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The Math and Reason Behind RI$K Allocation

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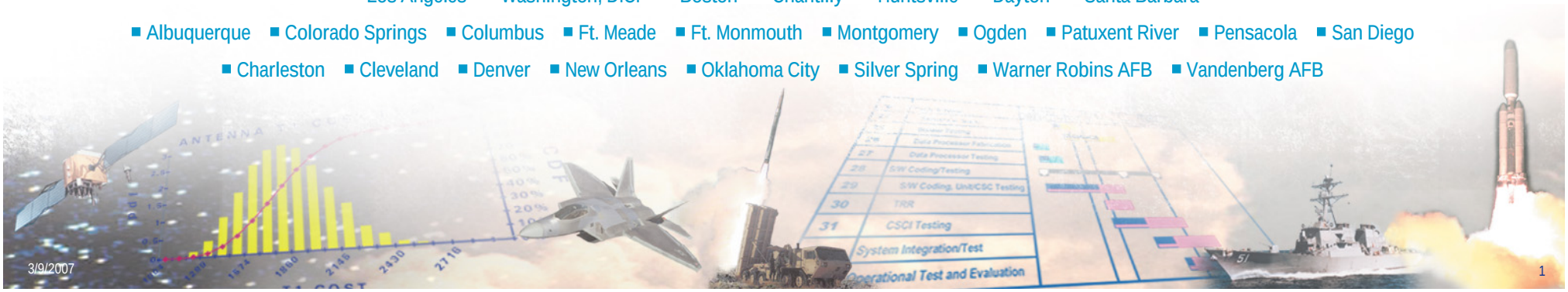


Finally Makes Sense

Time Equals Money

Knowledge is Power

Power Equals Work / Time

Therefore,

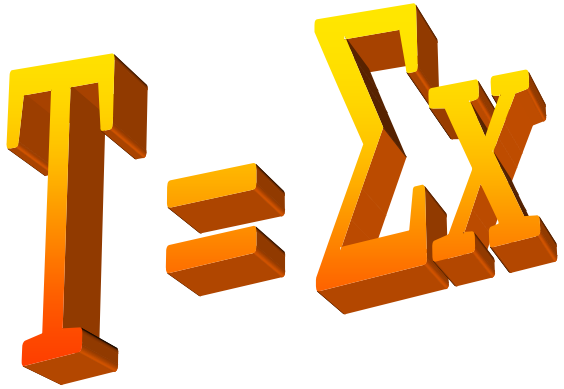
Knowledge = Work / Time

In other words,

The less you know, the more $ you make.

- Attributed to Scott Adams of *Dilbert* Fame

Topics Covered



- The Goal of Allocation
- ACE RI$K Allocation Report
- Choosing an Allocation Heuristic
- The Math and an Example
- Potential Enhancements

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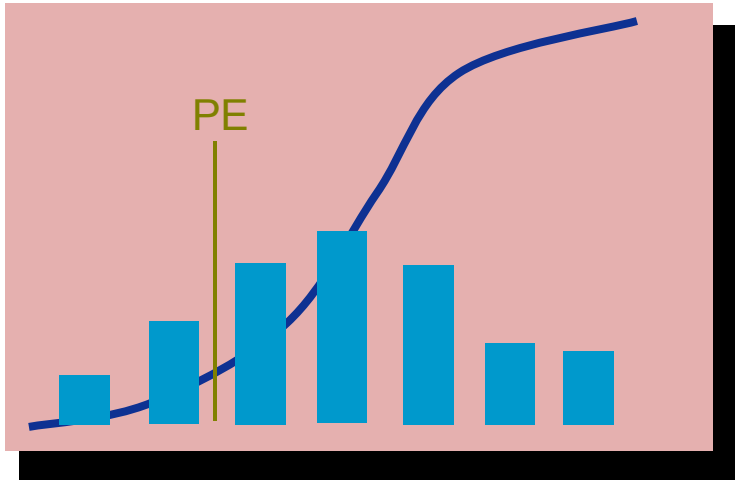
Goal of Allocation

RI$K = Context

- **Point Estimate lacks meaning**
- **Risk Statistics…**
- **…quantify model uncertainty**
  - As a range of possible outcomes
- **…giving P.E. context**

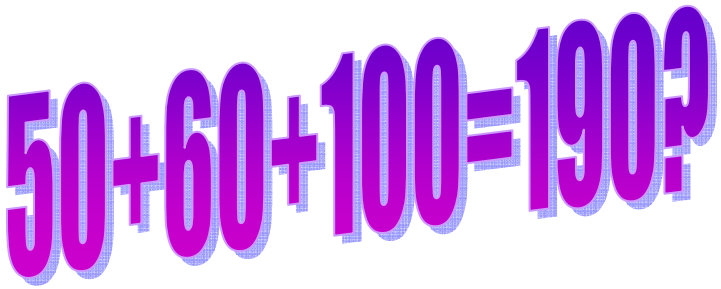


- **However, stats *don't* add up**

Sum of risk

is not equal to

risk of sum



It All Adds Up

- **Allocation Adjusts Children So That WBS Adds Up to Total**
  - For example*, ACE removes $2,446 from children
  - Notice how "risky" rows move more
- **You Pick Which Rows in WBS Are Fixed at Target Confidence**
  - Define your "pivot" rows based on where you manage your money

WBS/CES	75.0% Level	$ Change	Allocate@75%
Total *(pivot)*	**$166,463**	**$0**	**$166,463**
Manufacturing	$111,772	$24	$111,796
Air Vehicle	$98,669	($1315)	$97,354
Integration	$13,666	($224)	$13,442
SEPM	$55,727	($700)	$55,027
Other	$647	($7)	$640

* From "02 – Basic Risk.aceit" example file

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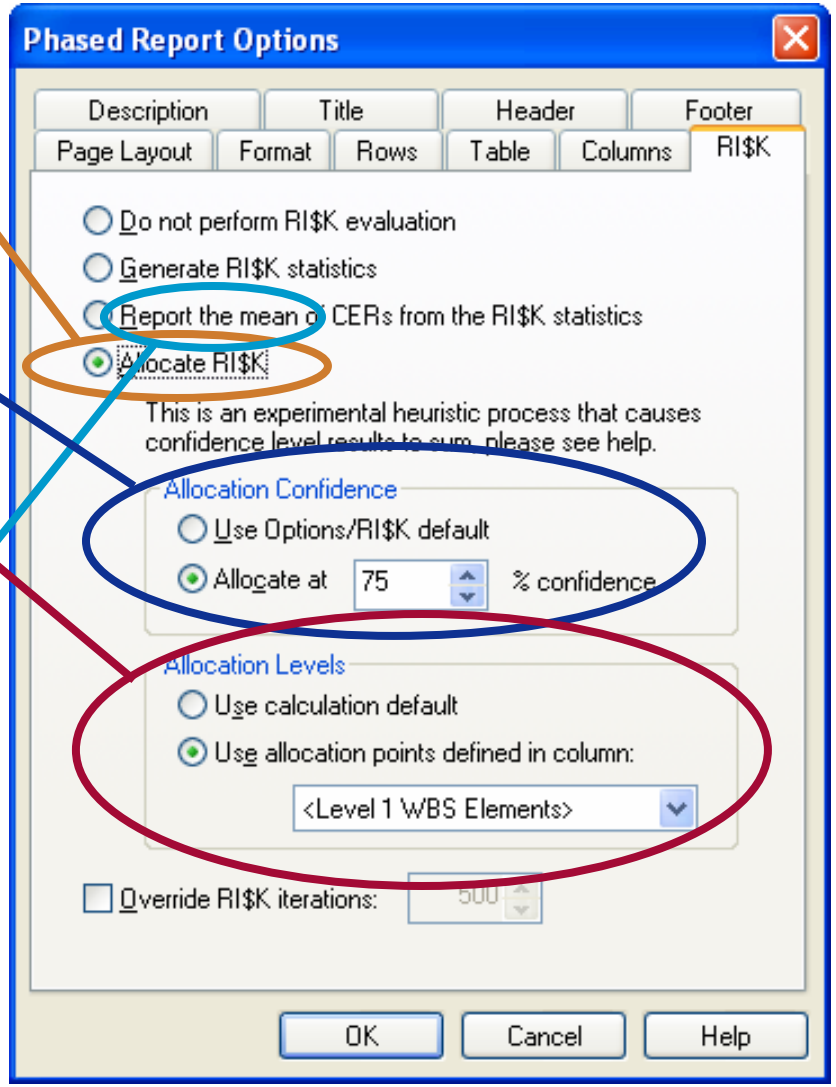
Allocation Report in ACE

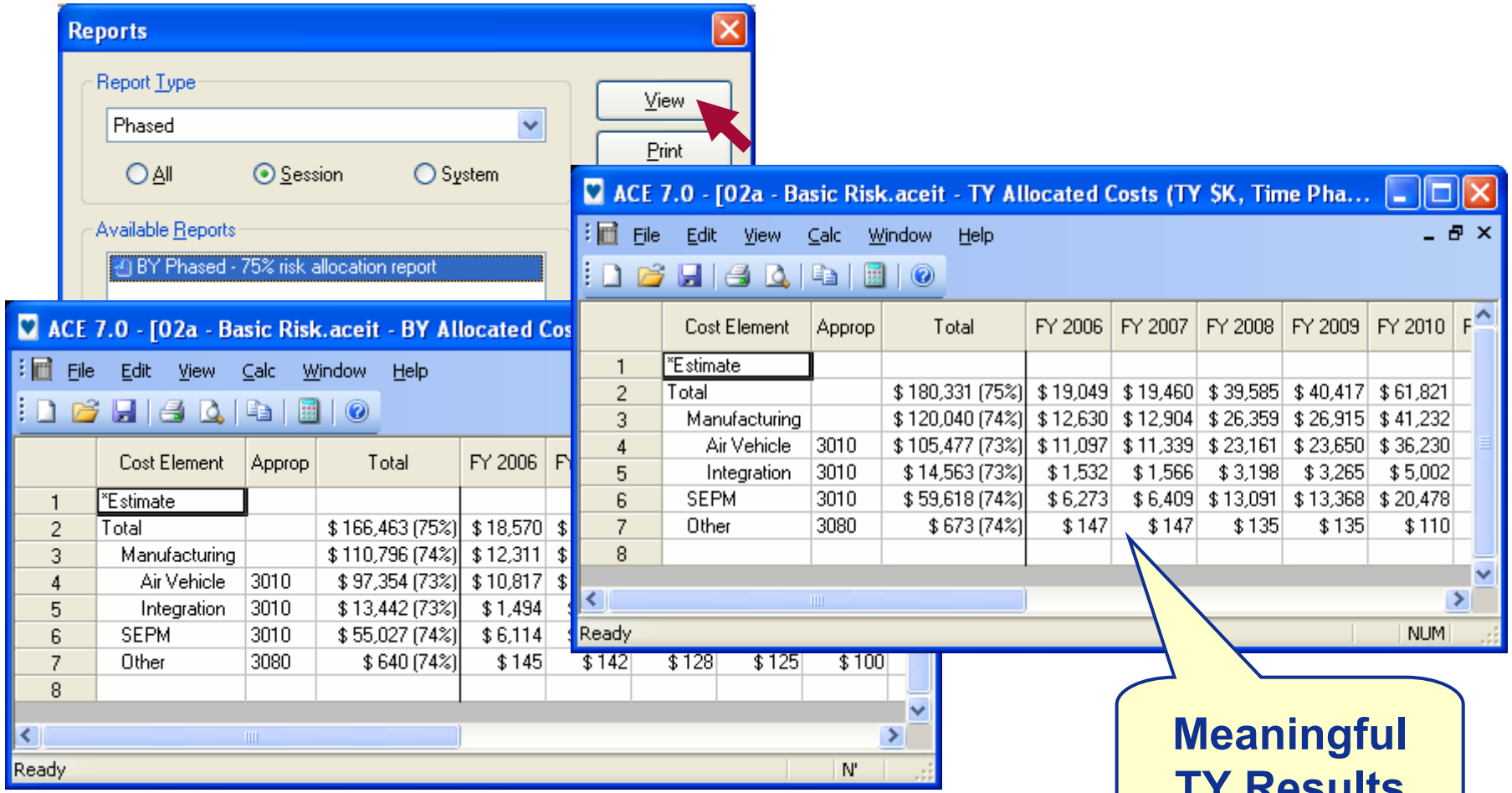
Allocate In ACE

- **The RI$K Allocation Report**
  - It's simply a switch in the Phased Report on the RI$K tab
- **Set the confidence for the "pivot" rows**
- **Set who the "pivot" rows are**
  - 1: Pick 1st, 2nd, 3rd level WBS
    - Easy – nothing more to do
  - 2: Manually define levels
    - Pick category column
    - Put text in cell of pivot rows
- **Report the Mean**
  - Third bullet on dialog
  - No "pivot" to worry about
    - Mean sums up



Generating Reports

- **Now comes the hard part… Press the "View" button**



Options Galore

- **You may use RI$K Allocation with various phased reports**
  - Phased, Budgetary, Cost Category
- **You may use RI$K Allocation with various report settings**
  - Detail by Category
  - Summary by Category
  - TY, SY, BY
  - Selected Rows, Sections, etc.
  - WBS/CES indenture limitations
- **POST works great with allocated results as well**
  - You can generate just about any report or chart using allocated results instead of the point estimate

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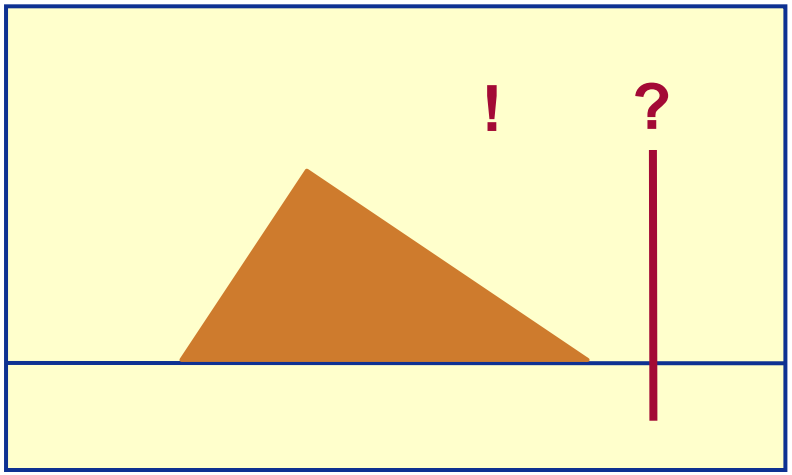
Choosing an Hueristic

Prioritization

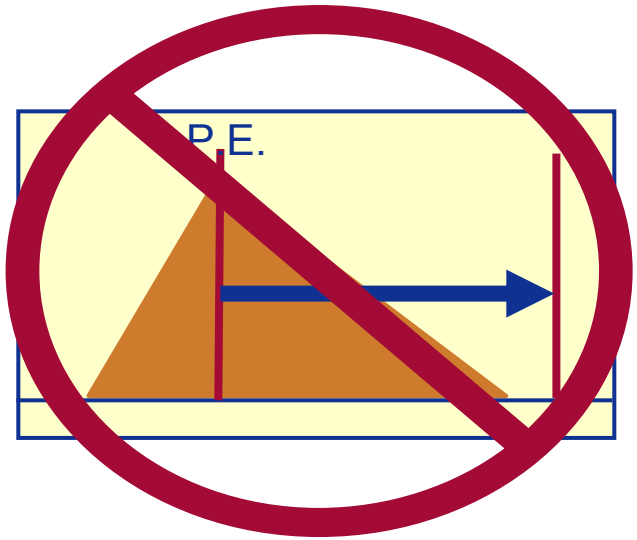
- **Primary Goal in ACE:** **Robustness**
- **We Always Want to Generate *Valid*, *Meaningful* Results**
- **Rows Land In Their Distribution Bounds**
  - For any confidence level – from 1% to 99%

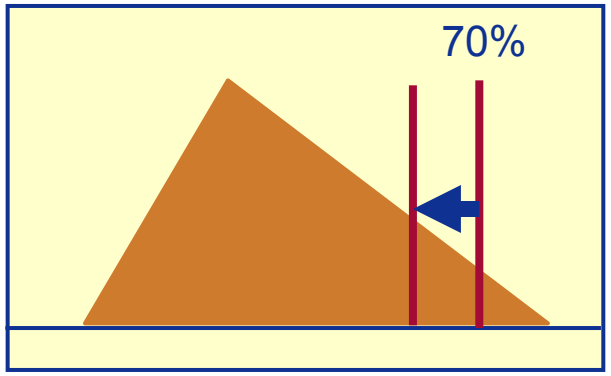


Starting Safe

- **All allocation heuristics add an amount to a starting point**
- **Where does ACE start?**
- **We want to avoid big swings**
  - Long distances increase likelihood we land out of bounds
- **We start at target confidence level**
  - Usually very close to destination
  - Intuitive – just a tweak to stats
  - Tendency to move toward mean
    - And away from extremes

$$Alloc\$ = Start\$ + Adjust\$$$





Falling Out Of Bounds

- **A Trivial Example (watch the low):**

WBS	Form	Mode	Low	High
Total				
A	Tri	400	200	600
B	Tri	100	**90**	200

Correlation Matrix	
	B
A	0.5

- **Allocations from ACE and another popular method:**

WBS	Point Estimate	Cost @ 20%	Other Allocation	ACE Allocation
Total	500	443	443	443
A	400	327	400	334
B	100	106	**43**	109

- **Shouldn't the result be within the original risk bounds?**

Staying Safe

- **How Much Does Each Element Get?**
  - Prorate using a weighting factor

$$Tot\$ = C\$ + Risk\$ \frac{w_i}{\sum w_k}$$

- **What Feels Good for w_i?**
  - 1) Always positive (safe for prorating),
  - 2) Increases proportionally with cost,
  - 3) Increases proportionally with uncertainty,
- **ACE Uses Standard Deviation (σ) to Weigh Elements**
  - Always positive
  - Increases with Mean
  - Increases with Coefficient of Variation (CV)

Example of "Fair"

The Results

- ACE increases confidences of all project elements regardless of costs
- Other heuristic loads up only large cost elements, neglecting smaller ones

WBS	Mean	Cost @ 80%	Other Allocation		ACE Allocation	
Total	5550	6790	6790	80%	6790	80%
Huge	5000	6264	6238	80%	6143	78%
A	4000	5012	4991	80%	4914	78%
B	1000	1253	1247	80%	1229	78%
Small	500	600	502	53%	590	78%
C	400	501	401	53%	472	74%
D	100	125	101	51%	118	74%
Tiny	50	58	50	50%	57	78%
E	40	50	40	50%	45	68%
F	10	13	10	50%	12	68%

Notice how little it costs to boost tiny projects

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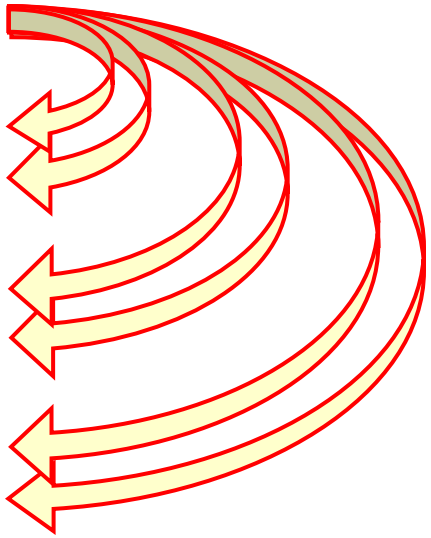
The Math

ACE RI$K Allocation

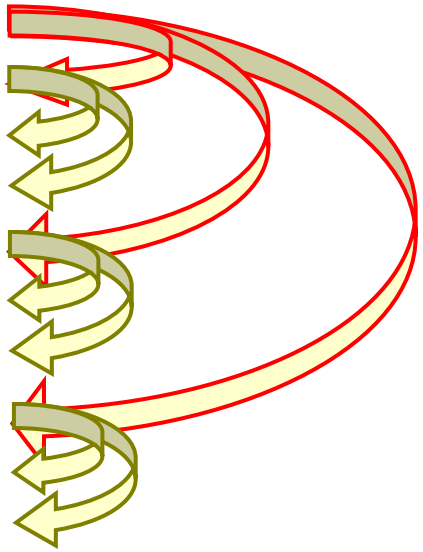
- **Most Allocation Schemes Prorate All At Once**
  - One step process is easier to implement in Excel

Total	850
R&D	130
R	50
D	80
Prod	575
Non-Rec	125
Rec	450
O&S	145
O	90
S	55



- **ACE RI$K Allocation Prorates Recursively**
  - This helps capture cumulative impacts to parent from all children

Total	850
R&D	126
R	46
D	80
Prod	524
Non-Rec	128
Rec	456
O&S	145
O	90
S	148

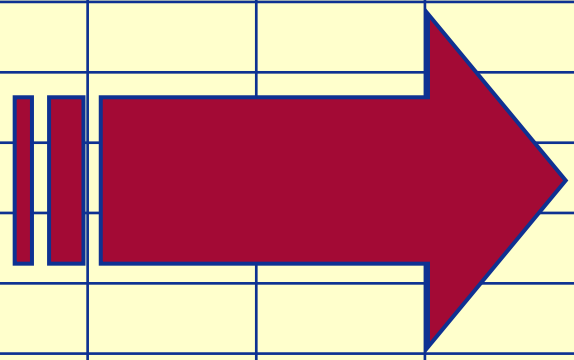


Work-a-long

Simple Example Session

- We will allocate at the 75% confidence of Total ($751)
- For ACE RI$K Allocation, all you need are the standard deviation and the costs at the target confidence

WBS	P.E.	75.0% Level	Std Dev					Allocated @ 75%
Total	$600	$751	$67					$751
R&D	$70	$135	$27					?
R	$20	$54	$17					?
D	$50	$90	$21					?
Prod	$440	$528	$60					?
NR	$90	$140	$29					?
Rec	$350	$403	$51					?
O&S	$90	$113	$16					?



Allocation (Step 1)

Step 1: For Each Pivot Row, *p*, Determine Adjustment

- Each child will "absorb" part of the adjustment, $\Delta\$_p$
- Total is passed down the WBS *(only total tracked in risk statistics)*

$$\Delta\$_p = C\$_p - \sum_{i}^{N_p} C\$_{pi}$$

Notation: i^{th} child of row p

Amount To Adjust Children

Sum of Row *p*'s Children

N_p = the number of children for row *p*
$C\$_p$ = total cost at desired confidence level for row *p*
$C\$_{pi}$ = total cost for the *ith* child of row *p* at desired confidence

Work-a-long (Step 1)

Calculate amount to adjust, $\Delta\$_p$

$\Delta\$_p$ = \$751 – (\$135+\$528+\$113) = \$(25)

(This is how much we must adjust children)

$$\Delta\$_p = C\$_p - \sum_i^{N_p} C\$_{pi}$$

WBS	P.E.	C$ @75%	Std Dev	$\Delta\$_p$				Allocated @ 75%
Total	\$600	**\$751**	\$67	**\$(25)**				
R&D	\$70	**\$135**	\$27					
R	\$20	\$54	\$17					
D	\$50	\$90	\$21					
Prod	\$440	**\$528**	\$60					
NR	\$90	\$140	\$29					
Rec	\$350	\$403	\$51					
O&S	\$90	**\$113**	\$16					

Allocation (Step 2)

- **Step 2: Prorate Δ_p among children of parent, *p*, to get new cost for child, $P\$_i$**
  - $P\$_i$ will get passed to children of row *i*, if row *i* has children

$$P\$_i = C\$_i + \Delta\$_p \frac{\sigma_i}{\frac{N_p}{\sum_j \sigma_j}}$$

This is the "allocated" cost for leaf rows, $A\$_i$

Sum of Std Devs for all siblings

$C\$_i$ = total cost for row, *i*, at desired confidence
$P\$_i$ = new total cost to use for subsequent prorating
σ_i = standard deviation of row *i*
σ_{pq} = standard deviations for children of row *p*

Work-a-long (Step 2)

Calculate new cost for each child

$\Sigma\sigma$ = \$27 + \$60 + \$16 = \$103

$P\$_{R\&D}$ = \$135 - \$25 * \$27/\$103 = \$128

$$P\$_i = C\$_i + \Delta\$_p \frac{\sigma_i}{\sum_j^{N_p} \sigma_j}$$

WBS	P.E.	Stats @75%	Std Dev	$\Delta\$_p$	$P\$_i$			Allocated @ 75%
Total	\$600	\$751	\$67	\$(25)				
R&D	\$70	**\$135**	**\$27**		**\$128**			
R	\$20	\$54	\$17					
D	\$50	\$90	\$21					
Prod	\$440	**\$528**	**\$60**		**\$514**			
NR	\$90	\$140	\$29					
Rec	\$350	\$403	\$51					
O&S	\$90	**\$113**	**\$16**		**\$109**			

We need its children to sum to this value

Allocation (Steps 3, 4)

Step 3: For each parent row, *p*, determine adjustment

- Look familiar? Similar formula to Step 1
- Difference is that adjustment is based on new parent cost, $P\$_p$

Step 4: Return to step 2

$$\Delta\$_p = P\$_p - \sum_i^{N_p} C\$_{pi}$$

Modified Cost of *p* From Step 2

N_p = the number of children for row *p*
$P\$_p$ = adjusted cost for row *p*
$C\$_{pi}$ = total cost for the *ith* child of row *p* at desired confidence

Work-a-long (Step 3)

$\Delta\$_{R\&D}$ = \$128 – (\$54 + \$90) = \$(16)

$\Delta\$_{Prod}$ = \$514 – (\$140 + \$403) = \$(29)

$$\Delta\$_p = P\$_p - \sum_i^{N_p} C\$_{pi}$$

WBS	P.E.	Stats @75%	Std Dev	$\Delta\$_p$	$P\$_i$	$\Delta\$_p$		Allocated @ 75%
Total	\$600	\$751	\$67	\$(25)				
R&D	\$70	\$135	\$27		\$128	\$(16)		
R	\$20	\$54	\$17					
D	\$50	\$90	\$21					
Prod	\$440	\$528	\$60		\$514	\$(29)		
NR	\$90	\$140	\$29					
Rec	\$350	\$403	\$51					
O&S	\$90	\$113	\$16		\$109			

Work-a-long (Step 2)

Calculate new cost for leaf rows

$\Sigma\sigma_{R\&D}$ = \$17 + \$21 = \$41

$P\$_R$ = \$54 - \$16 * \$17/\$41 = \$47

We now have our total for leaf rows

$$P\$_i = C\$_i + \Delta\$_p \frac{\sigma_i}{\sum_j^{N_p} \sigma_j}$$

WBS	P.E.	Stats @75%	Std Dev	$\Delta\$_p$	$P\$_i$	$\Delta\$_p$	$P\$_i$	Allocated @ 75%
Total	\$600	\$751	\$67	\$(25)				
R&D	\$70	\$135	\$27		\$128	\$(16)		
R	\$20	\$54	\$17				\$47	\$47
D	\$50	\$90	\$21				\$81	\$81
Prod	\$440	\$528	\$60		\$514	\$(29)		
NR	\$90	\$140	\$29				\$130	\$130
Rec	\$350	\$403	\$51				\$384	\$384
O&S	\$90	\$113	\$16		\$109			\$109

Allocation (Step 5)

- **Step 5: For Each Leaf Row, *i*, Adjust Fiscal Years**
  - This is a simple scaling based on adjusted total

$$P\$_{i,fy} = PE\$_{i,fy} \frac{P\$_i}{PE\$_{i,tot}}$$

$P\$_{i,fy}$ = allocated yearly cost for row *i* for year, *fy*
$PE\$_i$ = point estimate total for row
$PE\$_{i,fy}$ = point estimate's fiscal year value for row

Work-a-long (FY)

Calculate Fiscal Year Values

$P\$/PE\$_R$ =$9*($54/$20) = $24

$$A\$_{i,fy} = PE\$_{i,fy} \frac{P\$_i}{PE\$_{i,tot}}$$

We can now sum FY values up the WBS

It is important that we spread the fiscal year values at the "leaf" rows so that their parents have the appropriate FY totals

WBS	PE$	P$	2007	2008	2009	2010
R	$20	$54	$4	$9	$5	$2
$P\$_{R,fy}$			**$11**	**$24**	**$13**	**$6**

Allocation (Step 6)

- **Step 6: Roll costs back up entire WBS**
  - Sum up the children's FY values for each parent, *p*, in WBS

$$P\$_{p,fy} = \sum_{i}^{N_p} P\$_{pi,fy}$$

The sum of all children's fy values

N_p = the number of children for row *p*
$P\$_{p,fy}$ = yearly allocated cost for row *p* at year *fy*
$P\$_{pj,fy}$ = yearly allocated cost for the *jith* child of row *p*

Work-a-long (Final)

Final Results for ACE Allocation:

WBS	P.E.	Stats @75%	Std Dev	$\Delta\$_p$	$P\$_i$	$\Delta\$_p$	$P\$_i$	Allocated @ 75%
Total	$600	$751	$67	$(25)				**$751**
R&D	$70	$135	$27		$128	$(16)		**$126**
R	$20	$54	$17				$47	**$47**
D	$50	$90	$21				$81	**$81**
Prod	$440	$528	$60		$514	$(29)		**$584**
NR	$90	$140	$29				$130	**$130**
Rec	$350	$403	$51				$384	**$384**
O&S	$90	$113	$16		$109			**$109**

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Potential Enhancements

ACE Could Improve

- **ACE Could Provide a Means for Prioritizing Systems**
  - Important systems should receive more funding
- **ACE Could Support Schedule Risk Better**
  - All time-phased allocations based on point estimate phasing
- **ACE Could Provide Risk Loading**
  - Sometimes risk is in outlying years – ACE spreads it evenly
- **ACE Does Not Support Other Popular Allocation Methods**
  - Mandates and standards require use of other allocation schemes
- **ACE Does Not Calculate Confidence for Costs Above Pivot**
  - That's the reason for the "~" – e.g., "$55.5 (~25%)"
  - Esoteric subject – impacted by contract vehicle and mgmt reserve

If You Remember Anything

Commandment

ALWAYS Allocate at Rows

Where You Manage Your Money

In Conclusion

- **ACE Allocation Is The Most Robust Allocation Available**
  - Other allocation methods can leave you with silly results
  - Still up to you to verify results in terms of your model
- **Math Not So Bad To Do Manually**
- **ACE Has Plenty of Room For Enhancement**
  - Risk allocation, in general, has a long, long way to go
- **My Unbiased**(?!?) **Recommendation…**

Use ACE RI$K Allocation

Even if You Don't Use ACE For Your Estimate

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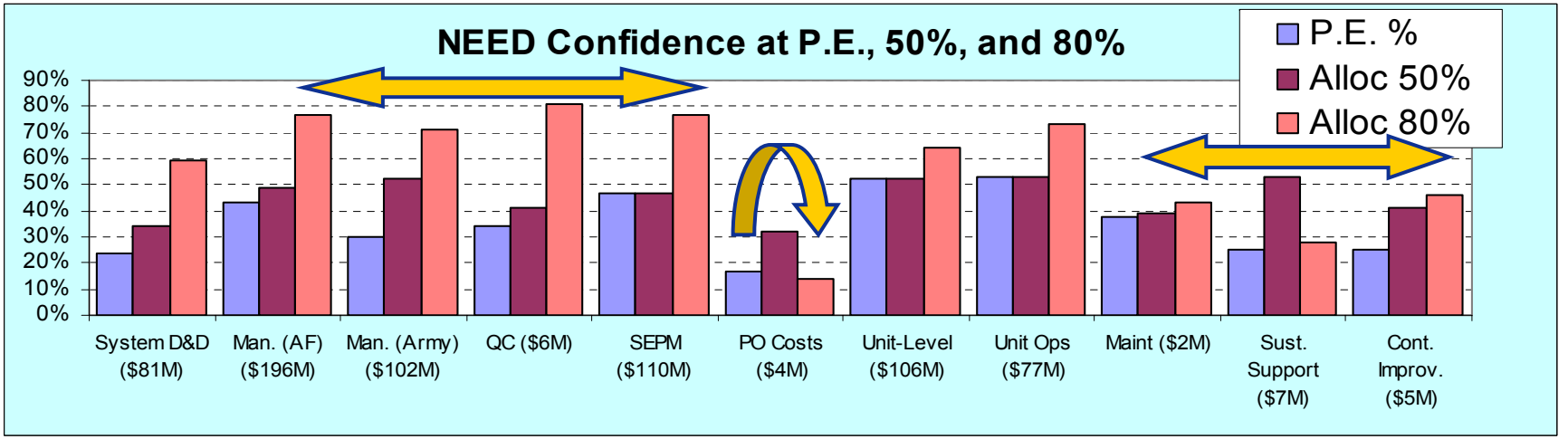
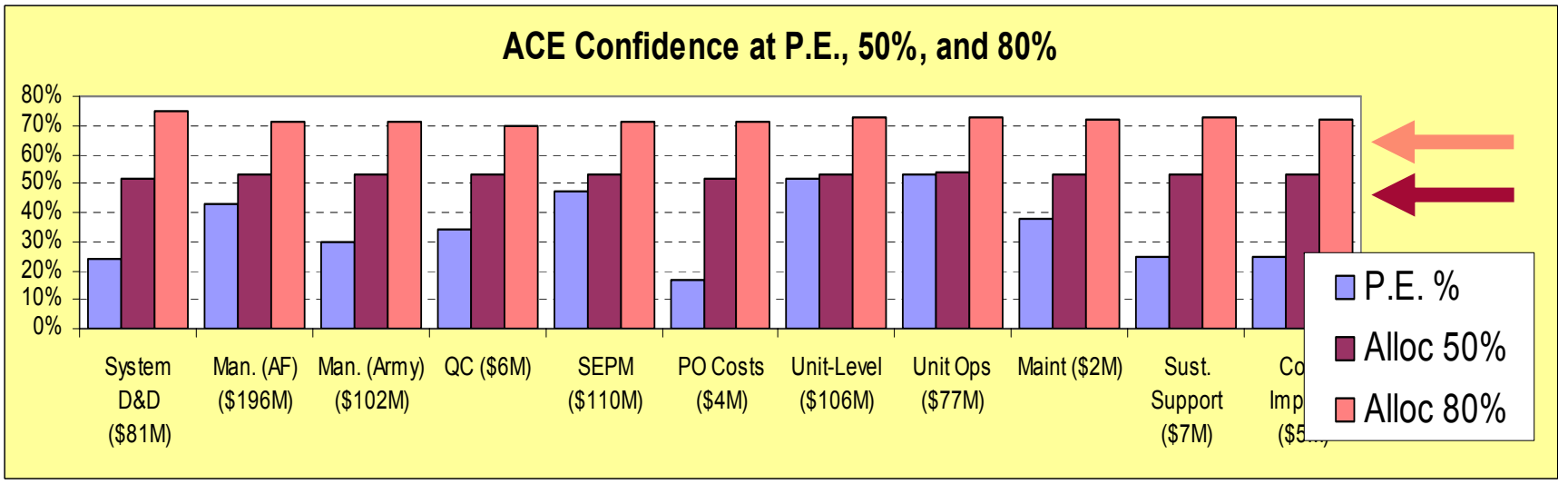
Comparison

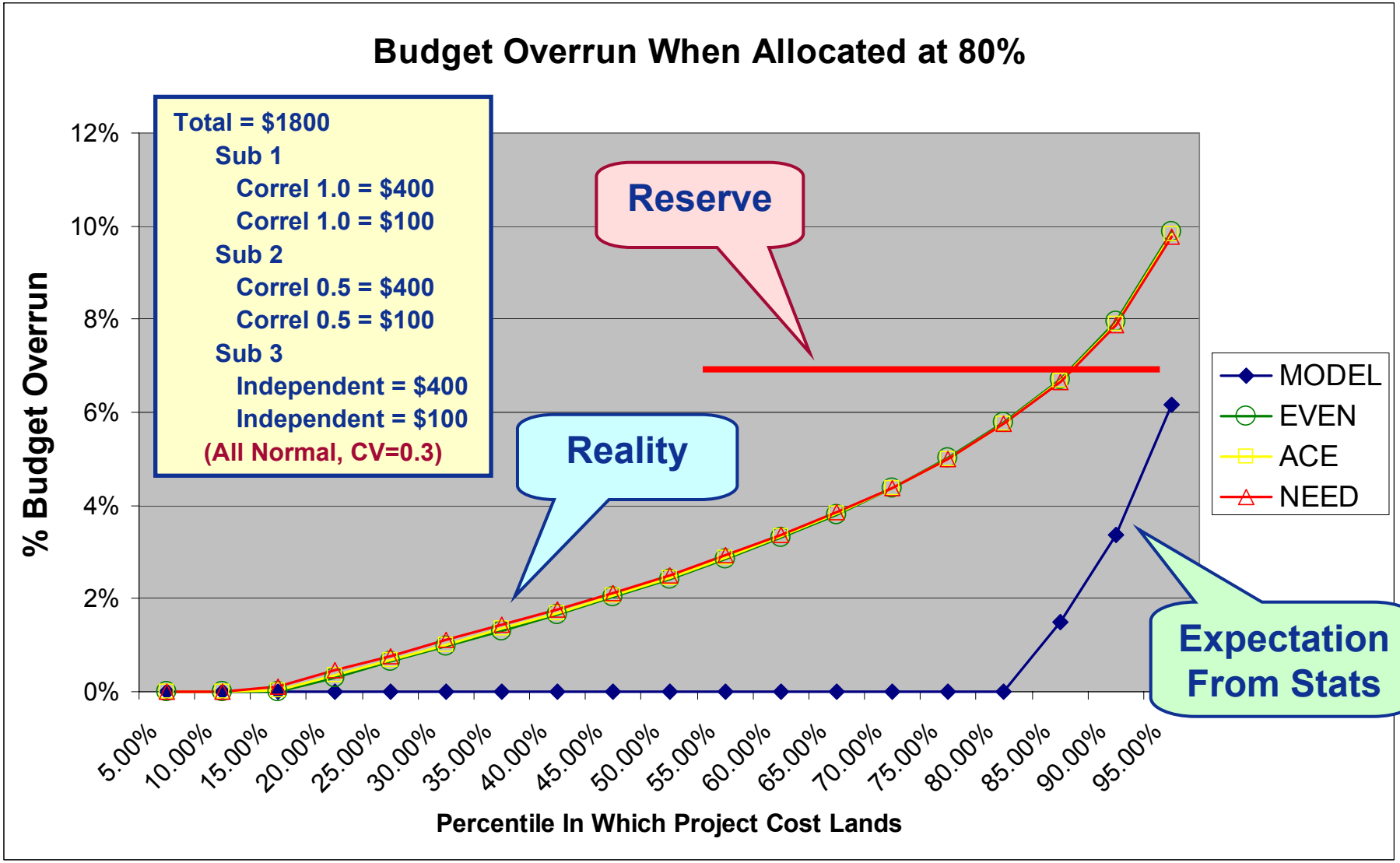
Comparison of "Need[1]" and ACE Allocations





[1] "Allocating Risk Dollars Back to WBS Elements" Stephen A. Book, Chief Technical Officer, MCR, LLC
SSCAG/EACE/SCAF Meeting 19-21 September 2006

Budget Overrun



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More Questions