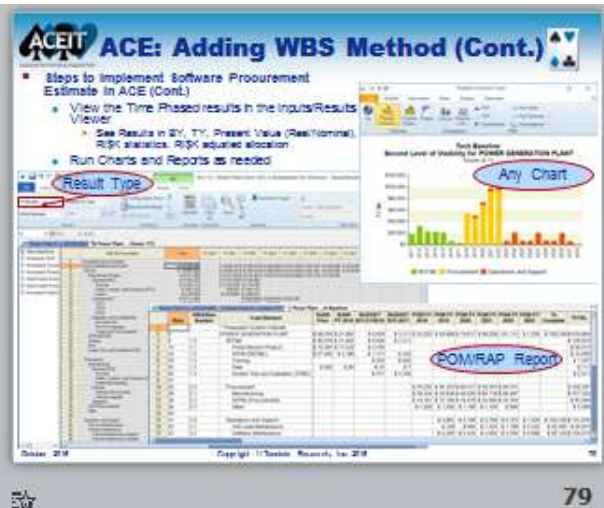
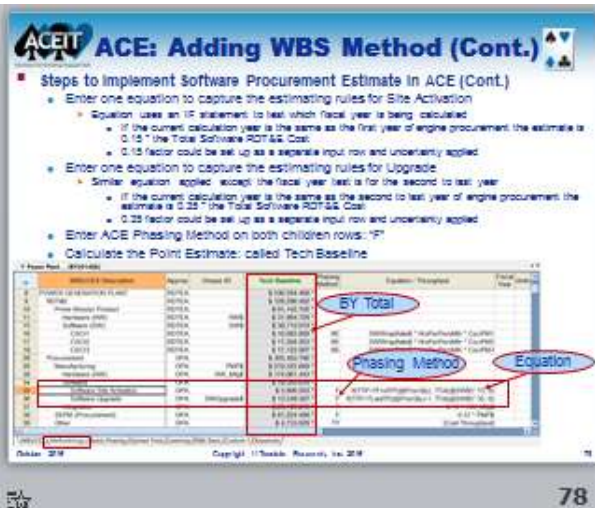
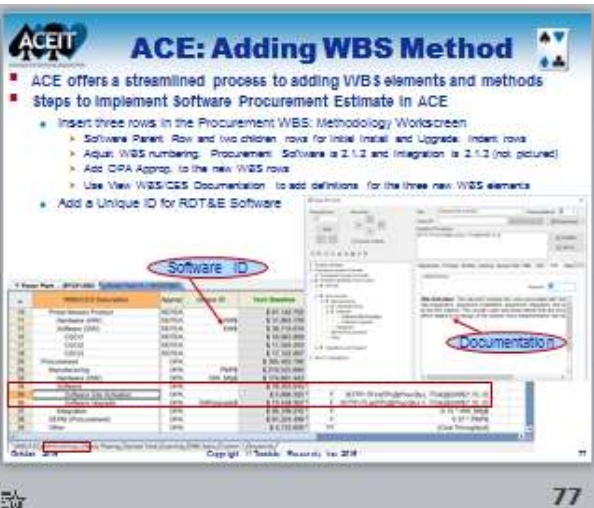
POWER GENERATION PLANT PROGRAM ESTIMATE and BUDGET

75

Adding two WBS items needs six slides to explain how to update estimate

Section #4 Highlights

- **Summary of steps to add new WBS methods to ACE**
 1. Add WBS elements: Insert new elements to WBS on Methodology Workscreen
 2. Develop estimating methods: enter one equation for each element
 - Set up all inputs: link to existing elements where possible
 - Develop equations
 - Calculate the estimate: press Calc. button
 3. View results in Input/Results Viewer: BY, TY etc.
 4. Run standard or custom reports and charts



ACE process has less steps and takes far less time to implement

Section #5 What If Drills

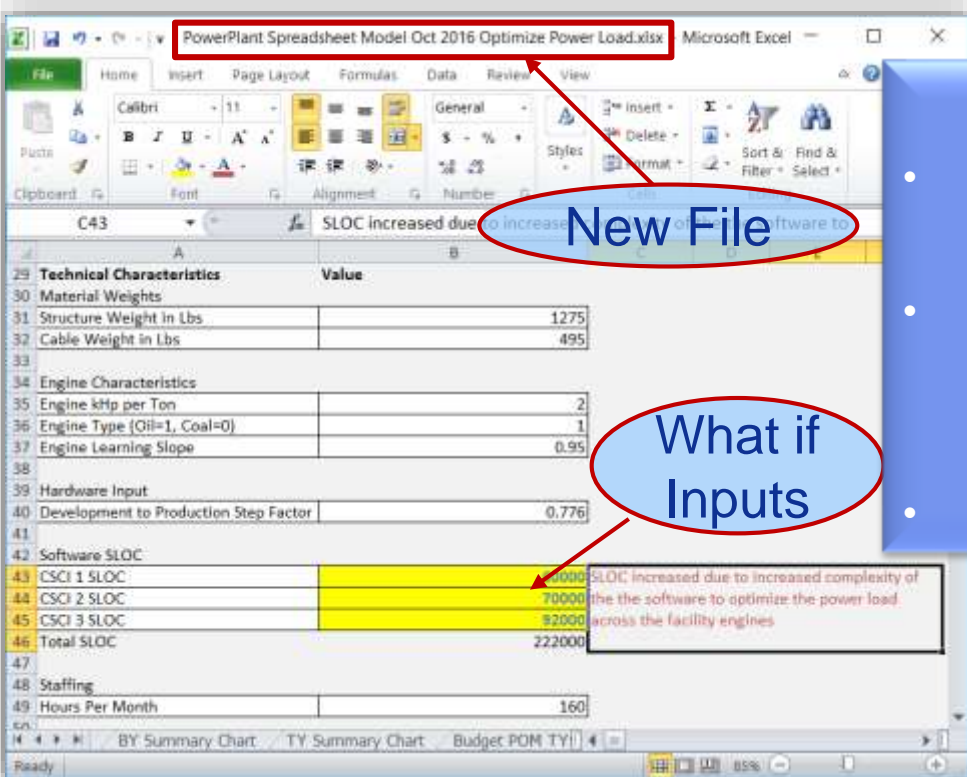
- Decision makers explore different program options to save money, time or meet a constrained budget
- Running what if drills can answer questions like:
 - “What’s the cost if we change the number of engines each year?”
 - “What’s the impact of two more years of system operation?”
 - “How much more will it cost if we add requirements to the software?”
 - “How many units can I buy for x budget?”
- Analysts need to provide a project estimate but also model various what if scenarios
 - Spreadsheets provide only an *estimate* solution
 - ACE provides both an *estimate* and *model* solution

What If case analysis is where ACE far out performs spreadsheets

Section #5 Spreadsheet: What Ifs

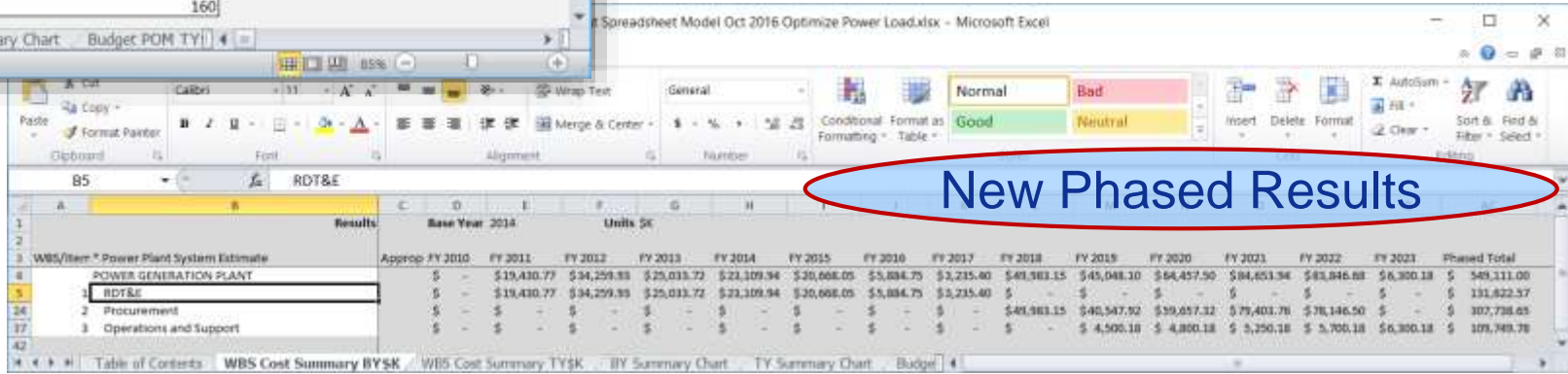


- Difficult to store inputs, calculate and view results in one workbook
- Most common approach: Multiple copies of the workbook



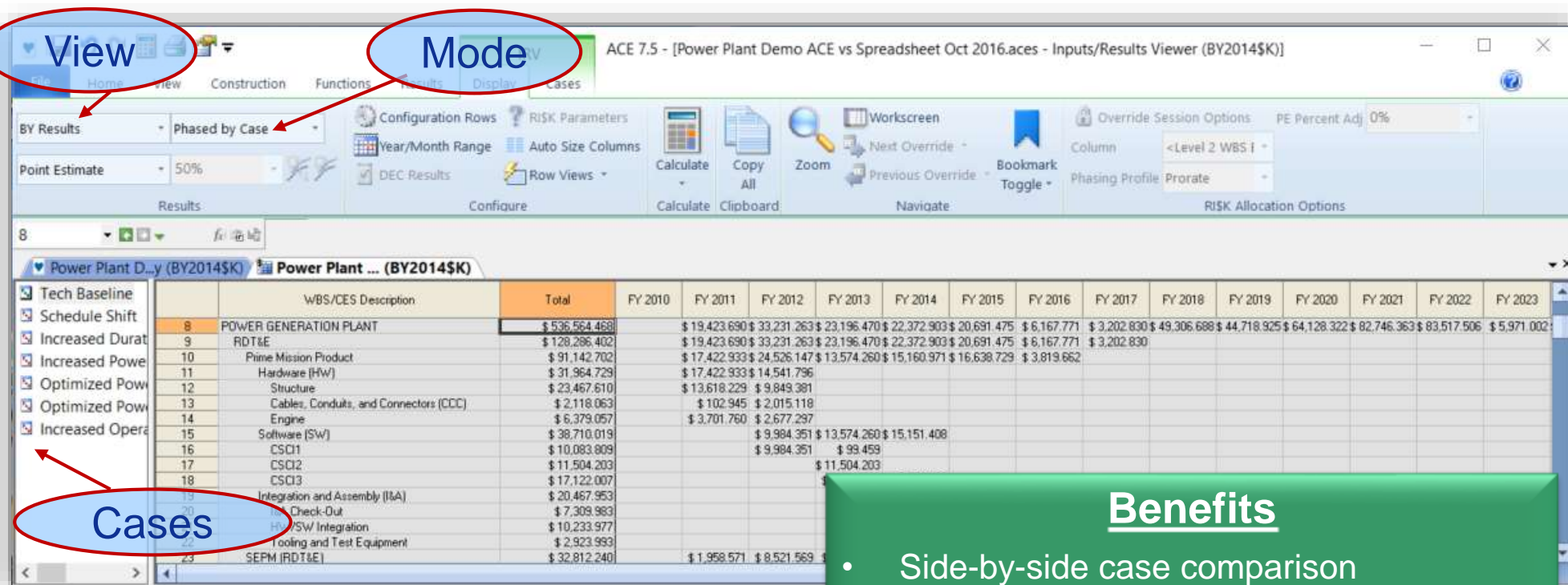
Challenges

- Managing multiple spreadsheet files for the program
 - Changes must be performed in all copies
- Comparing case results side by side
 - Results are in multiple spreadsheets
 - Cumbersome file links often fail
- Difficult to view case input changes





- Conduct an unlimited number of What if Drills in one file
- Inputs/Results Viewer designed to manage and view What if cases
 - View: Inputs, BY Results, TY Results, Present Value and RI\$K Statistics
 - Mode: Phased by Case, Phased by WBS, Cases by Total or Cases by FY



ACE 7.5 - [Power Plant Demo ACE vs Spreadsheet Oct 2016.aces - Inputs/Results Viewer (BY2014\$K)]

View: BY Results, Phased by Case

Mode: Phased by Case

Configuration Rows, RISK Parameters, Year/Month Range, Auto Size Columns, DEC Results, Row Views, Calculate, Copy All, Zoom, Workscreen, Next Override, Previous Override, Bookmark Toggle, Override Session Options, PE Percent Adj: 0%, Column: <Level 2 WBS 1>, Phasing Profile: Prorate, RISK Allocation Options

WBS/CES Description	Total	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023
POWER GENERATION PLANT	\$ 536,564,468	\$ 19,423,690	\$ 33,231,263	\$ 23,196,470	\$ 22,372,903	\$ 20,691,475	\$ 6,167,771	\$ 3,202,830	\$ 49,306,688	\$ 44,718,925	\$ 64,128,322	\$ 82,746,363	\$ 83,517,506	\$ 5,971,002	
RD&E	\$ 128,286,402	\$ 19,423,690	\$ 33,231,263	\$ 23,196,470	\$ 22,372,903	\$ 20,691,475	\$ 6,167,771	\$ 3,202,830							
Prime Mission Product	\$ 91,142,702	\$ 17,422,933	\$ 24,526,147	\$ 13,574,260	\$ 15,160,971	\$ 16,638,729	\$ 3,819,662								
Hardware (HW)	\$ 31,964,729	\$ 17,422,933	\$ 14,541,796												
Structure	\$ 23,467,610	\$ 13,618,229	\$ 9,849,381												
Cables, Conduits, and Connectors (CCC)	\$ 2,118,063	\$ 102,945	\$ 2,015,118												
Engine	\$ 6,379,057	\$ 3,701,760	\$ 2,677,297												
Software (SW)	\$ 38,710,019		\$ 9,984,351	\$ 13,574,260	\$ 15,151,408										
CSCI1	\$ 10,083,809		\$ 9,984,351	\$ 99,459											
CSCI2	\$ 11,504,203			\$ 11,504,203											
CSCI3	\$ 17,122,007														
Integration and Assembly (IA)	\$ 20,467,953														
Check-Out	\$ 7,309,983														
HW/SW Integration	\$ 10,233,977														
Tooling and Test Equipment	\$ 2,923,993														
SEPM (RD&E)	\$ 32,812,240	\$ 1,958,571	\$ 8,521,569												

Benefits

- Side-by-side case comparison
- Case viewer allows comparison without additional report set up

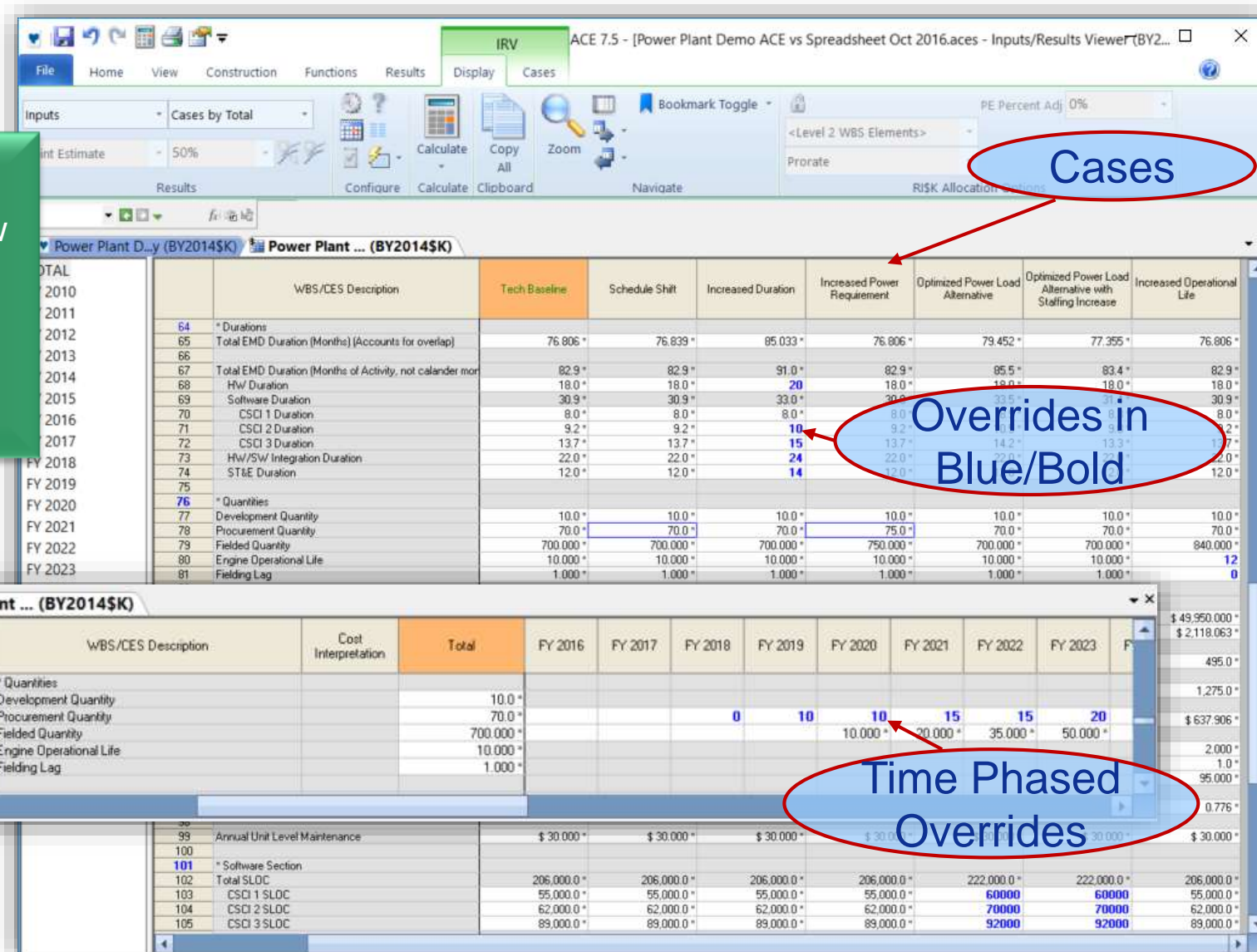
Section #5 ACE: What Ifs



Override model baseline total and time phased inputs

Benefits

- All cases in one view
- Total and time phased overrides
- Overrides clearly identified: blue/bold



Year	WBS/CES Description	Tech Baseline	Schedule Shift	Increased Duration	Increased Power Requirement	Optimized Power Load Alternative	Optimized Power Load Alternative with Staffing Increase	Increased Operational Life
2010	TOTAL							
2011								
2012	64 * Durations							
2013	65 Total EMD Duration (Months) (Accounts for overlap)	76,806*	76,839*	85,033*	76,806*	79,452*	77,355*	76,806*
2014	67 Total EMD Duration (Months of Activity, not calendar months)	82.9*	82.9*	91.0*	82.9*	95.5*	83.4*	82.9*
2015	68 HW Duration	18.0*	18.0*	20	18.0*	18.0*	18.0*	18.0*
2016	69 Software Duration	30.9*	30.9*	33.0*	30.9*	31.0*	31.0*	30.9*
2017	70 CSCI 1 Duration	8.0*	8.0*	8.0*	8.0*	8.0*	8.0*	8.0*
2018	71 CSCI 2 Duration	9.2*	9.2*	10	9.2*	9.2*	9.2*	9.2*
2019	72 CSCI 3 Duration	13.7*	13.7*	15	13.7*	14.2*	13.3*	13.7*
2020	73 HW/SW Integration Duration	22.0*	22.0*	24	22.0*	22.0*	22.0*	22.0*
2021	74 ST&E Duration	12.0*	12.0*	14	12.0*	12.0*	12.0*	12.0*
2022	75							
2023	76 * Quantities							
	77 Development Quantity	10.0*	10.0*	10.0*	10.0*	10.0*	10.0*	10.0*
	78 Procurement Quantity	70.0*	70.0*	70.0*	75.0*	70.0*	70.0*	70.0*
	79 Fielded Quantity	700,000*	700,000*	700,000*	750,000*	700,000*	700,000*	840,000*
	80 Engine Operational Life	10,000*	10,000*	10,000*	10,000*	10,000*	10,000*	10,000*
	81 Fielding Lag	1,000*	1,000*	1,000*	1,000*	1,000*	1,000*	1,000*
	82							

WBS/CES Description	Cost Interpretation	Total	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023
76 * Quantities										
77 Development Quantity		10.0*								
78 Procurement Quantity		70.0*								
79 Fielded Quantity		700,000*			0	10	10	15	15	20
80 Engine Operational Life		10,000*				10,000*	20,000*	35,000*	50,000*	
81 Fielding Lag		1,000*								
82										

Cases

Time Phased Overrides

Cases

Overrides in Blue/Bold

Section #5 ACE: What Ifs



Compare case results side by side

ACE 7.5 - [Power Plant Demo ACE vs Spreadsheet Oct 2016.aces - Inputs/Results Viewer (...)]

IRV

File Home View Construction Functions Results Display Cases

BY Results: Cases by Total

Point Estimate: 50%

Calculate Copy All Zoom

Bookmark Toggle

PE Percent Adj: 0%

<Level 2 WBS Elements>

Prorate

RISK Allocation Options

8

Power Plant D...y (BY2014\$K) Power Plant ... (BY2014\$K)

Cases

TOTAL	WBS/CES Description	Tech Baseline	Schedule Shift	Increased Duration	Increased Power Requirement	Optimized Power Load Alternative	Optimized Power Load Alternative with Stalling Increase	Increased Operational Life
FY 2010								
FY 2011								
FY 2012	7 * Powerplant System Estimate							
FY 2013	8 POWER GENERATION PLANT	\$ 536,564,468	\$ 536,578,249	\$ 542,384,066	\$ 557,363,010	\$ 550,229,557	\$ 556,080,484	\$ 548,506,472
FY 2014	9 RDT&E	\$ 128,286,402	\$ 128,300,182	\$ 134,106,000	\$ 128,286,402	\$ 132,741,120	\$ 138,592,046	\$ 128,286,402
FY 2015	10 Prime Mission Product	\$ 91,142,702	\$ 91,142,702	\$ 93,003,425	\$ 91,142,702	\$ 94,434,471	\$ 98,089,463	\$ 91,142,702
FY 2016	11 Hardware (HW)	\$ 31,964,729	\$ 31,964,729	\$ 31,964,729	\$ 31,964,729	\$ 31,964,729	\$ 31,964,729	\$ 31,964,729
FY 2017	12 Structure	\$ 23,467,610	\$ 23,467,610	\$ 23,467,610	\$ 23,467,610	\$ 23,467,610	\$ 23,467,610	\$ 23,467,610
FY 2018	13 Cables, Conduits, and Connectors (CCC)	\$ 2,118,063	\$ 2,118,063	\$ 2,118,063	\$ 2,118,063	\$ 2,118,063	\$ 2,118,063	\$ 2,118,063
FY 2019	14 Engine	\$ 6,379,057	\$ 6,379,057	\$ 6,379,057	\$ 6,379,057	\$ 6,379,057	\$ 6,379,057	\$ 6,379,057
FY 2020	15 Software (SW)	\$ 38,710,019	\$ 38,710,019	\$ 38,710,019	\$ 38,710,019	\$ 42,001,789	\$ 42,001,789	\$ 38,710,019
FY 2021	16 CSC1	\$ 10,083,809	\$ 10,083,809	\$ 10,083,809	\$ 10,083,809	\$ 11,096,654	\$ 11,096,654	\$ 10,083,809
FY 2022	17 CSC2	\$ 11,504,203	\$ 11,504,203	\$ 11,504,203	\$ 11,504,203	\$ 13,147,207	\$ 13,147,207	\$ 11,504,203
FY 2023	18 CSC3	\$ 17,122,007	\$ 17,122,007	\$ 17,122,007	\$ 17,122,007	\$ 17,757,927	\$ 17,757,927	\$ 17,122,007
FY 2024	19 Integration and Assembly (I&A)	\$ 20,467,953	\$ 20,467,953	\$ 22,328,676	\$ 20,467,953	\$ 20,467,953	\$ 24,122,945	\$ 20,467,953
FY 2025	20 I&A Check-Out	\$ 7,309,983	\$ 7,309,983	\$ 7,974,527	\$ 7,309,983	\$ 7,309,983	\$ 8,771,980	\$ 7,309,983
FY 2026	21 HW/SW Integration	\$ 10,233,977	\$ 10,233,977	\$ 11,164,338	\$ 10,233,977	\$ 10,233,977	\$ 11,695,973	\$ 10,233,977
FY 2027	22 Tooling and Test Equipment	\$ 2,923,993	\$ 2,923,993	\$ 3,189,811	\$ 2,923,993	\$ 2,923,993	\$ 3,654,992	\$ 2,923,993
FY 2028	23 SEPM (RDT&E)	\$ 32,812,240	\$ 32,826,021	\$ 36,326,820				
FY 2029	24 Training	\$ 958,942	\$ 958,942	\$ 958,942				
FY 2030	25 Data	\$ 706,747	\$ 706,747	\$ 706,747				
FY 2031	26 System Test and Evaluation (ST&E)	\$ 2,665,771	\$ 2,665,771	\$ 3,110,066				
FY 2032	27							
FY 2033	28 Procurement	\$ 305,483,796	\$ 305,483,796	\$ 305,483,796				
FY 2034	29 Manufacturing	\$ 219,525,669	\$ 219,525,669	\$ 219,525,669				
FY 2035	30 Hardware (HW)	\$ 174,061,443	\$ 174,061,443	\$ 174,061,443				
FY 2036	31 Structure	\$ 127,476,056	\$ 127,476,056	\$ 127,476,056				
FY 2037	32 Cables, Conduits, and Connectors (CCC)	\$ 11,505,317	\$ 11,505,317	\$ 11,505,317				
FY 2038	33 Engine (with learning)	\$ 35,080,070	\$ 35,080,070	\$ 35,080,070				
FY 2039	34 Software	\$ 19,355,010	\$ 19,355,010	\$ 19,355,010				
FY 2040	35 Software Site Activation	\$ 5,806,503	\$ 5,806,503	\$ 5,806,503				
FY 2041	36 Software Upgrade	\$ 13,548,507	\$ 13,548,507	\$ 13,548,507				
FY 2042	37 Integration	\$ 26,109,216	\$ 26,109,216	\$ 26,109,216				
FY 2043	38 SEPM (Procurement)	\$ 81,224,498	\$ 81,224,498	\$ 81,224,498				
FY 2044	39 Other	\$ 4,733,629	\$ 4,733,629	\$ 4,733,629				
FY 2045	40							
FY 2046	41 Operations and Support	\$ 102,794,271	\$ 102,794,271	\$ 102,794,271				
FY 2047	42 Unit Level Maintenance	\$ 21,000,000	\$ 21,000,000	\$ 21,000,000				
FY 2048	43 Software Maintenance	\$ 81,794,271	\$ 81,794,271	\$ 81,794,271				
FY 2049	44 Software Maintenance Support	\$ 50,323,025	\$ 50,323,025	\$ 50,323,025	\$ 50,323,025	\$ 54,602,325	\$ 54,602,325	\$ 58,065,029
FY 2050	45 Software Maintenance Upgrade	\$ 31,471,246	\$ 31,471,246	\$ 31,471,246	\$ 31,471,246	\$ 34,147,454	\$ 34,147,454	\$ 31,471,246

- Benefits**
- One file: No links between files that break
 - Reorder cases as project evolves
 - Compare cases for any row
 - Switch between Total and Time Phased comparisons

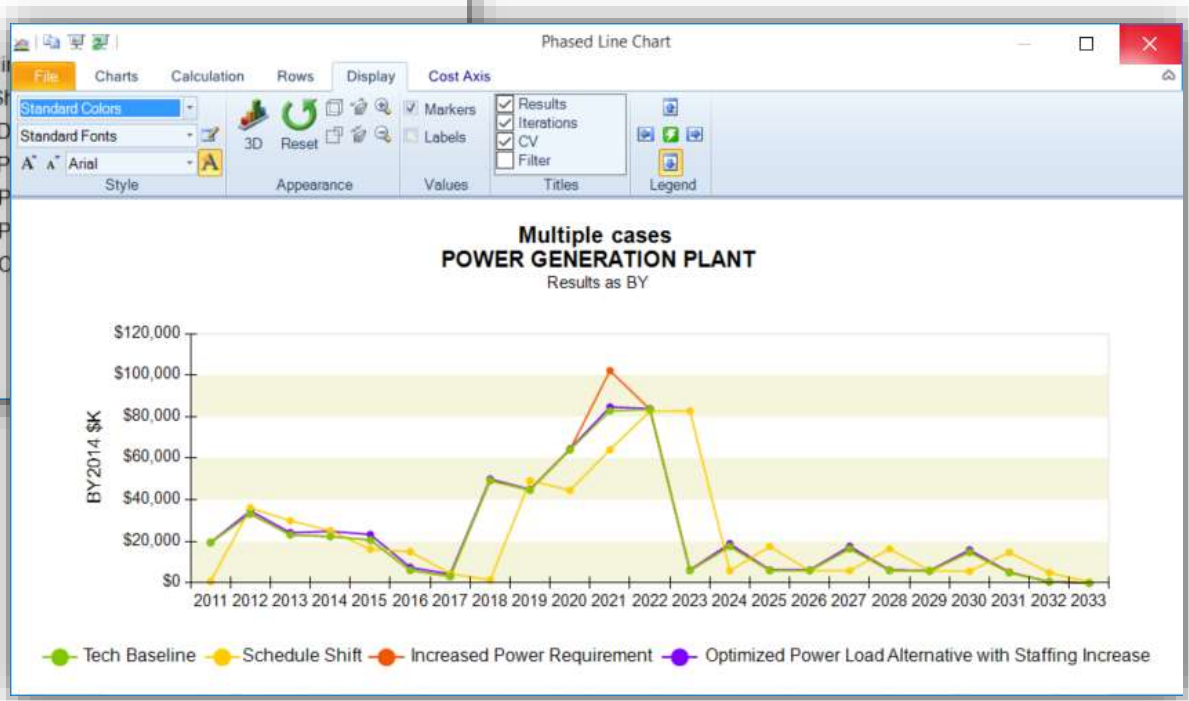
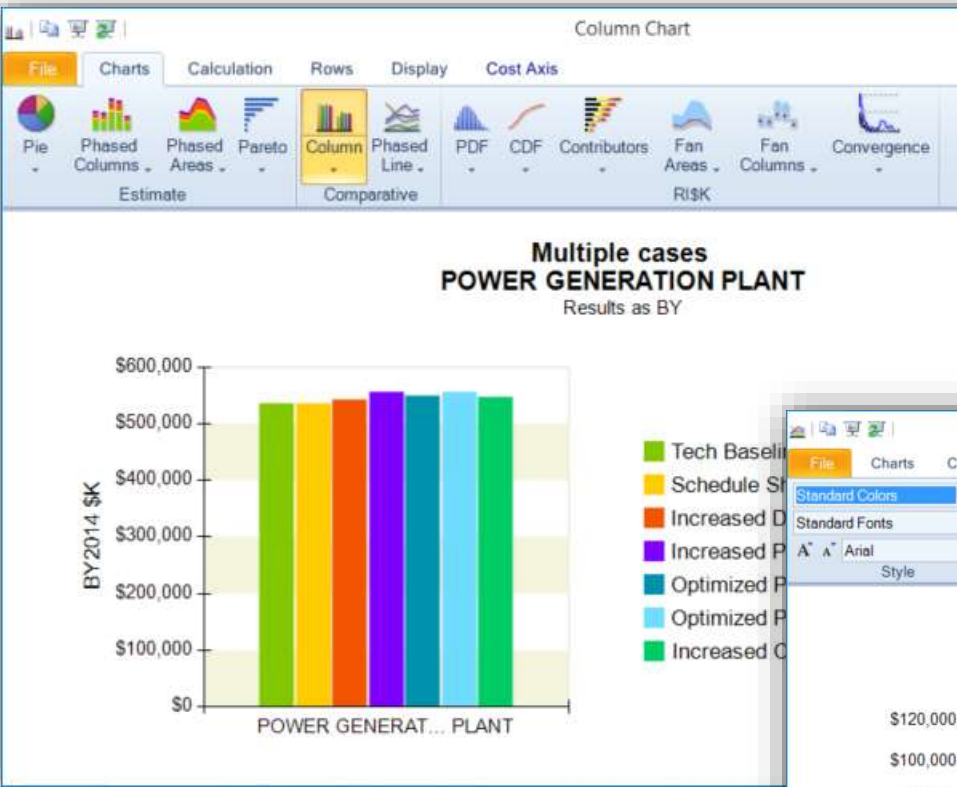
Section #5 ACE: What Ifs



- Generate charts highlighting case results
- Export charts to Power Point with one click update

Benefits

- Built in charting tool
- All cases in one file: No file links
- Chart any or all cases, total and time phased



The rest of the story

- **This is only a taste of the benefits of ACE over spreadsheets**
 - **Uncertainty:** RI\$K is integrated into the ACE software; it is not an add on
 - **Documentation:** ACE includes integrated and automated documentation
 - **Session Properties:** Easily change the session Base Year, Units, Fiscal Years and Inflation Tables without having to change any equations
 - **Phasing Methods:** ACE Phasing methods direct how to time phase the estimate without repeating equations across the fiscal years
 - **CER Estimating Methods:** ACE implements CERs once with proper cost parameters and documentation
 - **Schedule Logic:** ACE easily incorporates schedule logic into its time phasing
 - **Cost Estimating Functions:** ACE offers many calculations functions specifically tailored to cost analysis
 - **Utilities and Wizards:** added features to assist with proper set up and best practices
 - **API and Plug-ins:** Full functional API, connect to other tools

■ A cost analyst must perform many activities to develop credible point estimates

- Develop a model by estimating each WBS element, with the best method from available data
- Include estimating ground rules and assumptions that best address the scenario
- Express the results in constant and budget dollars
- Time phase the results based on a program schedule
- Add WBS elements or update the model as the project evolves

Avoid the traps of spreadsheets and use a tool built for cost analysis

■ The US Army, US Air Force, DHS, FAA and Australia DoD use ACE as a standard tool

■ This brief summarizes *“Challenges with Using Spreadsheets for Cost Analysis: Why ACE is a Superior Option”*

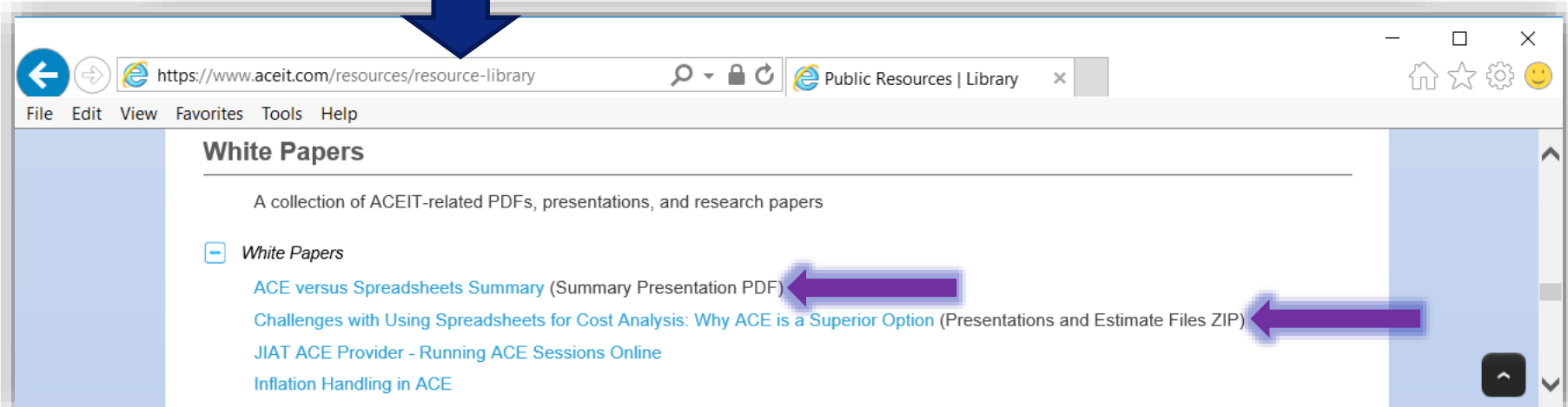
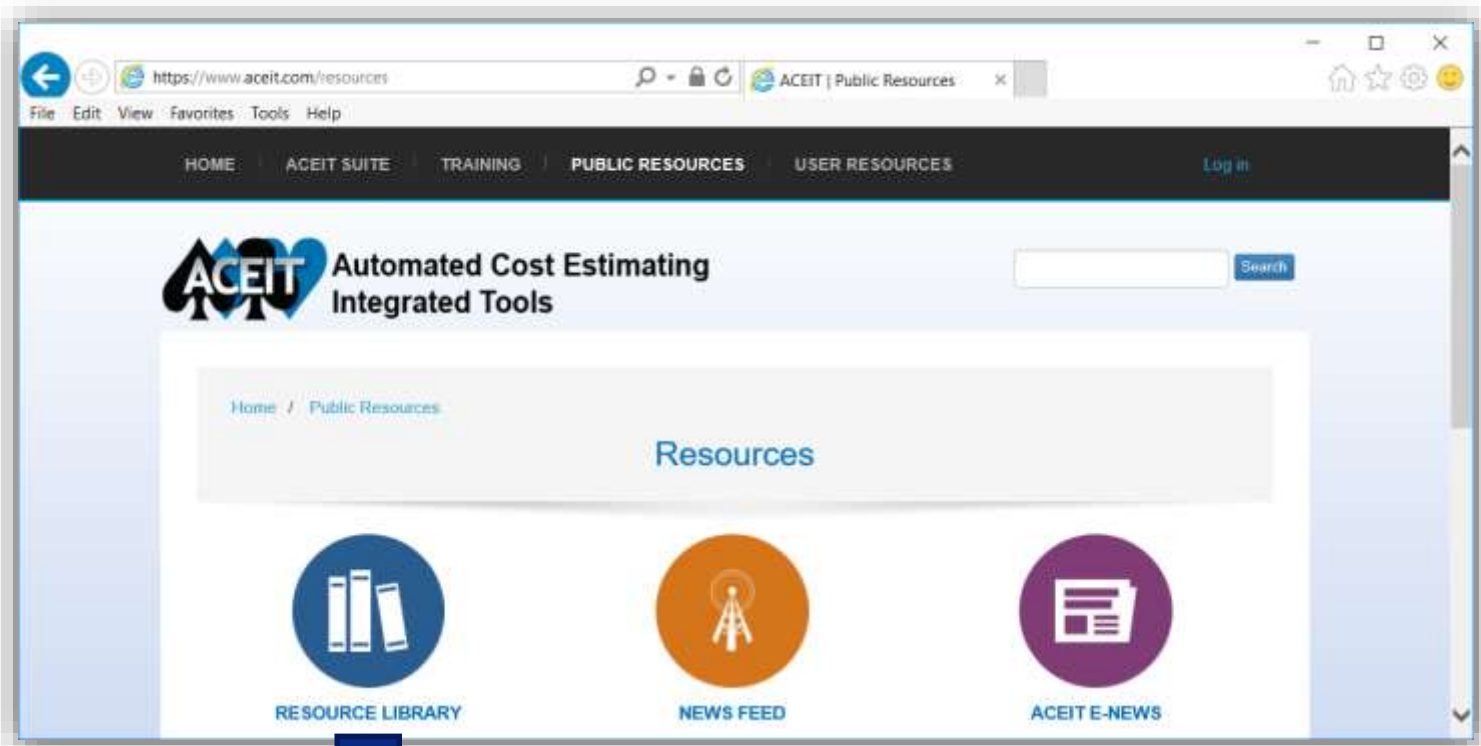
■ Detailed Package includes:

- **PowerPoint Presentation:** *ACE versus Spreadsheets Summary.pptx*
- **Spreadsheet Example:** *PowerPlant Spreadsheet Model Oct 2016.xlsx*
- **ACE Example:** *Power Plant Demo ACE vs Spreadsheet Oct 2016.aces*

■ The larger brief can be downloaded from www.aceit.com and studied for deeper exploration

Download Information

- Detailed example files available in the Resource Library at www.aceit.com





THANK YOU

