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

ACEIT version 7.5

May 2017

Introduction

- Would you continue to use this…

- If you had one of these…

Executive Summary

- **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

The ACEIT Concept

- **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

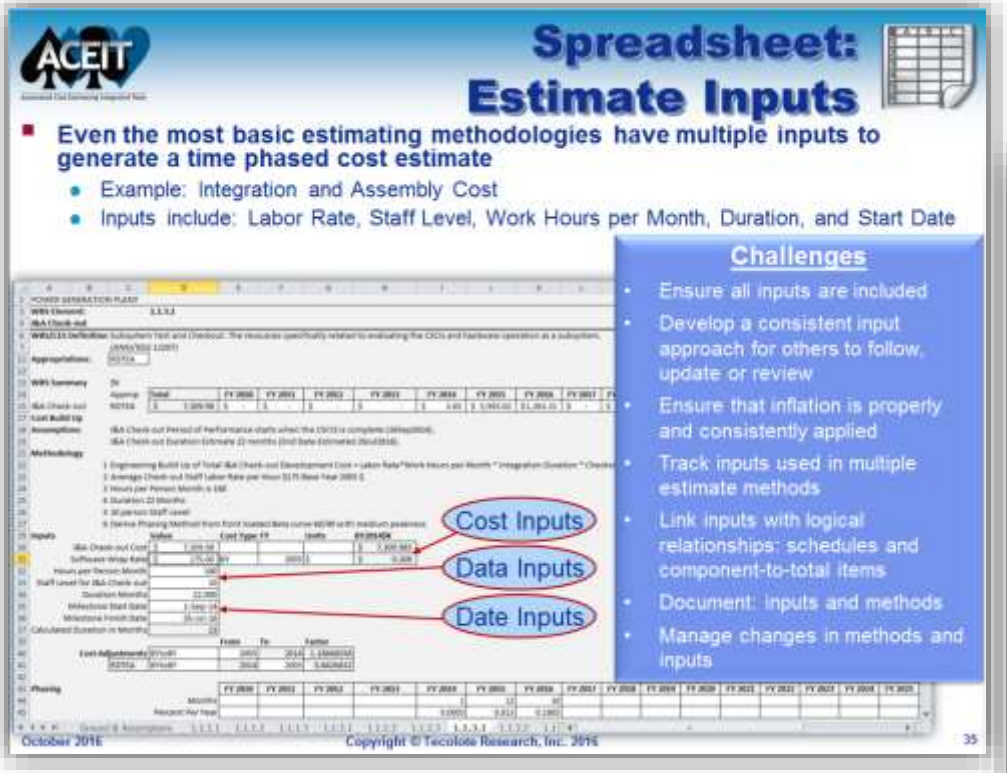
Power Generation Plant Example

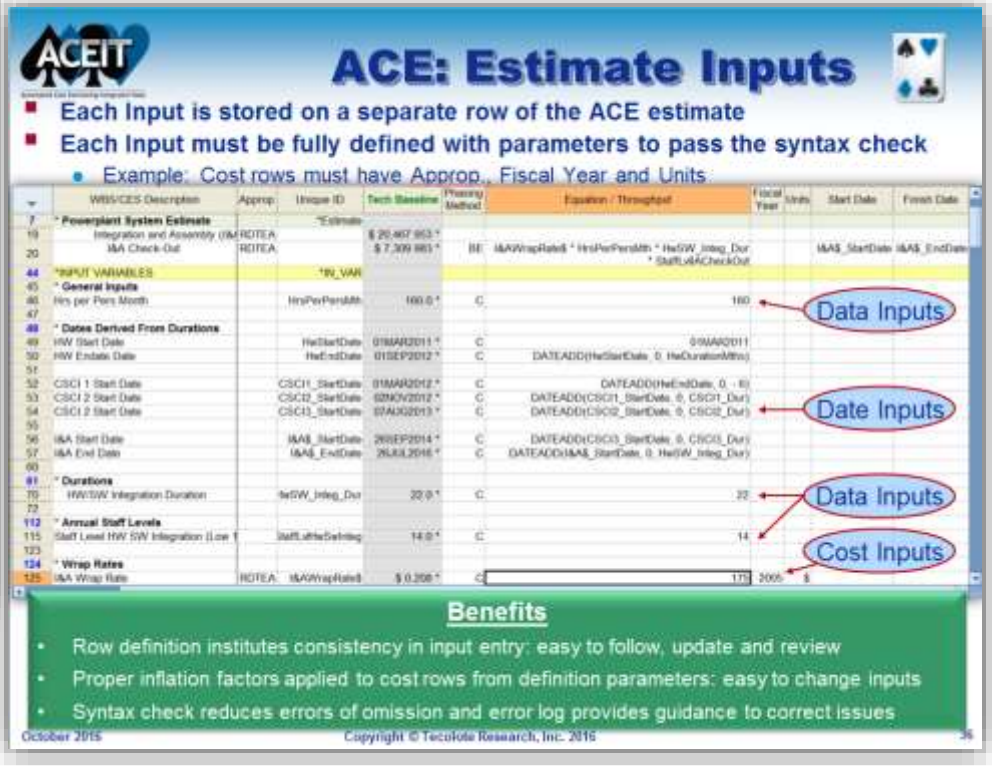
- Defined WBS
  - RDT&E, Procurement and OS Phases
- Defined Ground Rules and Assumptions
  - Detailed Schedule
  - Plant Engine Quantities
    - 10 development
    - 70 time phased procurement
    - 10 year engine service life
  - Technical Characteristics
    - Material weights
    - Engine specifications
  - 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



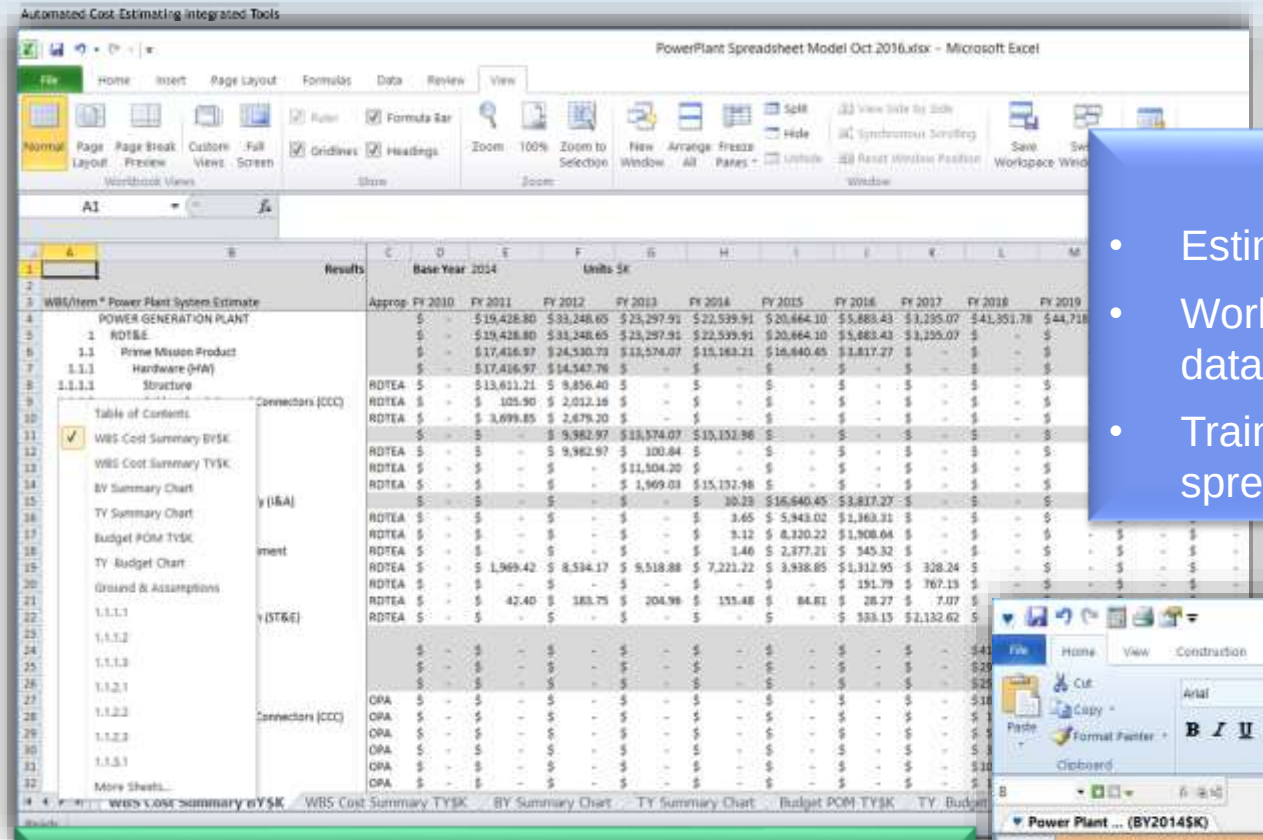


Section #1
Basic Estimate Structure

- **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

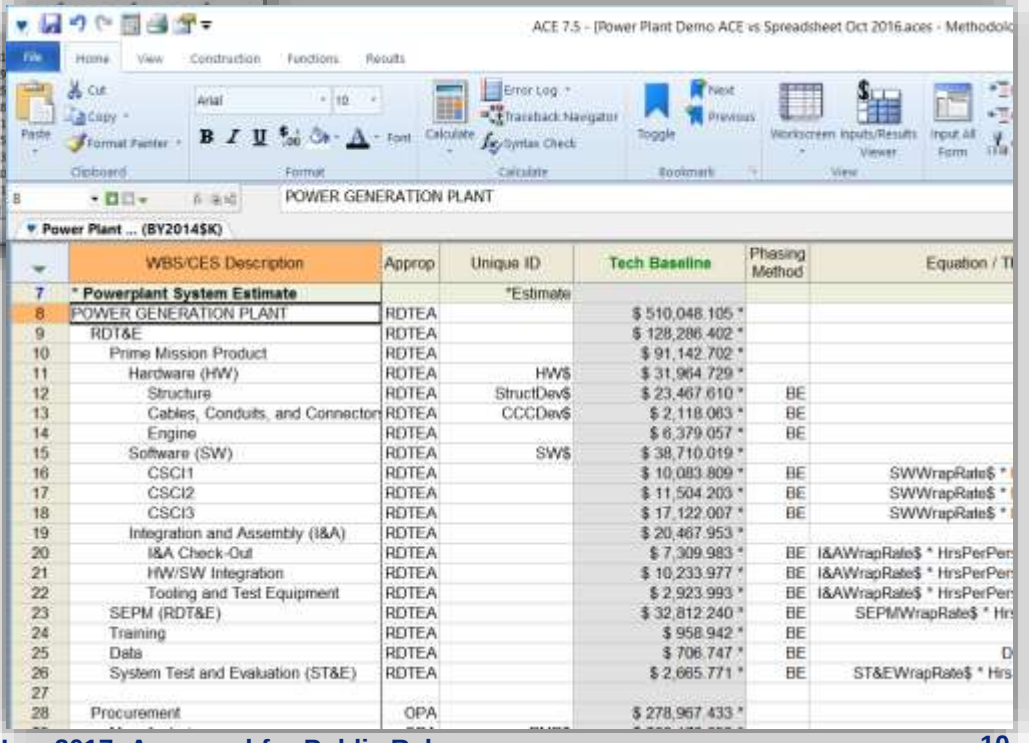
If the structure is not standardized the estimate quickly becomes unmanageable

Section #1 Estimate Layout



Challenges

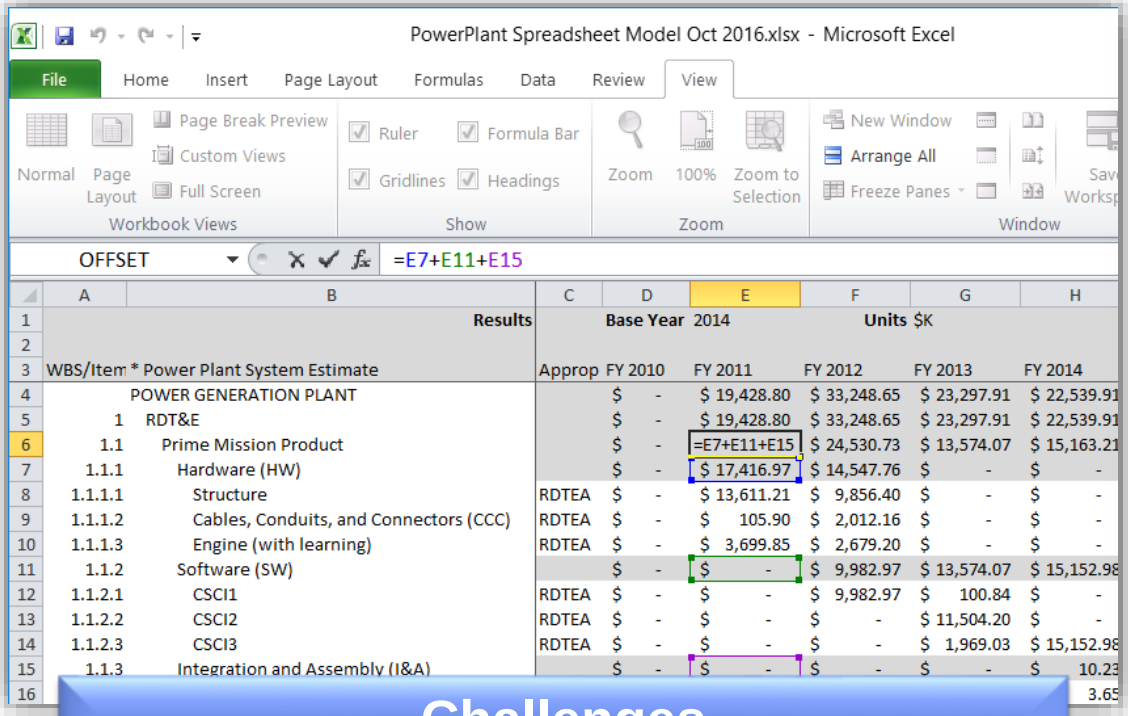
- Estimate start focuses on estimate layout
- Work in many worksheets to organize data, calculations, and reports
- Training: new analyst must learn spreadsheet layout before work can begin

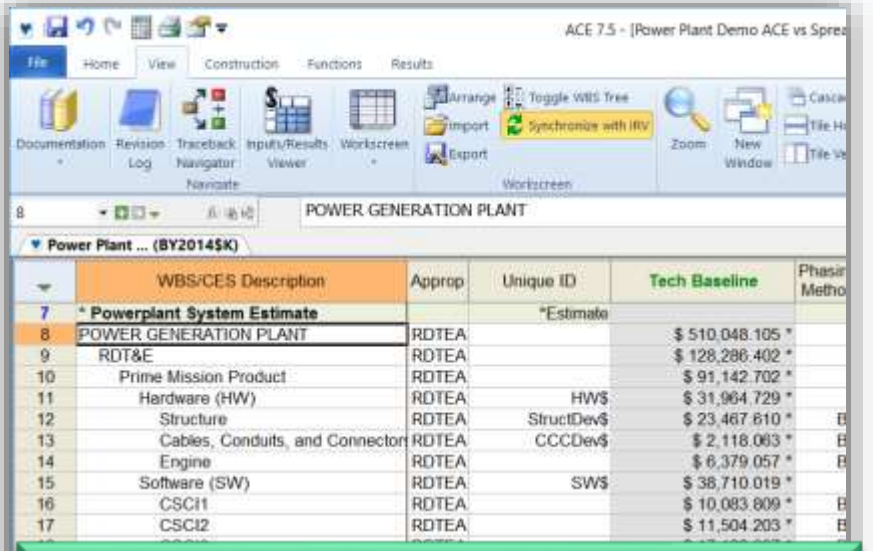


Benefits

- 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

Section #1 WBS Roll-up





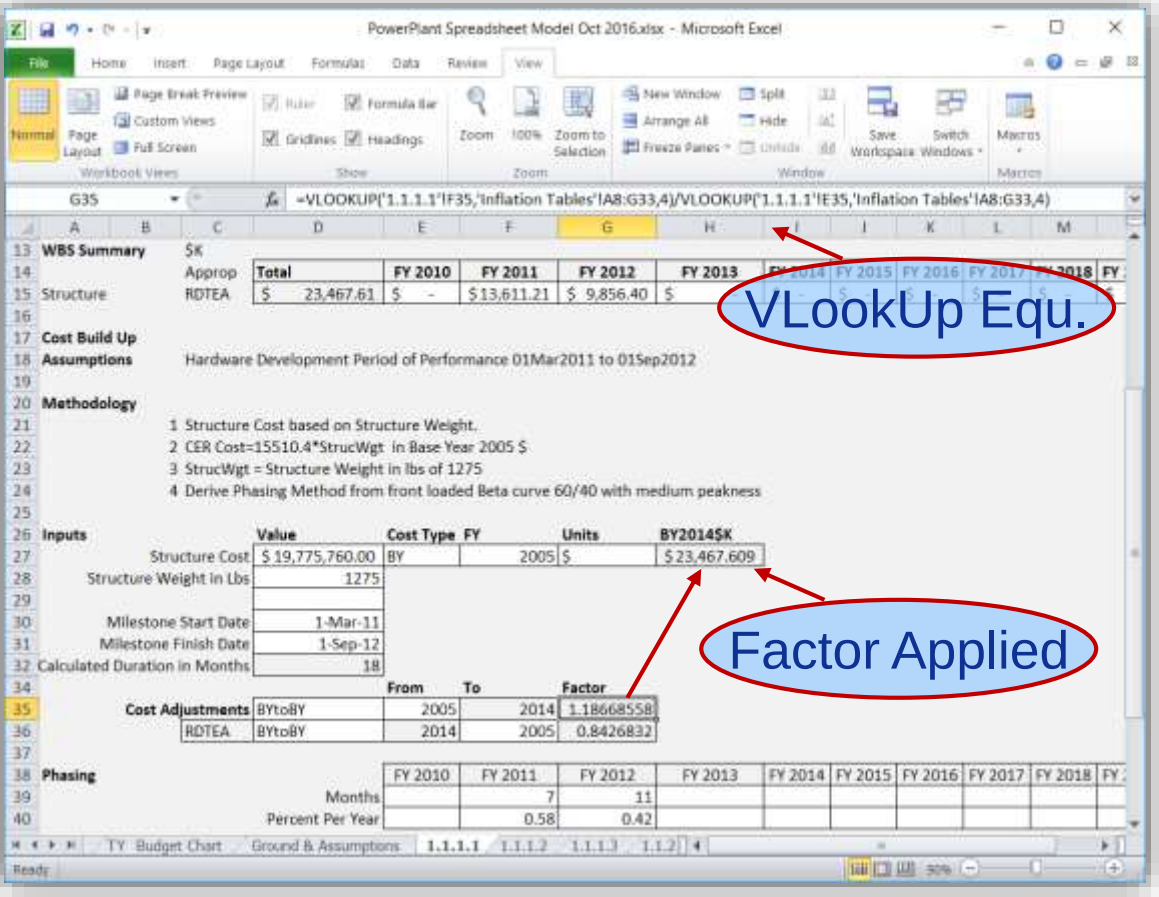
Challenges

- 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

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



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

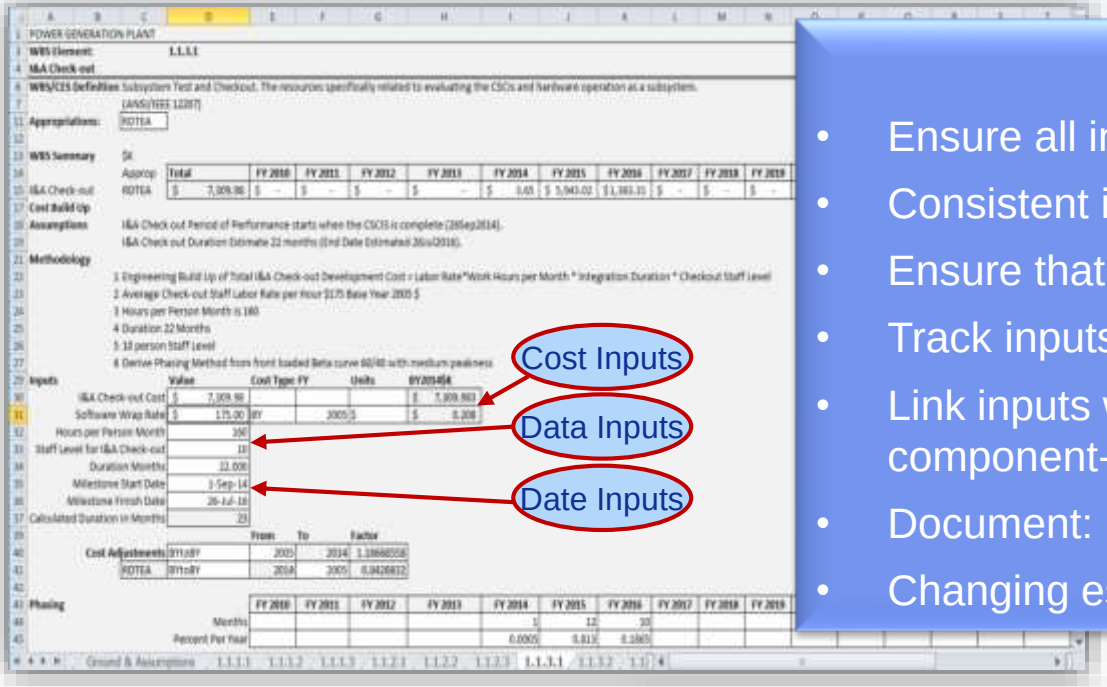
	WBS/CES Description	Approp	Unique ID	Tech Baseline	Phasing Method	Equation / Throughput	Fiscal Year	Units
105	* **Wrap Rates**							
106	I&A Wrap Rate	RDTEA	I&AWrapRate$	$ 0.208 *	C	175	2005	$
107	Software Wrap Rate	RDTEA	SWWrapRate$	$ 0.261 *	C	220	2005	$
108	SEPM Wrap Rate	RDTEA	SEPMWrapRate$	$ 0.178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

Section #2
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 defendable estimate

Section #2 Estimate Inputs

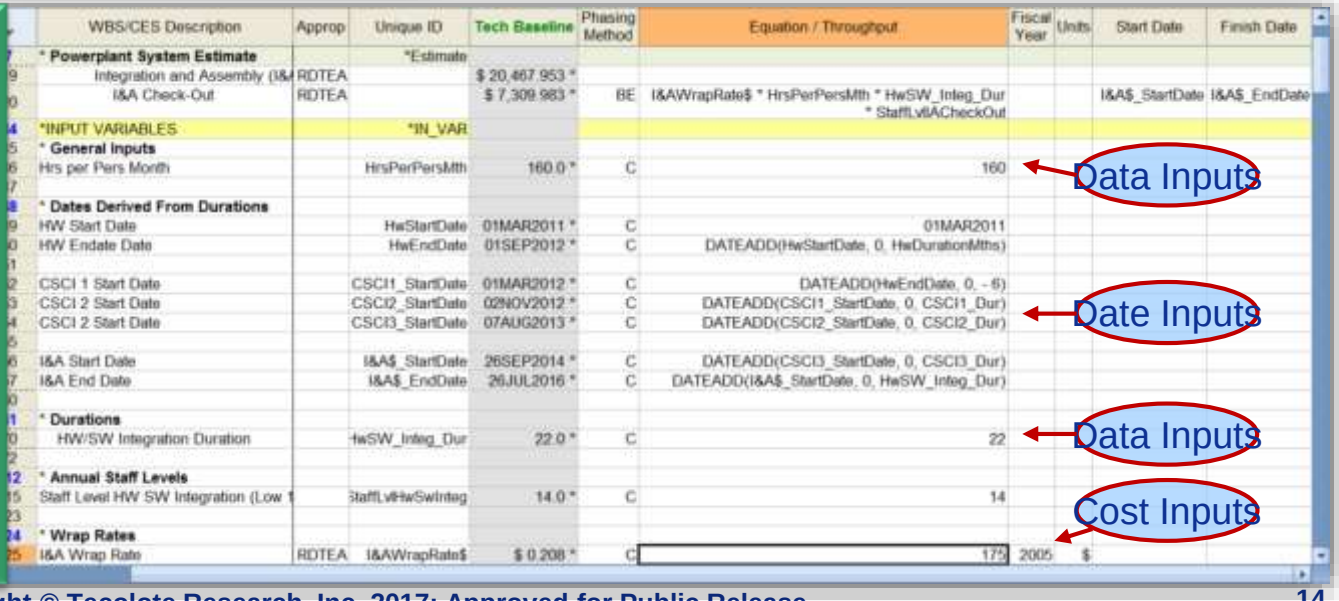


Challenges

- 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

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



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

Section #3
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

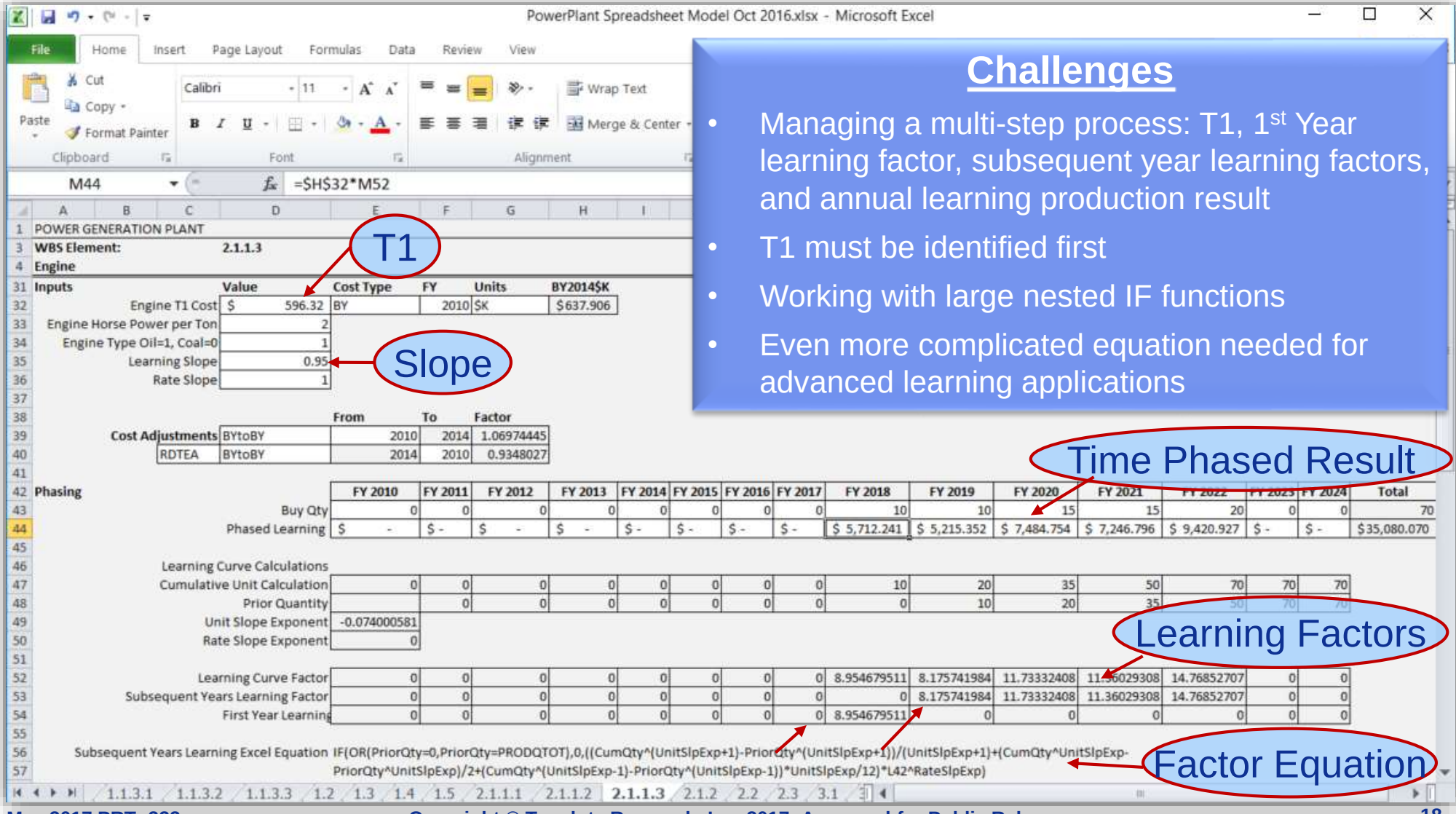
ACE can solve complex estimate problems

Contact our support team and we can show you how

- **ACEIT support team at aceit_support@tecolote.com**

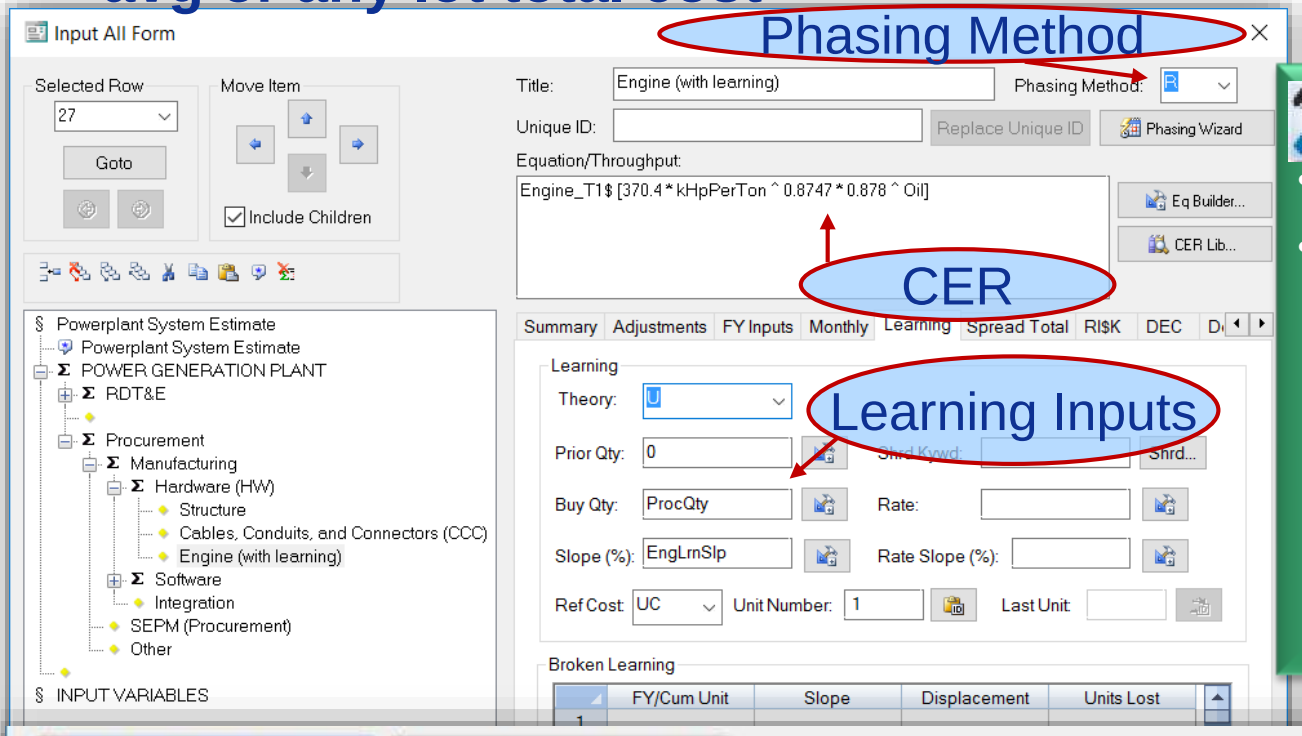
Section #3 Learning Curves

- **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)



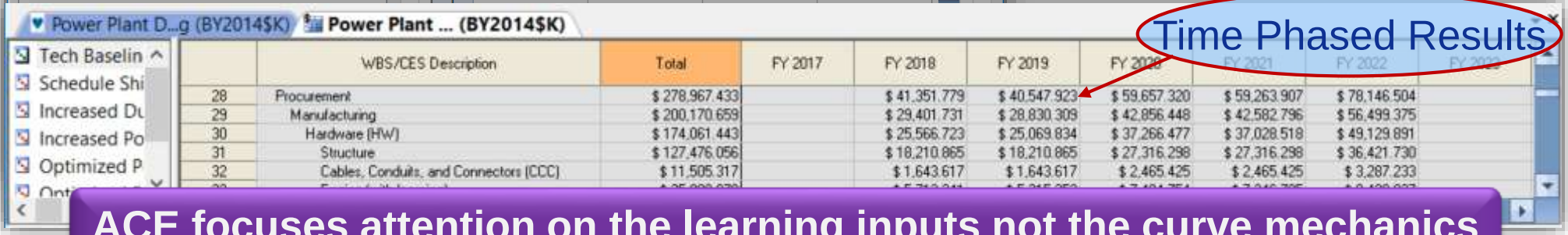
Section #3 Learning Curves

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



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



ACE focuses attention on the learning inputs not the curve mechanics

Section #3 Fielded Schedules

- Fielded schedules should be calculated from production quantities

U22 =SUM(K21:T21)

	A	B	C	K	L	M	N	O	P	Q
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	
25										
26	Engine Operational Life	Total	10	Manually Adjust Fielded quantity equations to reflect these						
27	Lag between Procurement and Fielding	Total	1							

TY Summary Chart | Budget POM TY$K | TY Budget Chart | Ground & Assumptions | 1.1.1.1 | 1.1.1.2 | 1.1.1.3

Challenges

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

79 OpFieldedUnits(@ProcQty,OpLife,Lag)

Power Plant ... (BY2014$K) | Power Plant D...r (BY2014$K)

	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...y (BY2014$K) | Power Plant ... (BY2014$K)

	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

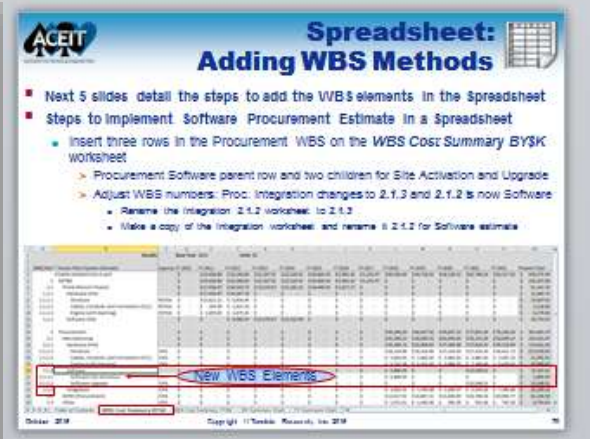
- Functions calculate from simple set of parameters
- Time phased parameters offer even more flexibility
- The parameters can also be variables for What ifs

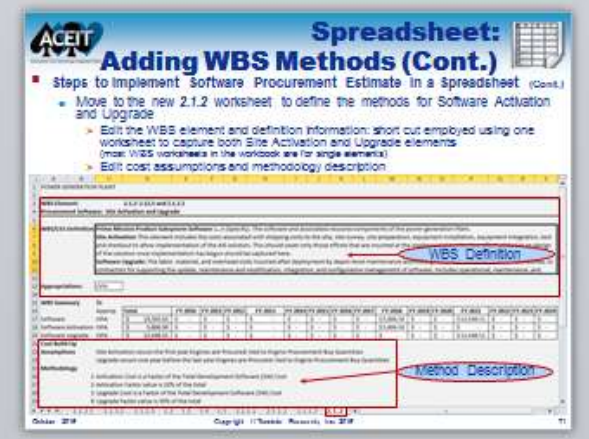
Section #4 Adding WBS Elements to the Estimate

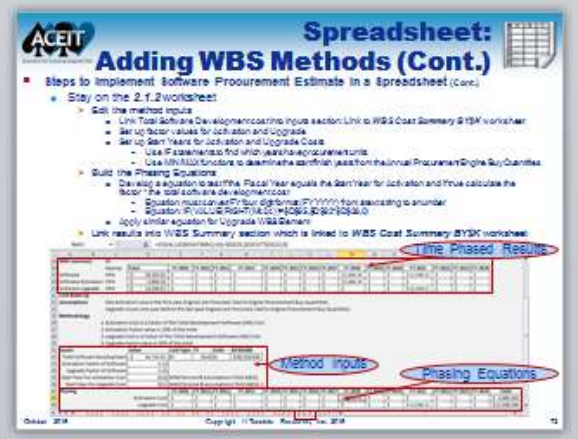
- **Estimates evolve over the life cycle of a program**
  - Projects become more defined and more detailed estimate are required
  - Adding WBS elements to an estimate is common and necessary
- **Adding a WBS element to a spreadsheet**
  - Requires many steps
  - Requires repeated entry of the same information on multiple worksheets
- **ACE is designed to easily make changes to the WBS**

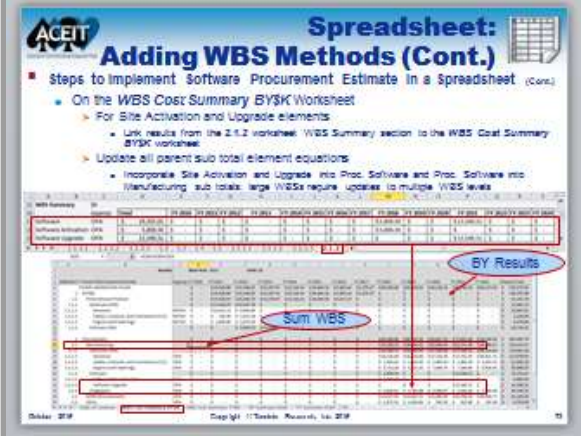
Section #4 Highlights

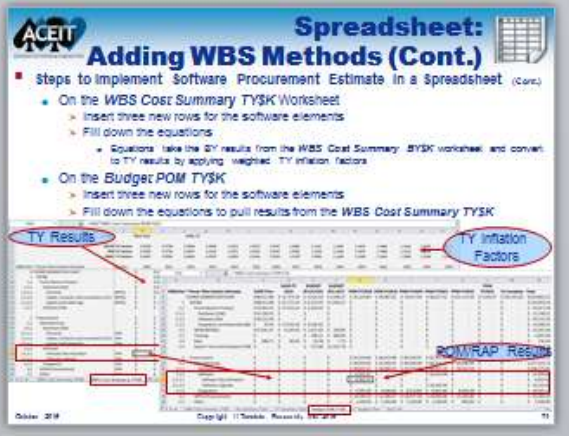
- **Spreadsheet steps outlined**
  - Example adds software site activation and upgrade to the estimate







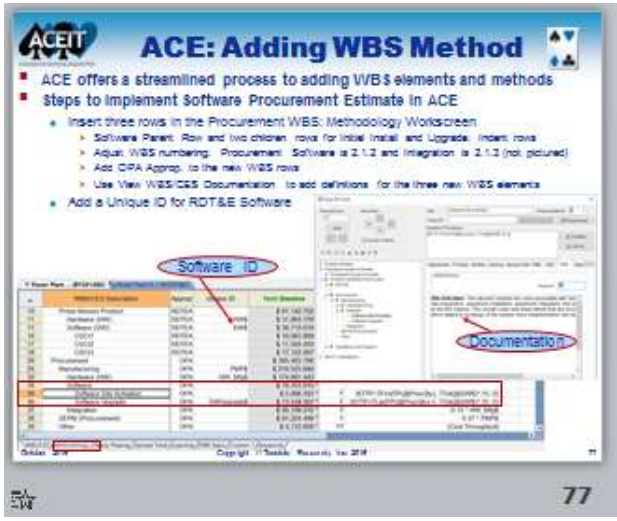


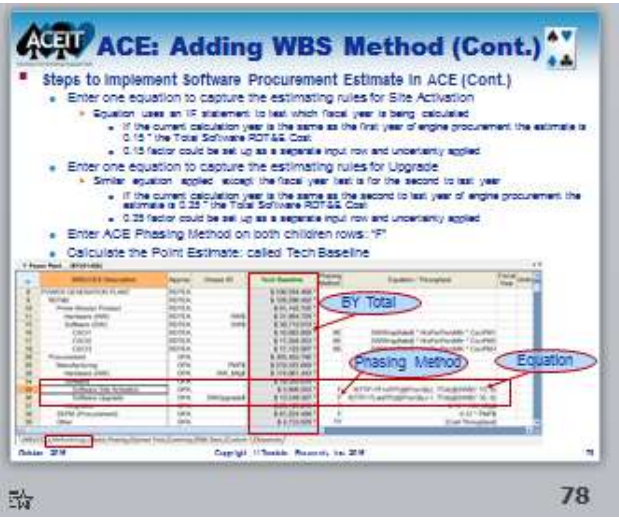


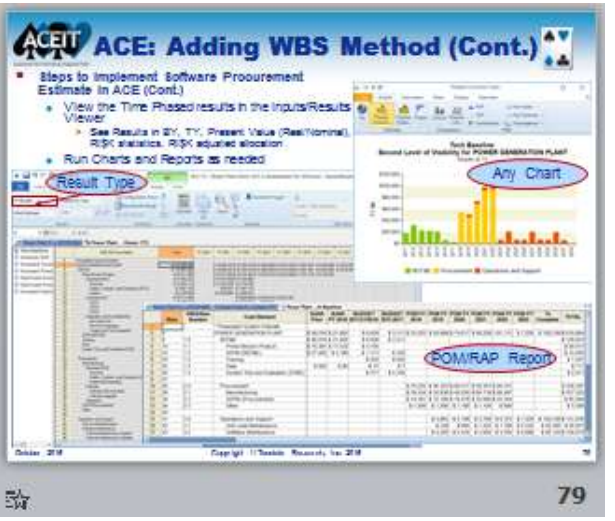
Adding two WBS items needs six slides to explain how to update estimate

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

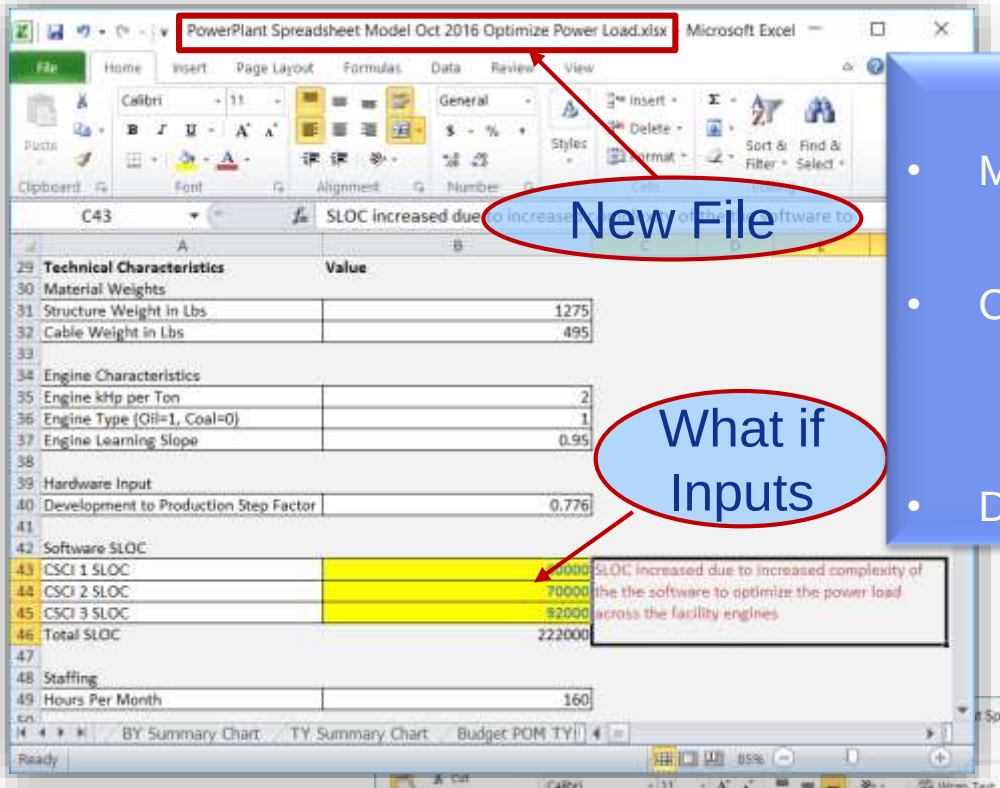
Section #5 What If Drills

- **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

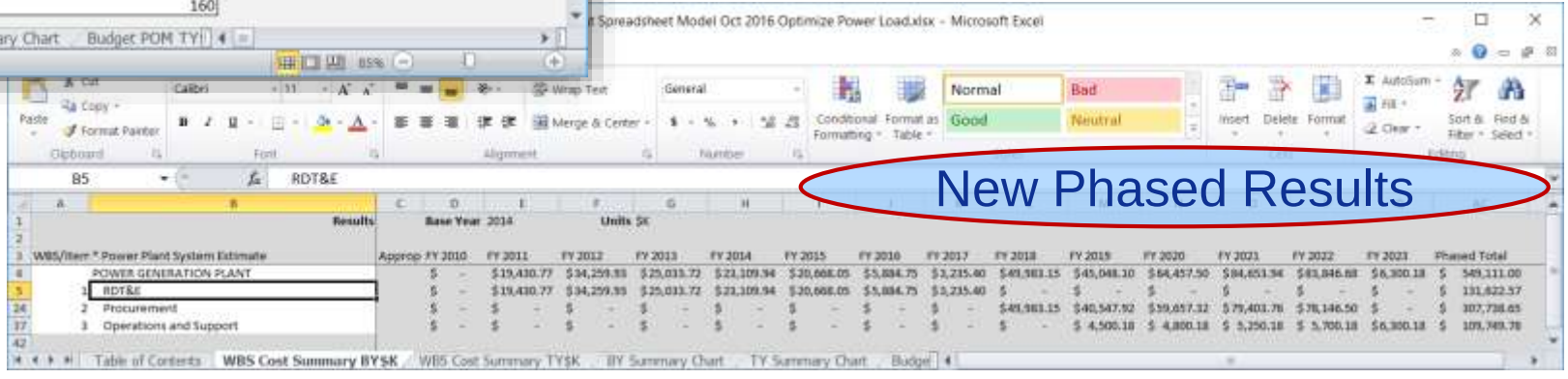
Section #5 Spreadsheet: What Ifs

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



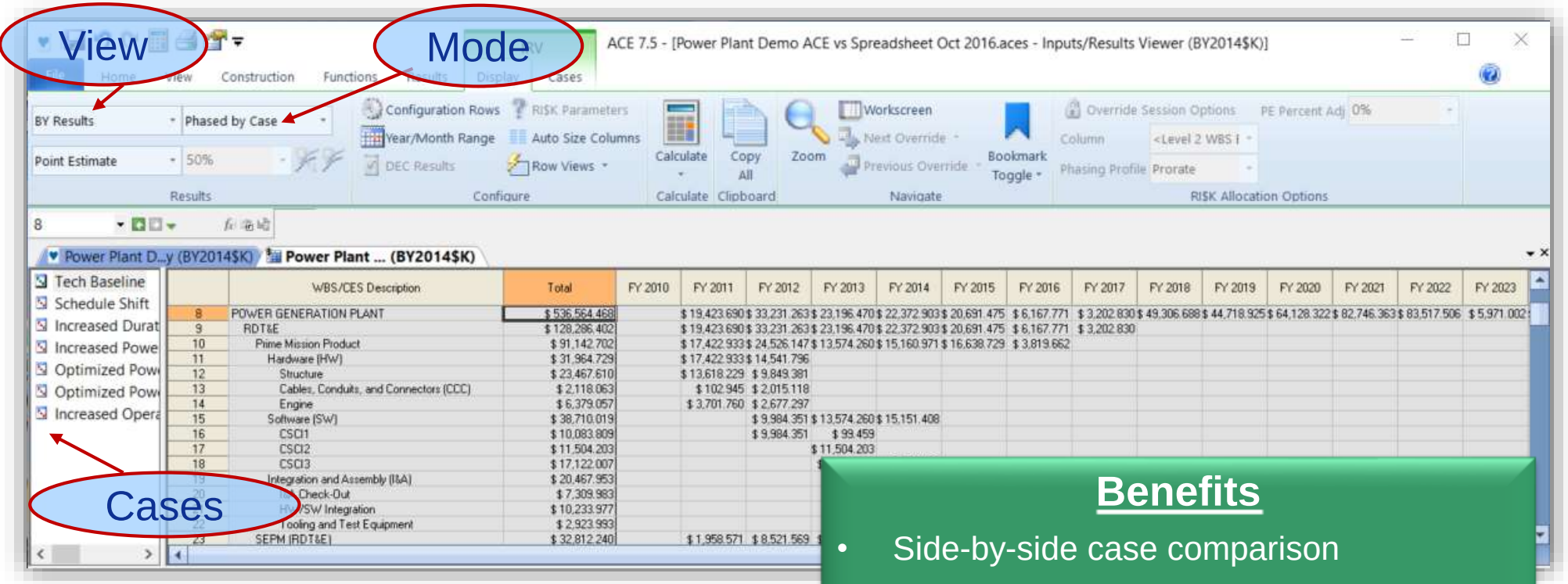
Challenges

- 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



Section #5 ACE: What Ifs

- **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



Benefits

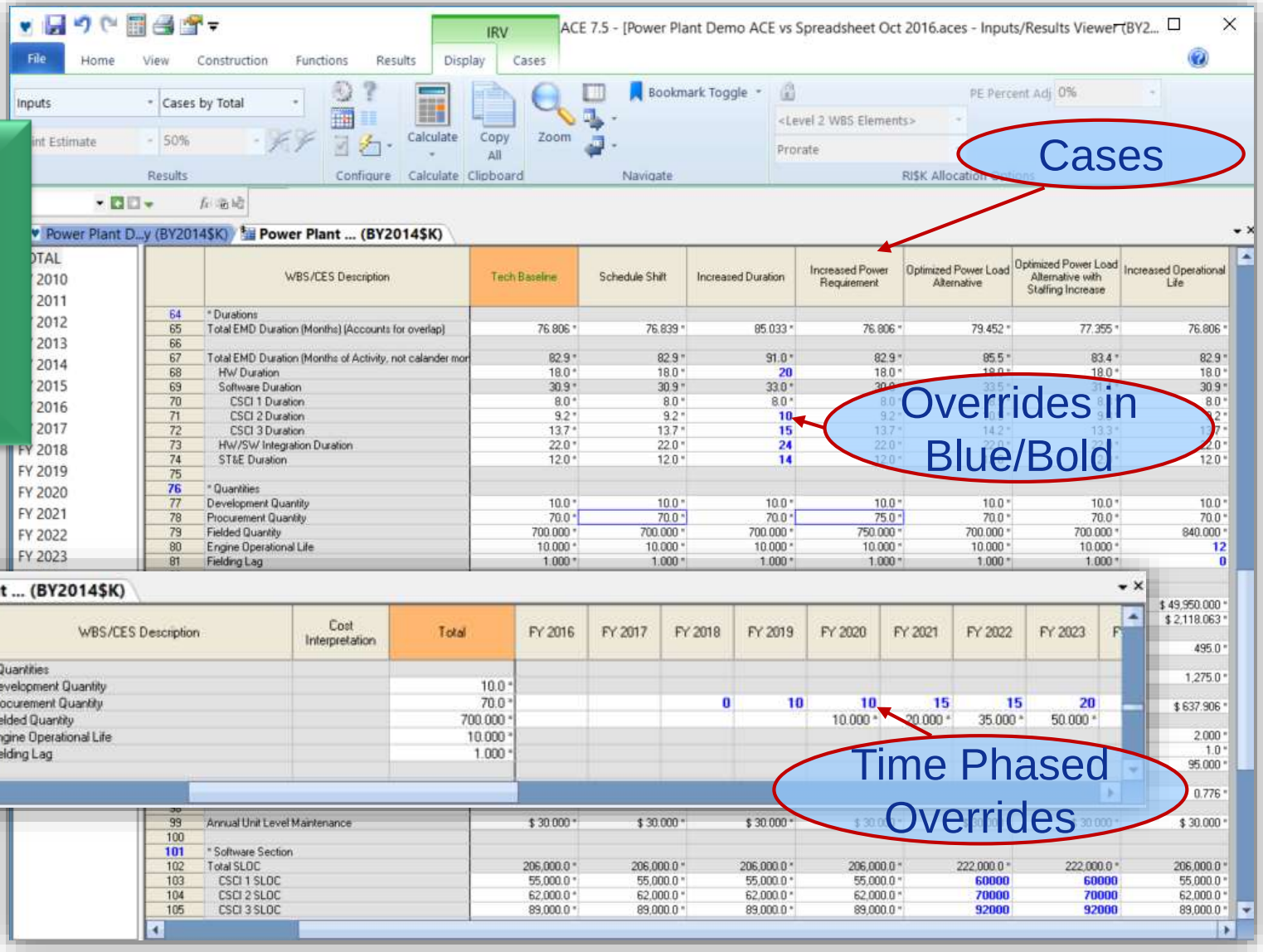
- Side-by-side case comparison
- Case viewer allows comparison without additional report set up

Section #5 ACE: What Ifs

- **Override model baseline total and time phased inputs**

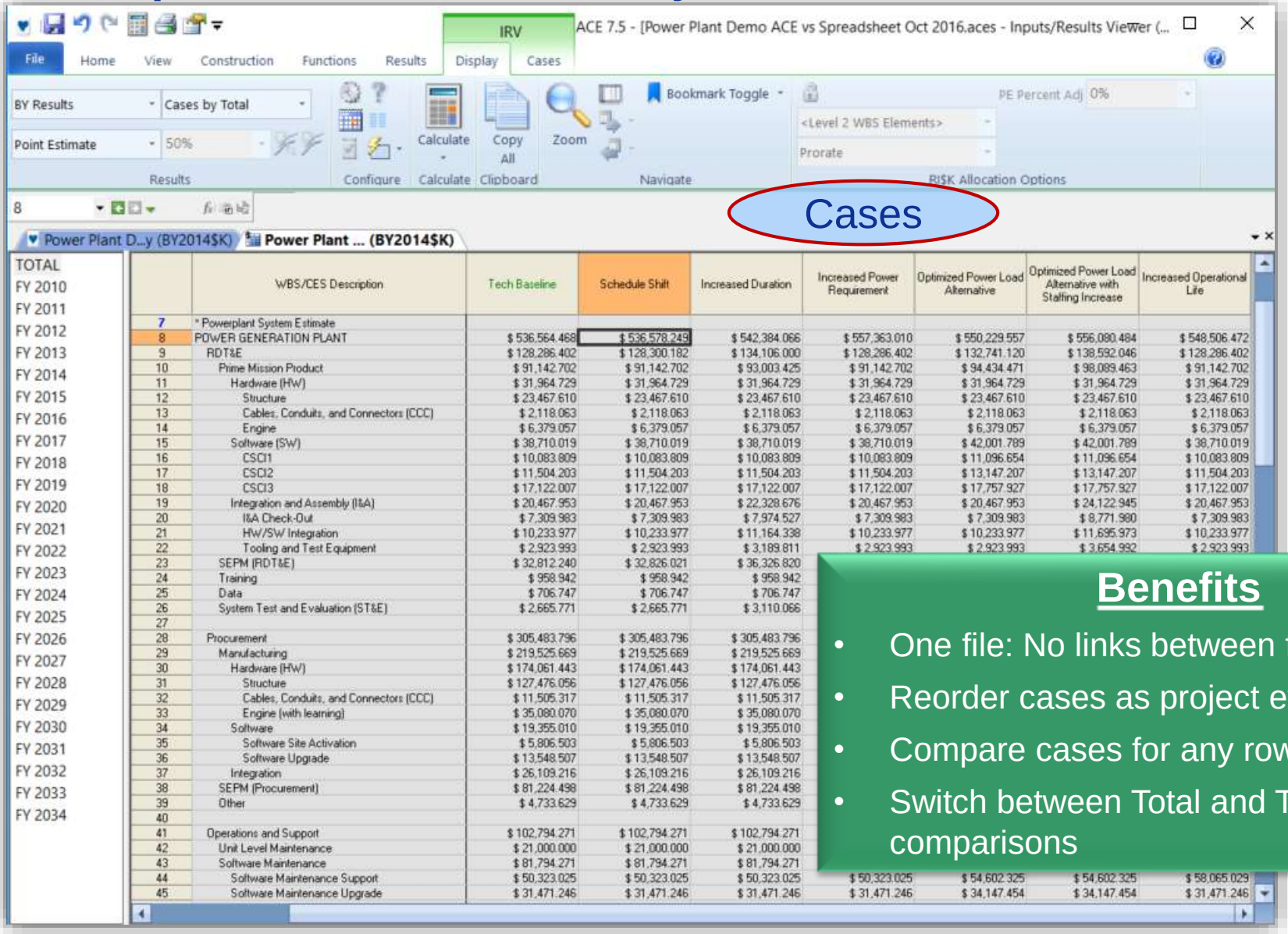
Benefits

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



Section #5 ACE: What Ifs

- **Compare case results side by side**



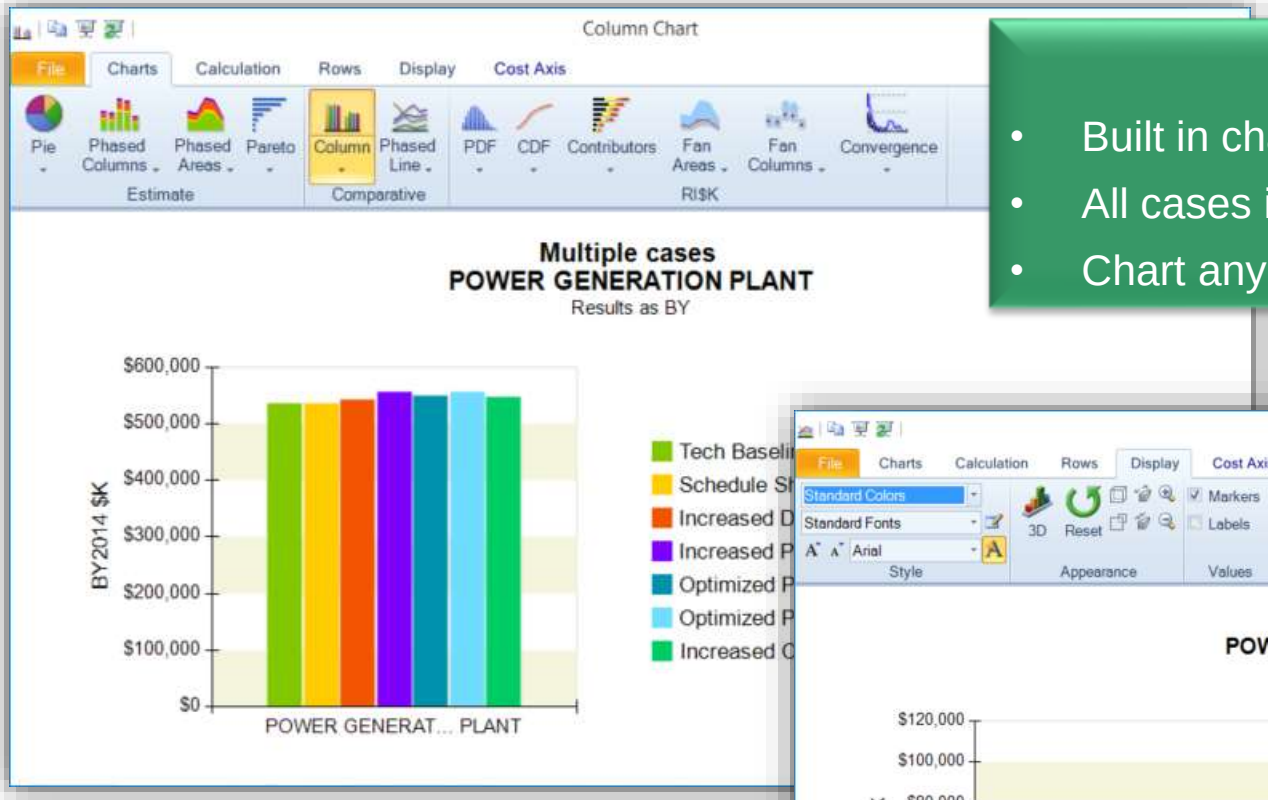
	WBS/CES Description	Tech Baseline	Schedule Shift	Increased Duration	Increased Power Requirement	Optimized Power Load Alternative	Optimized Power Load Alternative with Staffing Increase	Increased Operational Life
7	* Powerplant System Estimate							
8	POWER GENERATION PLANT	$ 536,564,468	$ 536,578,249	$ 542,384,066	$ 557,363,010	$ 550,229,557	$ 556,080,484	$ 548,506,472
9	RDT&E	$ 128,286,402	$ 128,300,182	$ 134,106,000	$ 128,286,402	$ 132,741,120	$ 138,592,046	$ 128,286,402
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
11	Hardware (HW)	$ 31,964,729	$ 31,964,729	$ 31,964,729	$ 31,964,729	$ 31,964,729	$ 31,964,729	$ 31,964,729
12	Structure	$ 23,467,610	$ 23,467,610	$ 23,467,610	$ 23,467,610	$ 23,467,610	$ 23,467,610	$ 23,467,610
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
14	Engine	$ 6,379,057	$ 6,379,057	$ 6,379,057	$ 6,379,057	$ 6,379,057	$ 6,379,057	$ 6,379,057
15	Software (SW)	$ 38,710,019	$ 38,710,019	$ 38,710,019	$ 38,710,019	$ 42,001,789	$ 42,001,789	$ 38,710,019
16	CSCI1	$ 10,083,809	$ 10,083,809	$ 10,083,809	$ 10,083,809	$ 11,096,654	$ 11,096,654	$ 10,083,809
17	CSCI2	$ 11,504,203	$ 11,504,203	$ 11,504,203	$ 11,504,203	$ 13,147,207	$ 13,147,207	$ 11,504,203
18	CSCI3	$ 17,122,007	$ 17,122,007	$ 17,122,007	$ 17,122,007	$ 17,757,927	$ 17,757,927	$ 17,122,007
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
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
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
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
23	SEPM (RDT&E)	$ 32,812,240	$ 32,826,021	$ 36,326,820				
24	Training	$ 958,942	$ 958,942	$ 958,942				
25	Data	$ 706,747	$ 706,747	$ 706,747				
26	System Test and Evaluation (ST&E)	$ 2,665,771	$ 2,665,771	$ 3,110,066				
27								
28	Procurement	$ 305,483,796	$ 305,483,796	$ 305,483,796				
29	Manufacturing	$ 219,525,669	$ 219,525,669	$ 219,525,669				
30	Hardware (HW)	$ 174,061,443	$ 174,061,443	$ 174,061,443				
31	Structure	$ 127,476,056	$ 127,476,056	$ 127,476,056				
32	Cables, Conduits, and Connectors (CCC)	$ 11,505,317	$ 11,505,317	$ 11,505,317				
33	Engine (with learning)	$ 35,080,070	$ 35,080,070	$ 35,080,070				
34	Software	$ 19,355,010	$ 19,355,010	$ 19,355,010				
35	Software Site Activation	$ 5,806,503	$ 5,806,503	$ 5,806,503				
36	Software Upgrade	$ 13,548,507	$ 13,548,507	$ 13,548,507				
37	Integration	$ 26,109,216	$ 26,109,216	$ 26,109,216				
38	SEPM (Procurement)	$ 81,224,498	$ 81,224,498	$ 81,224,498				
39	Other	$ 4,733,629	$ 4,733,629	$ 4,733,629				
40								
41	Operations and Support	$ 102,794,271	$ 102,794,271	$ 102,794,271				
42	Unit Level Maintenance	$ 21,000,000	$ 21,000,000	$ 21,000,000				
43	Software Maintenance	$ 81,794,271	$ 81,794,271	$ 81,794,271				
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
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

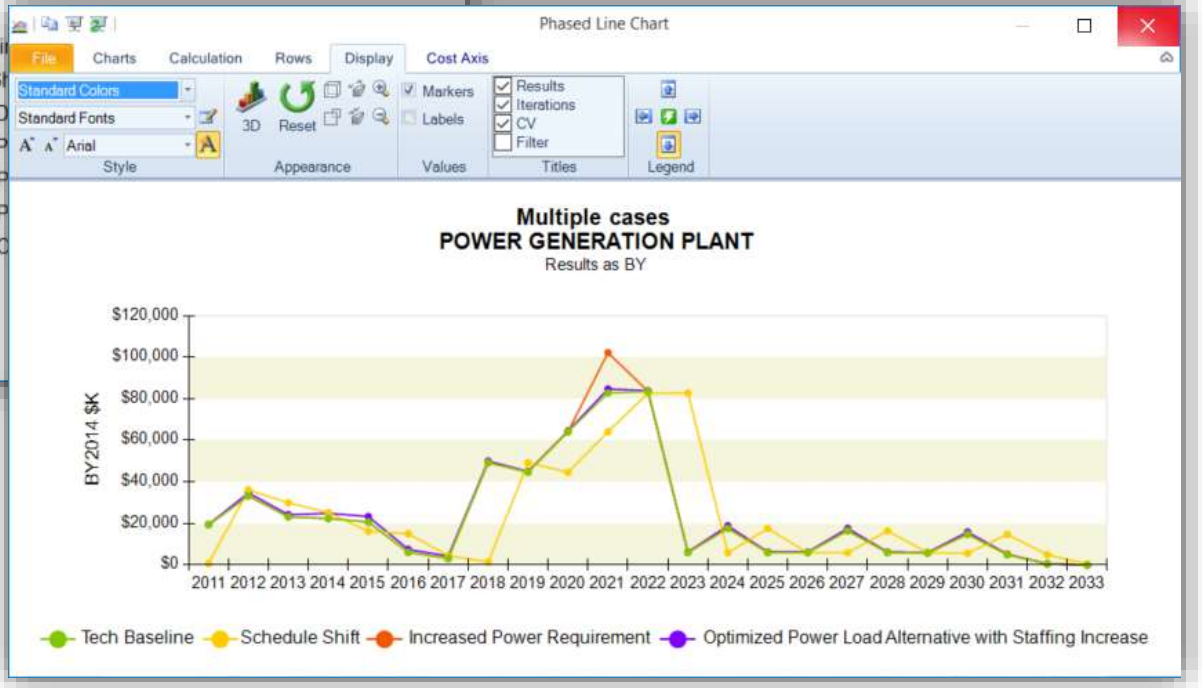
Section #5 ACE: What Ifs

- 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

Conclusion

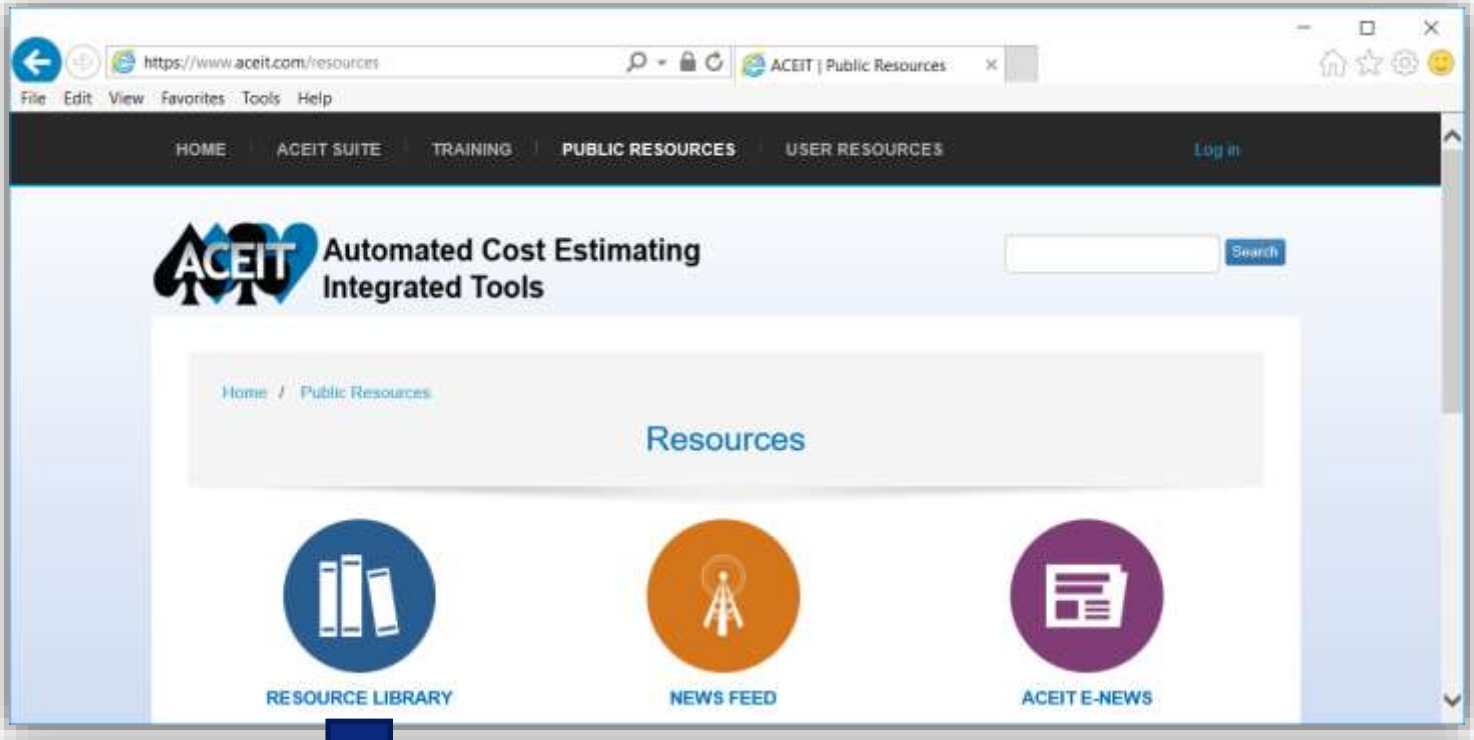
- **A cost analyst must perform many activities to develop credible point estimates**
  - Develop a model by estimating each WBS element, with the best method from available data
  - Include estimating ground rules and assumptions that best address the scenario
  - Express the results in constant and budget dollars
  - Time phase the results based on a program schedule
  - Add WBS elements or update the model as the project evolves

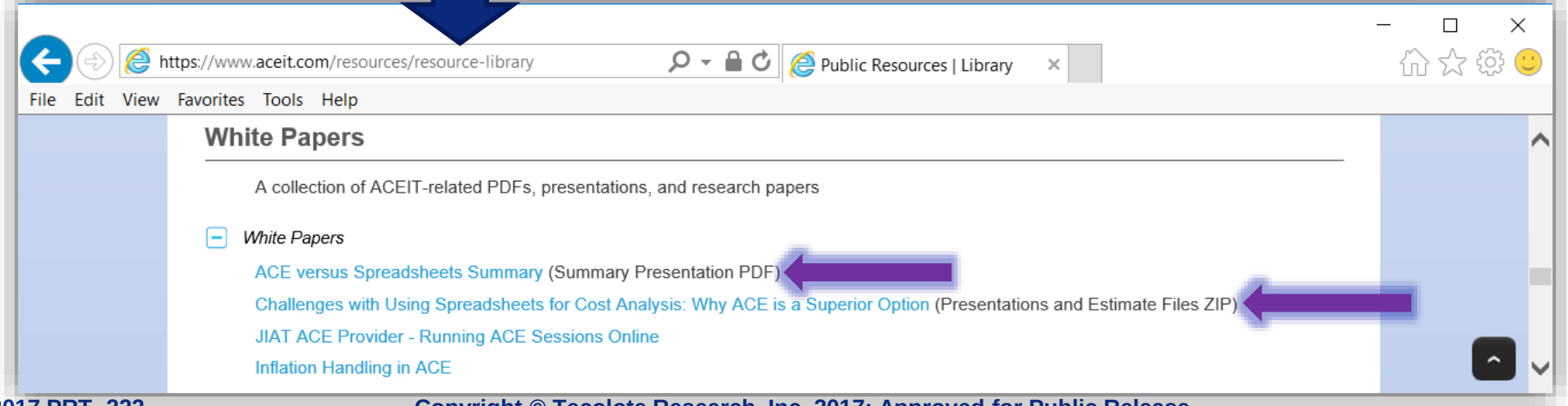
Avoid the traps of spreadsheets and use a tool built for cost analysis

- **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