THE RACM PROCESS

PRESENTED TO

NDIA Program Management Systems Committee

January, 2004

BACKGROUND

- FBM NEVER HAD AN OVERRUN IN 30+ YEAR HISTORY
- BUT - COSTS AND SCHEDULES ON FBM AND OTHER PROGRAMS HAD BECOME EXCESSIVE.
- THEREFORE: A THREE YEAR STUDY BY LOCKHEED WAS INITIATED IN THE 1990s.

STUDY QUESTIONS

- WHAT IS THE EXPECTED COST?
- WHAT IS THE PROBABILITY OF MEETING THE COST GOALS?
- HOW CAN WE BEST MANAGE THE BUDGET TO MEET THE COST GOALS?
- HOW CAN WE MAKE THIS VISIBLE TO MANAGEMENT?

GENERAL CONCLUSION

- OUR BUDGET **FORECASTING** METHODS ARE **INCREASING** THE COST OF DOING BUSINESS BY **10% TO 30%** OR MORE.
- OUR BUDGET **MANAGEMENT** METHODS ARE **INCREASING** THE COST OF DOING BUSINESS.
- WE DO NOT UNDERSTAND THE **PROBABILITY OF SUCCESS (Ps)** ASSOCIATED WITH THE FORECASTED COST AND POTENTIAL BUDGET DECISIONS.
- **OVERRUNS MAY OCCUR** EVEN WHEN THE BUDGET IS ADEQUATE.

SOLUTION – THE RACM PROCESS

- WE MODELED THE PROCESS – BUT THERE WERE TWO PROBLEMS:
  - ✓ GOVERNMENT WOULD THINK WE ARE BUYING IN
  - ✓ IF MODEL SHOWN TO GOVERNMENT, IT REVEALS TOO MUCH

WHAT DO WE DO WITH THIS?

- WENT TO OSD ACQUISITION - PERFORMANCE ANALYSIS (WAYNE ABBA AND GARY CHRISTLE)
  - ✓ THEN TO: COST ANALYSIS IMPROVEMENT GROUP (CAIG) - Dr. David McNicol; ACQUISITION REFORM; ECONOMIC SECURITY; and RESEARCH AND ENGINEERING
  - ✓ THEN TO: BMDO - PROGRAM OFFICE – (twice), ARPA - DIRECTORATE; USAF: COST ANALYSIS; AERONAUTICAL SYSTEMS CENTER; AFSC (ESD); US NAVY: COST ANALYSIS; NAVAIR ASW; FBM; and US ARMY - COST ANALYSIS.
- WENT TO ACADEMIA
  - ✓ NORTHWESTERN
  - ✓ PENN STATE
  - ✓ SANTA CLARA UNIVERSITY
  - ✓ MIT
- WENT TO SOCIETIES
  - ✓ SCEA - SOCIETY OF COST ESTIMATING AND ANALYSIS
  - ✓ ISPA
  - ✓ PMA & NSIA - 6TH ANNUAL INTERNATIONAL CONFERENCE
- FINALLY! GARY CHRISTLE AND WAYNE ABBA FUNDED IDA - INSTITUTE FOR DEFENSE ANALYSES – Dr. Matt Goldberg. Dr. Chuck Weber.

FINDINGS

INSTITUTE FOR DEFENSE ANALYSES (IDA)

- "THE APPROACH TO COST ESTIMATION AND COST MANAGEMENT IS A NEW, UNIQUE APPROACH TO PROGRAM MANAGEMENT AND PERFORMANCE MANAGEMENT"
- RACM "CAN CHANGE AND IMPROVE THE FINAL COST OUTCOME OF THE PROGRAM; I.e. REALIZE SIGNIFICANT COST SAVINGS"
- RACM is "UNIQUE IN CONTAINING A MODULE FOR MANAGING RISK RESERVES"
- "DOD WOULD BE WELL ADVISED TO DEMAND RISK ESTIMATES"
- "THE RACM DEVELOPERS DREW AN IMPORTANT DISTINCTION BETWEEN 'ARITHMETIC SUMMING' AND 'STATISTICAL SUMMING'"

CONFIRMATION of FINDINGS (cont.)

- DEFENSE NEWS (12 JANUARY 2004) –

  REAL BUDGETS, PLEASE -

  - ✓ "…THE WAY THE PENTAGON ESTIMATES ITS PROGRAM COSTS IS FLAWED."
  - ✓ "THE U.S. MILITARY'S UNWILLINGNESS TO ADMIT THE RISKS ASSOCIATED WITH DEVELOPING COMPLEX SYSTEMS IS WHY MOST MAJOR PROGRAMS GO OVER BUDGET AND FALL BEHIND SCHEDULE."
  - ✓ "A CHIEF CULPRIT? MAJOR ACQUISITION PROGRAMS ARE BUDGETED ON A "50-50" BASIS, MEANING THAT OFFICIALS ASSUME THERE IS A 50 PERCENT CHANCE THAT THE EFFORT WILL COME IN ON TIME AND COST. WOULD YOU BUDGET YOUR HOUSEHOLD ON A 50 PERCENT RISK? OF COURSE NOT."

STANDARD ESTIMATING METHODS

- **STANDARD ESTIMATING METHODS ARE USUALLY POINT ESTIMATES USING THE FOLLOWING METHODS:**

  - ✓ **TOP DOWN (BLACKBOARD ESTIMATES)**
    - KNOWLEDGEABLE PERSONNEL ESTIMATE THE COST OF THE PROJECT BASED ON THEIR KNOWLEDGE OF PRIOR HISTORY.
    - EACH ESTIMATE REPRESENTS ALL COST ESTIMATING CONSIDERATIONS.
    - COSTS ARE THEN ALLOCATED TO DISCIPLINES FOR ANALYSIS.
  - ✓ **BOTTOMS-UP**
    - DECOMPOSE THE PROJECT INTO ITS SMALLEST COMPONENTS AND ESTIMATE EACH COMPONENT; THEN TOTAL ALL OF THE COMPONENTS TO OBTAIN THE TOTAL WORK EFFORT OF THE PROJECT.
  - ✓ **COST ESTIMATING RELATIONSHIPS (CERS)**
    - A TECHNIQUE USED TO ESTIMATE A PARTICULAR COST OR PRICE BY USING AN ESTABLISHED RELATIONSHIP WITH AN INDEPENDENT VARIABLE. CERS ARE SAID TO REPRESENT THE USE OF ONE OR MORE INDEPENDENT VARIABLES TO PREDICT OR ESTIMATE A DEPENDENT VARIABLE (COST).

POINT ESTIMATES SHOULD CONSIDER

- **HISTORICAL COSTS** FOR EACH ELEMENT, EITHER ACTUAL OR INTUITIVE (BASELINE DATA)
- POTENTIAL **SCHEDULE IMPACTS** ON EACH COST ELEMENT.
- POTENTIAL **IMPROVEMENTS** ANTICIPATED FOR EACH COST ELEMENT
- PROGRAM LEVEL **SCHEDULE IMPACTS**
- THE EFFECTS OF **UNFORESEEN PROBLEMS** ON THE PROGRAM.
- **MANAGEMENT POLICY** (DISTRIBUTION OF BUDGET AND MANAGEMENT OF RESERVES)
- MANAGEMENT'S **TARGET Ps**

CAN ALL OF THIS BE CONSIDERED IN ONE NUMBER?

CONCERNS

- THESE METHODS DO NOT:
  - ✓ INDEPENDENTLY CONSIDER ALL OF THE "COST ESTIMATING FACTORS" (CEF)
  - ✓ IDENTIFY THE MOST EFFECTIVE DISTRIBUTION OF THE BUDGET.
  - ✓ IDENTIFY THE RESERVES WHICH SHOULD BE MAINTAINED IN ORDER TO MEET THE THE PROGRAM'S Ps.
  - ✓ PROVIDE MANAGEMENT VISIBILITY INTO ASSUMPTIONS
  - ✓ DETERMINE THE RISK (Ps) OF COMPLETING THE PROGRAM WITHIN BUDGET.
  - ✓ PROVIDE EQUAL Ps FOR ALL ACCOUNT MANAGERS.
- IF ARITHMETIC SUMMING IS USED, IT WILL PROBABLY INCREASE COSTS DRAMATICALLY.
- IN COMPETITIVE MODE, RISK CAN BE INCREASED AND POTENTIALLY CAUSE A PROGRAM FAILURE

FIRST CONCERN

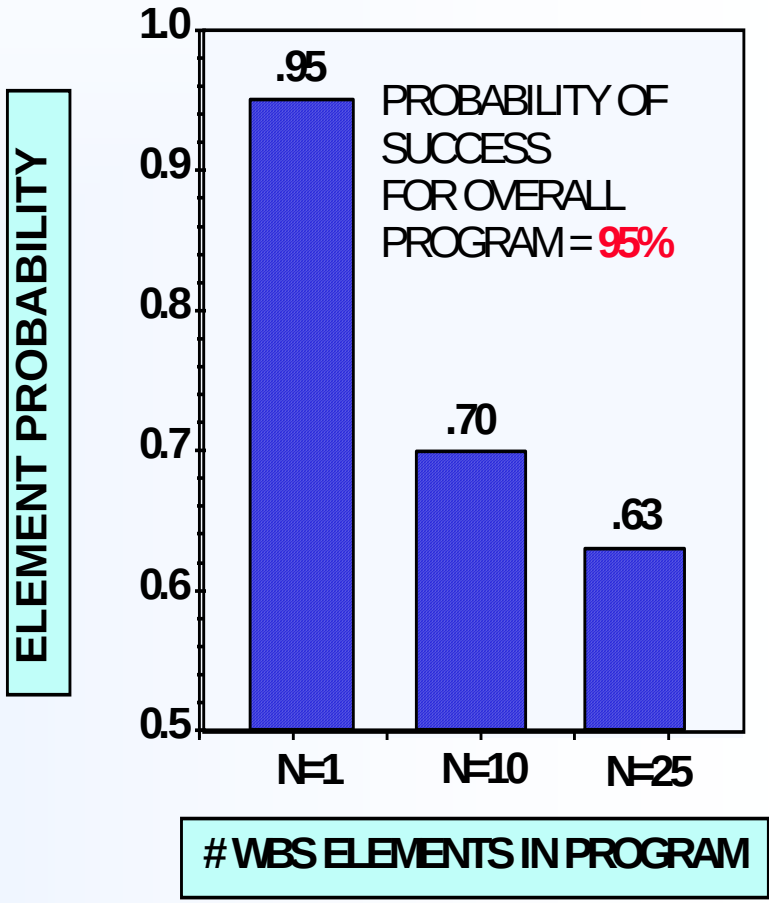
INDEPENDENT CONSIDERATION

- **IT IS NOT POSSIBLE TO CONCURRENTLY AND INDEPENDENTLY CONSIDER ALL OF THE "COST ESTIMATING FACTORS" (CEF) PREVIOUSLY MENTIONED AND REPEATED BELOW:**
  - ✓ **IMPROVEMENTS ANTICIPATED FOR EACH COST ELEMENT**
  - ✓ **SCHEDULE IMPACTS ON EACH COST ELEMENT.**
  - ✓ **PROGRAM LEVEL SCHEDULE IMPACTS.**
  - ✓ **PROGRAM LEVEL COST IMPACTS.**
  - ✓ **EFFECTS OF BUDGET DISTRIBUTION AND MANAGEMENT RESERVE.**
  - ✓ **EQUAL Ps FOR ALL ACCOUNT MANAGERS.**

SECOND CONCERN

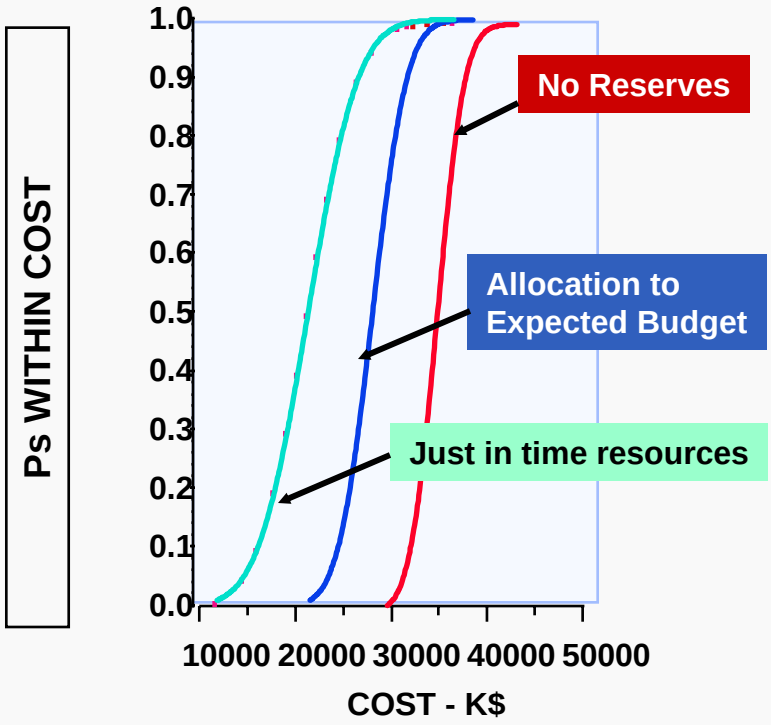
DISTRIBUTION OF THE BUDGET

- RESOURCES DISTRIBUTED SHOULD BE **NO GREATER THAN** WHAT IS STATISTICALLY CONSISTENT WITH THE NUMBER AND MAGNITUDE OF THE ELEMENTS IN THE WBS.
- THE GREATER THE NUMBER OF ELEMENTS INVOLVED IN THE BUDGET ALLOCATION, THE **LOWER** THE Ps NEEDS TO BE FOR EACH ELEMENT TO ACHIEVE THE DESIRED OVERALL PROBABILITY FOR THE PROGRAM.



THIRD CONCERN

ADEQUATE MANAGEMENT RESERVE

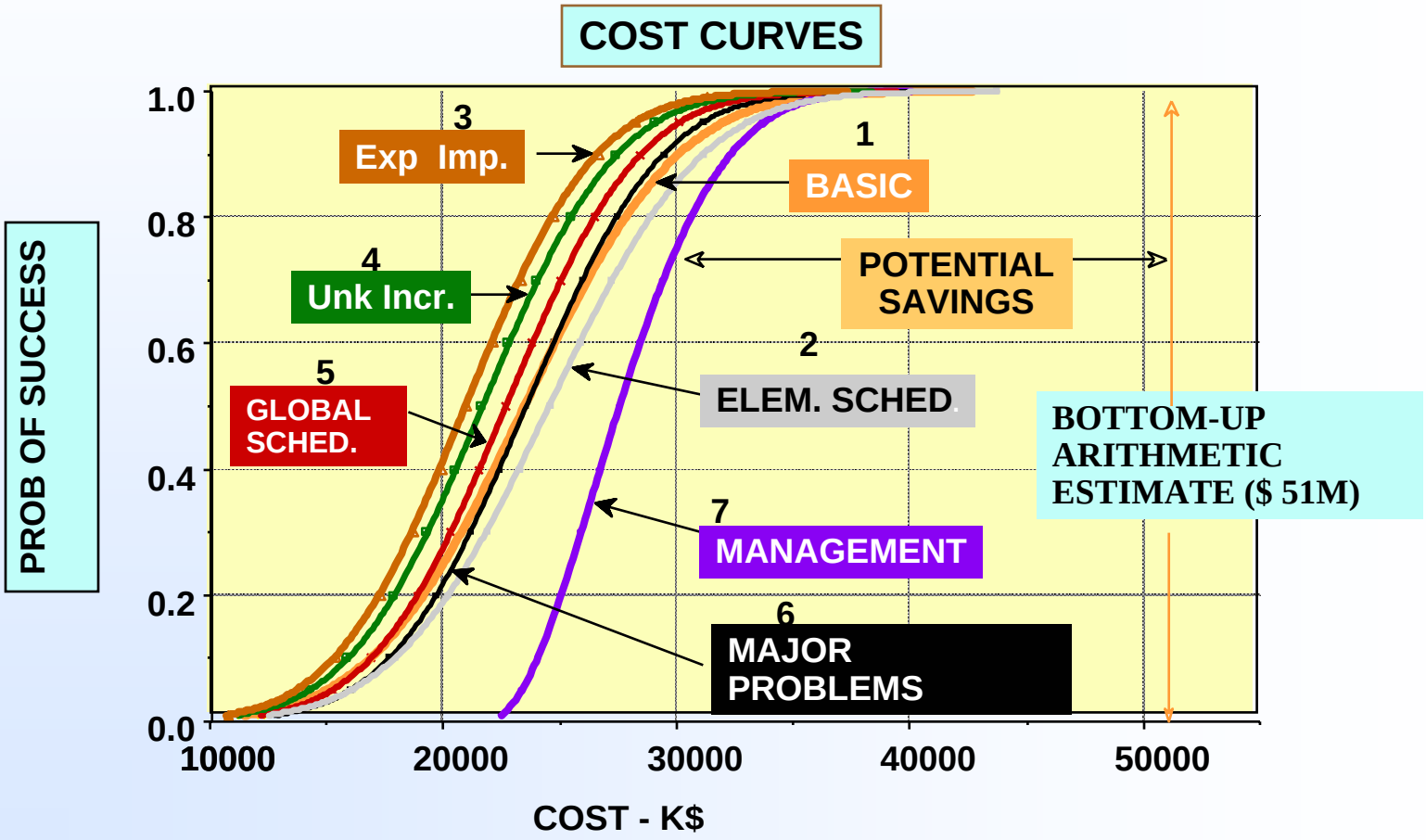


MUST CONSIDER:

- PROGRAM STRUCTURE
- UNCERTAINTY IN THE ESTIMATE.
- COST WHICH IS NOT WBS ELEMENT IDENTIFIABLE.
- TRANSFER OF FUNDS BETWEEN ACCOUNTS.
- MAXIMIZING “PROFIT”.

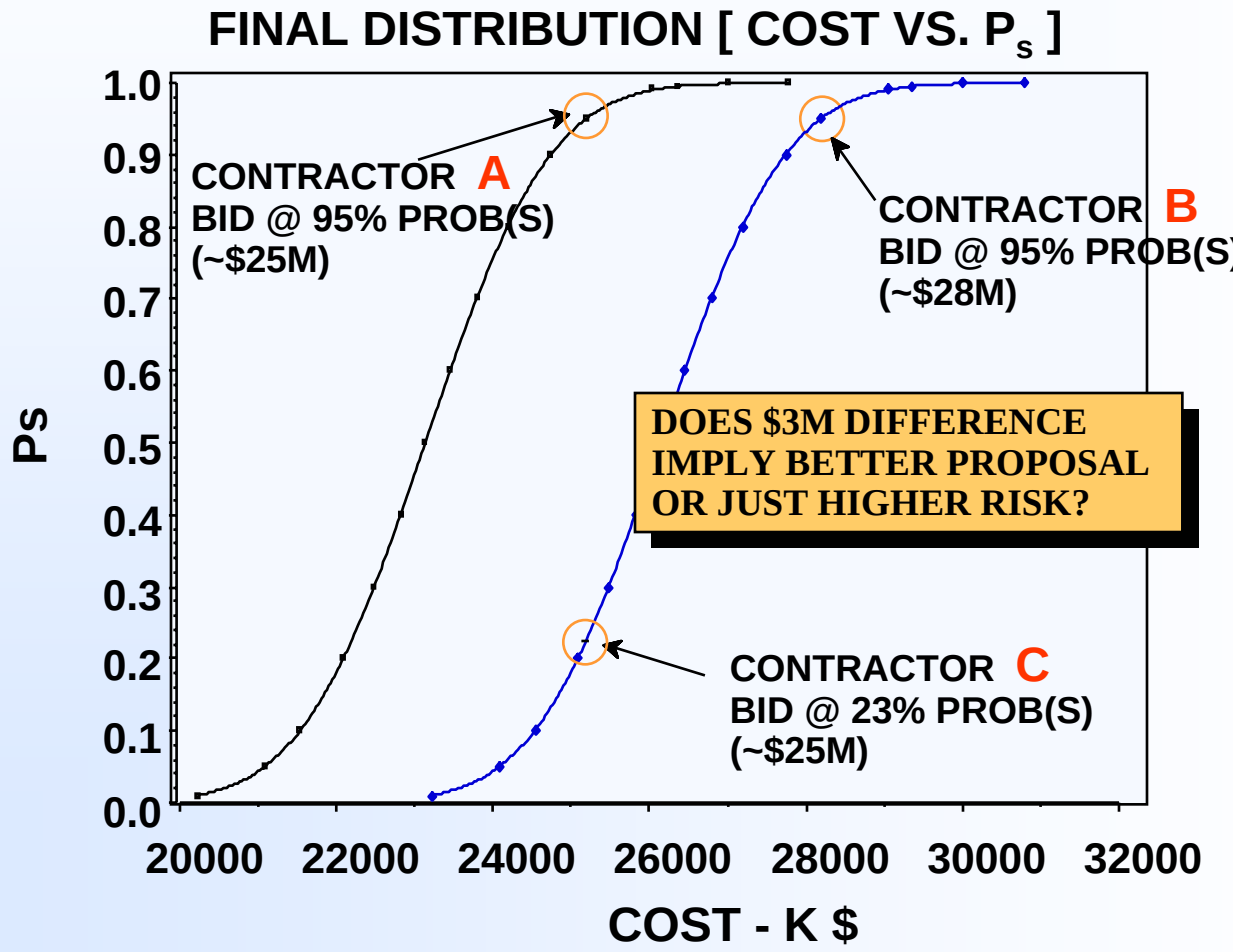
FOURTH CONCERN

MANAGEMENT VISIBILITY



Note: Each Sequential Cost Curve Reflects Cumulative Effects To That Point.

MORE VISIBILITY
ANALYSIS OF CONTRACTORS & S/C

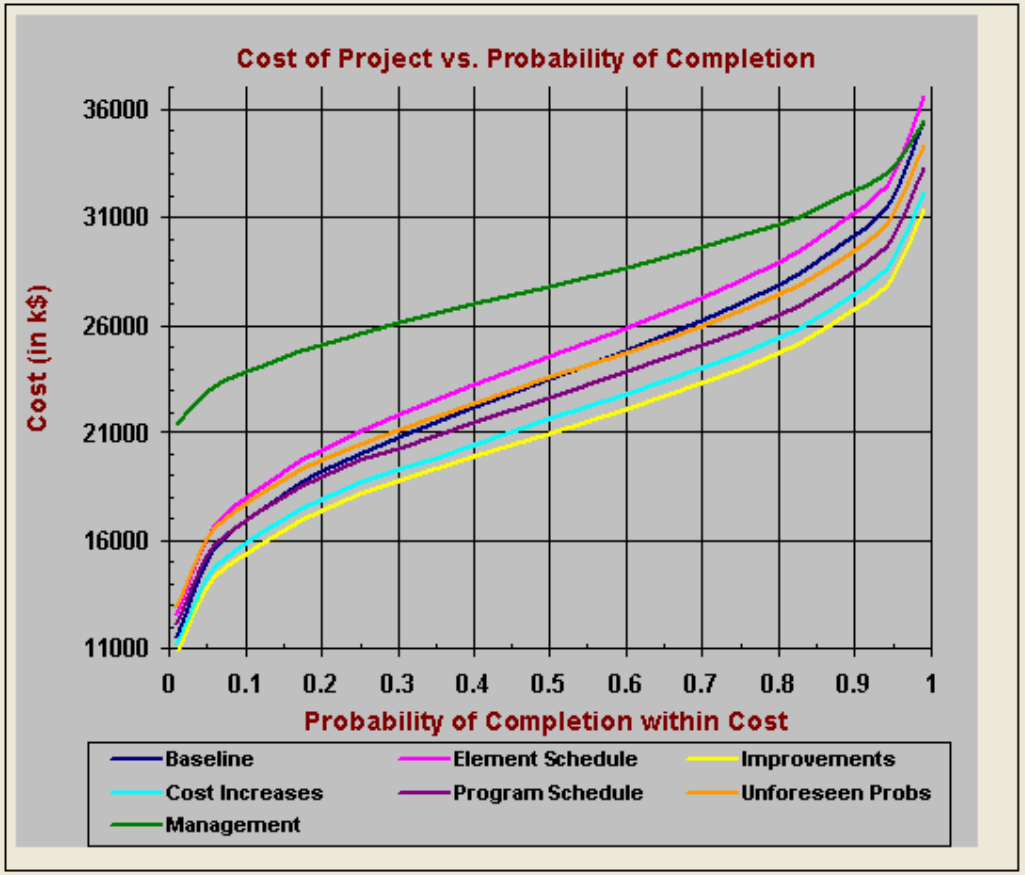


FIFTH CONCERN

KNOWING THE PROBABILITY OF SUCCESSFULLY COMPLETING THE PROGRAM

Apollo Rocket Project (Demo)

Probability	Unforeseen Problems	Management	Impact
0.01	12874	21429	8555.8
0.05	16010	22917	6907.7
0.1	17682	23856	6174.2
0.2	19706	25114	5407.8
0.3	21166	26092	4926.5
0.4	22413	26967	4553.7
0.5	23579	27810	4230.5
0.6	24745	28670	3924.7
0.7	25993	29601	3609.0
0.8	27452	30695	3242.8
0.9	29477	32193	2715.9
0.95	31149	33390	2241.0
0.99	34285	35473	1188.2



SIXTH CONCERN

EQUAL Ps FOR EACH ACCOUNT MANAGER

ALLOCATION: WHO GETS WHAT?

- EQUALITY OF RISK FOR EACH ACCOUNT
- IDA: THIS METHOD:
  - OPTIMIZES COST/RISK
  - MINIMIZES MAIMS
- EVM STYLE TRACKING FACILITATED

NOTE: THIS IS A SUGGESTED ALLOCATION. HOWEVER, A DIFFERENT ALLOCATION WOULD PROBABLY ADVERSELY AFFECT THE Ps OF THE PROGRAM.

Suggested Initial Allocation for 90% Probability of Success

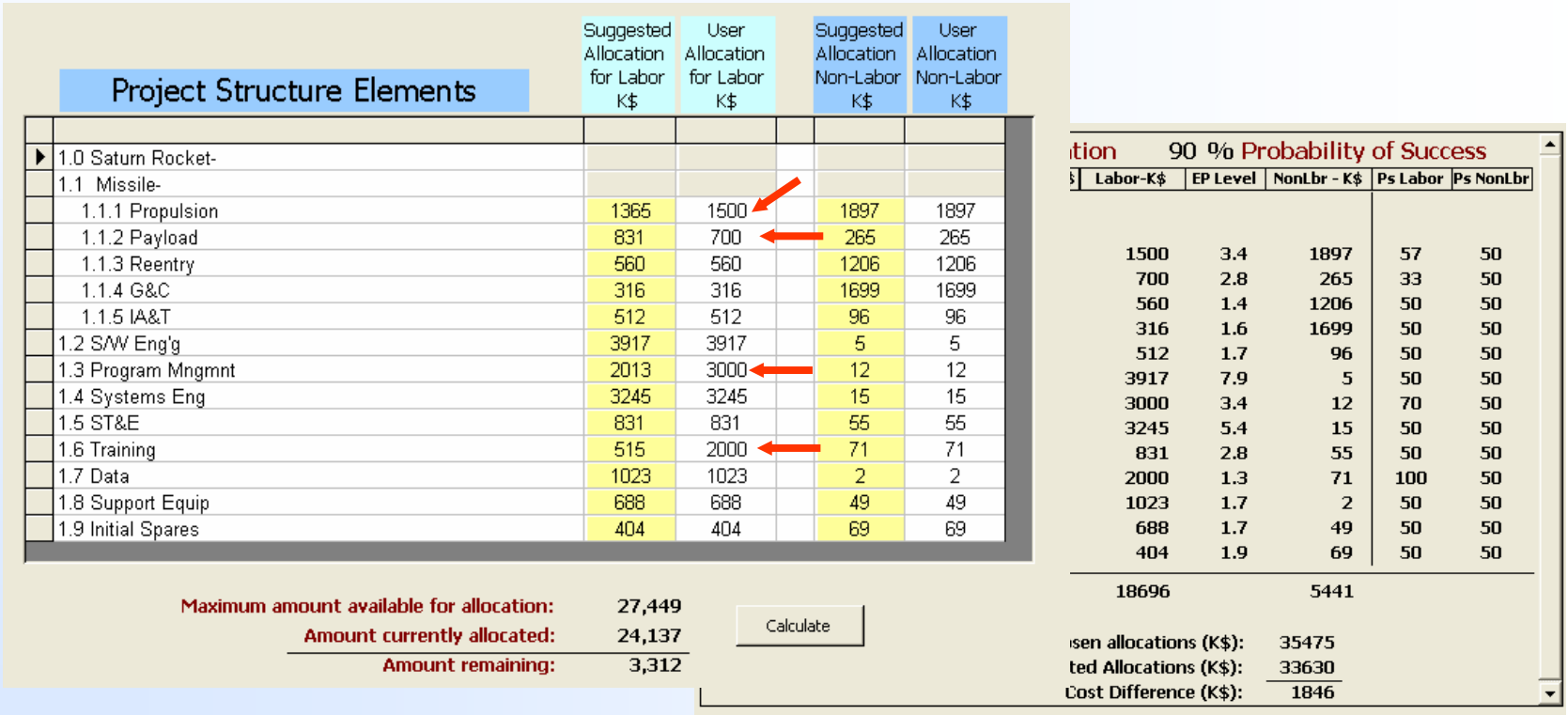
Project Element	Total-Dist	Labor-K$	EP Level	NonLbr - K$	Ps Labor	Ps NonLbr
1.0 Saturn Rocket-						
1.1 Missile-						
1.1.1 Propulsion	3263	1365	3.4	1897	50	50
1.1.2 Payload	1096	831	2.8	265	50	50
1.1.3 Reentry	1766	560	1.4	1206	50	50
1.1.4 G&C	2015	316	1.6	1699	50	50
1.1.5 IA&T	608	512	1.7	96	50	50
1.2 S/W Eng'g	3922	3917	7.9	5	50	50
1.3 Program Mngmnt	2025	2013	3.4	12	50	50
1.4 Systems Eng	3260	3245	5.4	15	50	50
1.5 ST&E	885	831	2.8	55	50	50
1.6 Training	586	515	1.3	71	50	50
1.7 Data	1025	1023	1.7	2	50	50
1.8 Support Equip	737	688	1.7	49	50	50
1.9 Initial Spares	473	404	1.9	69	50	50
Total Initial Allocation:	21661	16220		5441		
Reserves:	10532					
Total Project Cost:	32193					

SIXTH CONCERN

EQUAL Ps FOR EACH ACCOUNT MANAGER

EXAMPLE

- IF NOT? IN THIS EXAMPLE COSTS INCREASED 5.5% OR Ps DECREASED FROM 90% TO 73%.



Project Structure Elements	Suggested Allocation for Labor K$	User Allocation for Labor K$	Suggested Allocation Non-Labor K$	User Allocation Non-Labor K$
1.0 Saturn Rocket-				
1.1 Missile-				
1.1.1 Propulsion	1365	1500	1897	1897
1.1.2 Payload	831	700	265	265
1.1.3 Reentry	560	560	1206	1206
1.1.4 G&C	316	316	1699	1699
1.1.5 IA&T	512	512	96	96
1.2 S/W Eng'g	3917	3917	5	5
1.3 Program Mngmnt	2013	3000	12	12
1.4 Systems Eng	3245	3245	15	15
1.5 ST&E	831	831	55	55
1.6 Training	515	2000	71	71
1.7 Data	1023	1023	2	2
1.8 Support Equip	688	688	49	49
1.9 Initial Spares	404	404	69	69

Maximum amount available for allocation: 27,449
Amount currently allocated: 24,137
Amount remaining: 3,312

Calculate

ition 90 % Probability of Success

Labor-K$	EP Level	NonLbr - K$	Ps Labor	Ps NonLbr
1500	3.4	1897	57	50
700	2.8	265	33	50
560	1.4	1206	50	50
316	1.6	1699	50	50
512	1.7	96	50	50
3917	7.9	5	50	50
3000	3.4	12	70	50
3245	5.4	15	50	50
831	2.8	55	50	50
2000	1.3	71	100	50
1023	1.7	2	50	50
688	1.7	49	50	50
404	1.9	69	50	50
18696		5441		

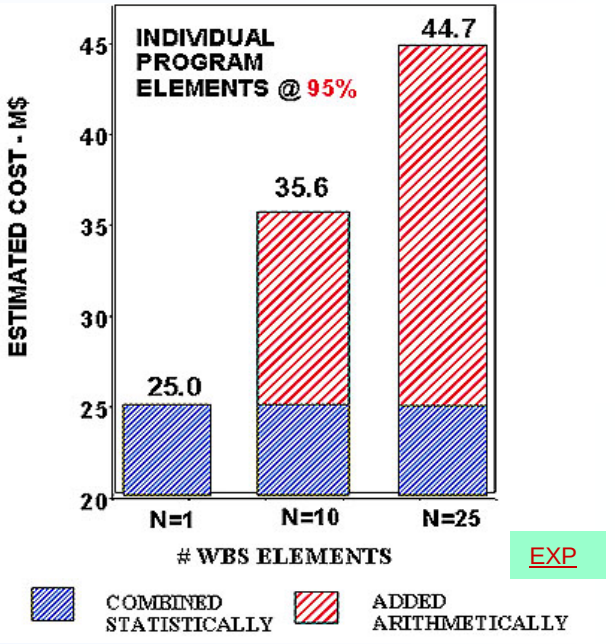
sen allocations (K$): 35475
ted Allocations (K$): 33630
Cost Difference (K$): 1846

SEVENTH CONCERN

ARITHMETIC SUMMING CAN DRAMATICALLY INCREASE COSTS

EFFECTS OF ADDING POINT ESTIMATES WHICH HAVE A Ps GREATER THAN 50%. E.g. Estimates at a 95% P_S for each element in the WBS.

- IN THIS EXAMPLE, WITH ONLY 25 ELEMENTS IN A WBS, ARITHMETIC SUMMING MAY RESULT IN A NEAR DOUBLING OF THE TOTAL PROGRAM'S COST ESTIMATE TO $44.7M (>99.99% PS).
- A STATISTICAL APPROACH WOULD RESULT IN A $25M ESTIMATE FOR THE DESIRED 95% PROBABILITY.
- ARITHMETIC SUMMING IS ONLY VALID IF EACH ESTIMATE IS A 50% Ps VALUE AND THE PROBABILITY DENSITY FUNCTION IS SYMMETRICAL.



EXP

If 10 people estimate 10 equal elements of a WBS at 100 units each (assume it is a comfortable estimate at 95% Ps), then the arithmetic sum is 1000 units and the Ps is 99.999%

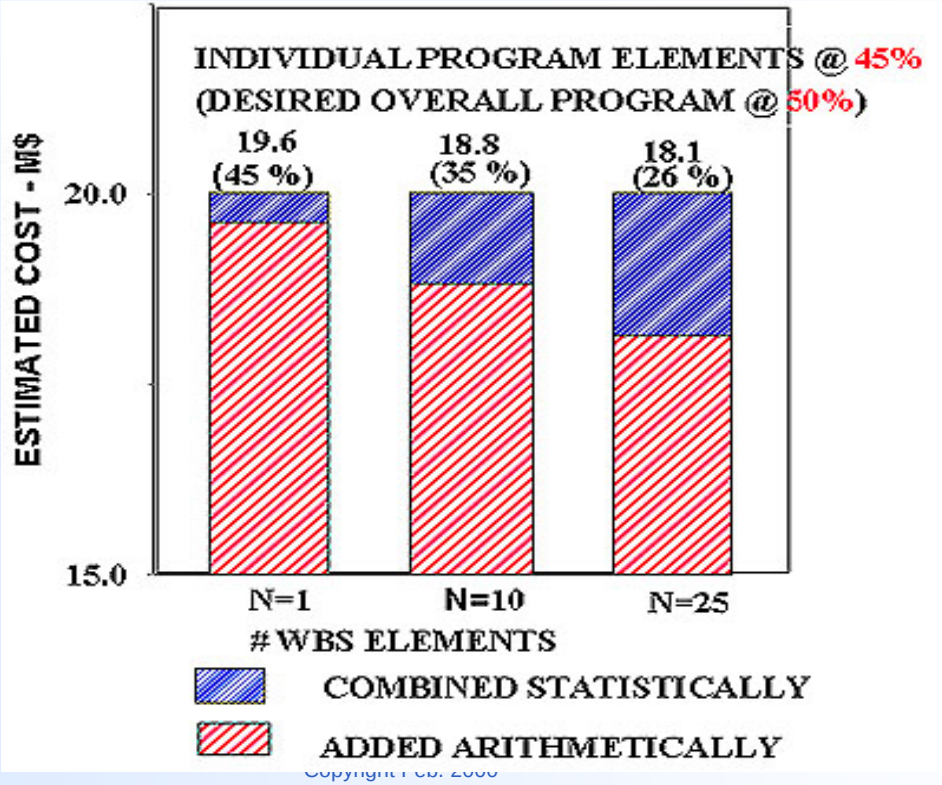
But not all need that much budget. Statistically they only need a total of 673 units at 90% Ps. Each element would require 55 units at 50% Ps with a reserve of 128 units.

What can make the arithmetic sum become true or even exceed budget? Money allocated is money spent – especially labor (once hired difficult to fire) and non-labor (once contracted…).

EIGHTH CONCERN

ARITHMETIC SUMMING CAN RESULT IN Ps <50% (Program Failure)

IF INDIVIDUAL ESTIMATES ARE VERY NEAR THE 50% Ps/EXPECTED VALUES, E.G. 45% Ps, THE RESULT IS A PROGRAM WITH LITTLE CHANCE OF SUCCESS.

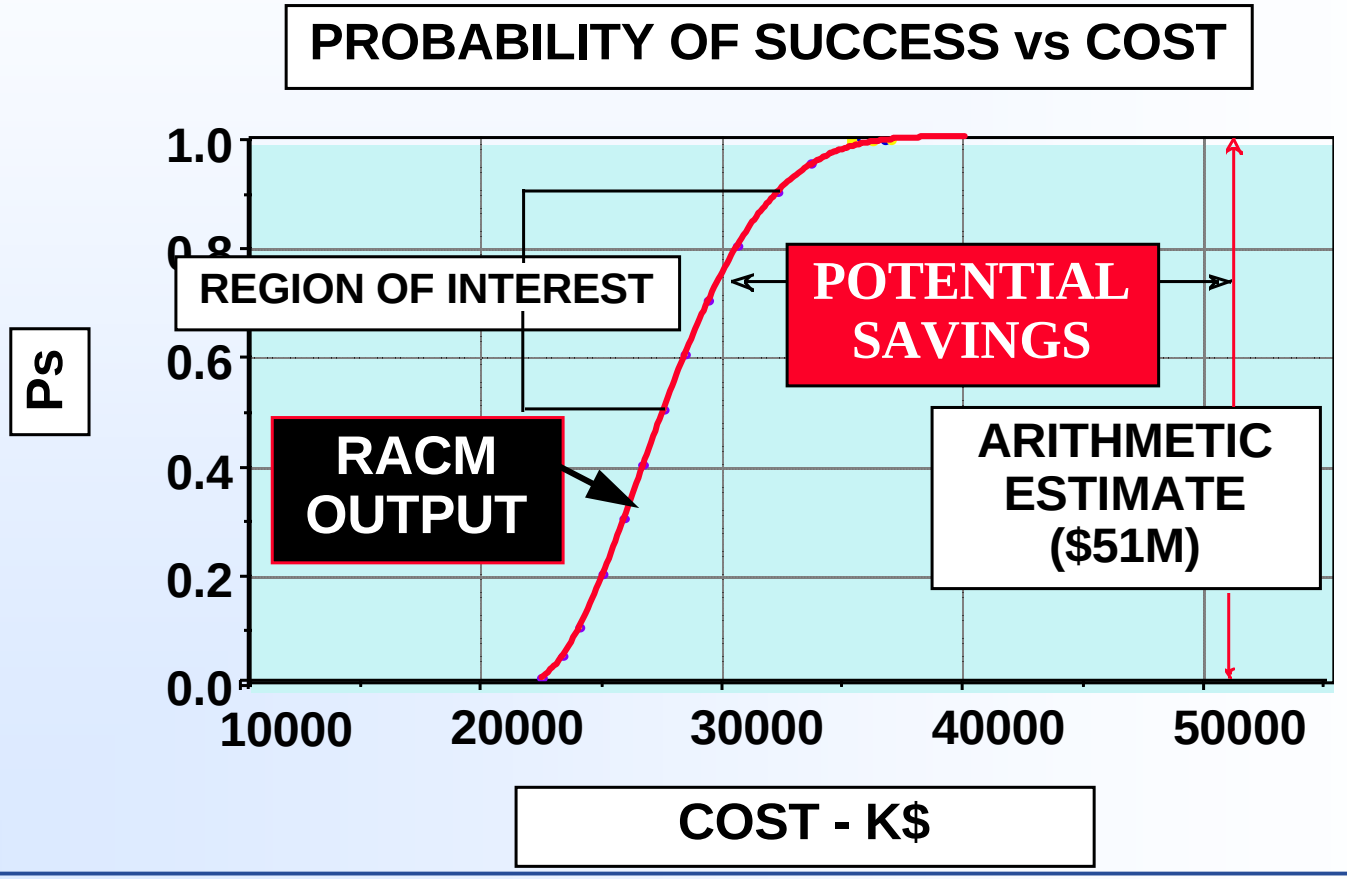


RECOMMENDATION

(RACM PROCESS)

- SEPARATELY CONSIDERS COST ESTIMATING FACTORS (CEF) FOR EACH ELEMENT.
- PROVIDE PROGRAM MANAGEMENT A METHOD OF DETERMINING EFFICIENT BUDGET ALLOCATION.
- IDENTIFY A MANAGEMENT RESERVE THAT PROVIDES THE BEST POSSIBILITY OF MEETING THE PROGRAM'S COST GOALS.
- PROVIDE MANAGEMENT VISIBILITY OF MAJOR ASSUMPTIONS AFFECTING THE PROGRAM'S PS.
- COMPUTE THE PROGRAM'S PROBABILITY OF SUCCESS (Ps).
- ALLOW RIGOROUS TESTING OF MAJOR ASSUMPTIONS.
- PROVIDE INPUTS INTO THE EVM PROCESS AND REDISTRIBUTE THE BUDGET WHEN NECESSARY TO MAXIMIZE Ps

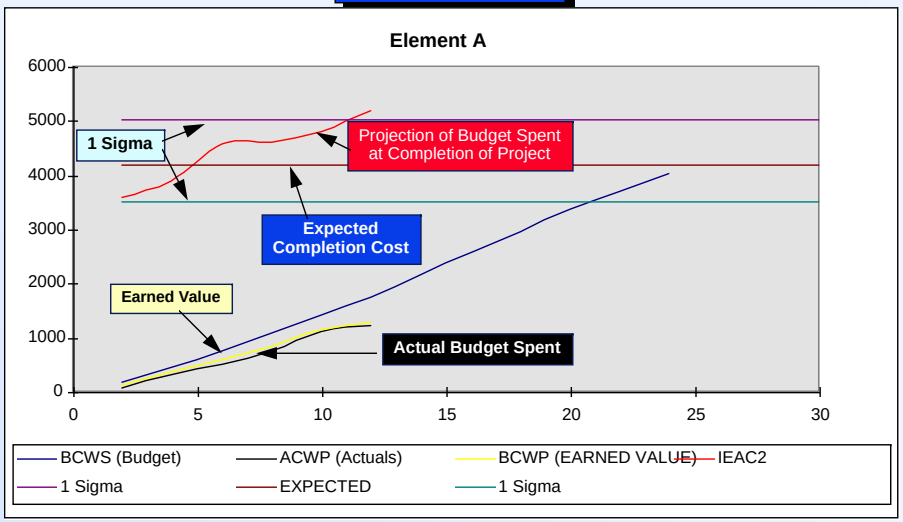
RESULT OF IMPLEMENTING RECOMMENDATIONS - SAVINGS



EARNED VALUE CONSIDERATIONS

- THE EVMS SYSTEM CAN BE USED TO UPDATE RACM AS A REFINEMENT OF EACS.
- IF THE RACM PROCESS, IN CONSONANCE WITH EARNED VALUE PROCESS, IS APPLIED THROUGHOUT THE LIFE OF THE PROGRAM, CORRECTIONS CAN BE MAXIMIZED THROUGH REDISTRIBUTION OF THE BUDGET IN ACCORDANCE WITH Ps REQUIREMENTS.

EARNED VALUE



EXAMPLE OFAN APPROACH TO ACCOMPLISHING THIS

- IN THIS EXAMPLE EACH WBS ELEMENT OR COST ACCOUNT IS ANALYZED FOR BOTH LABOR AND NON-LABOR. THE BUDGET IS PLOTTED AT THE "EXPECTED COMPLETION COST," I.E. 50% PS. ABOUT THIS PLOT, TWO "SIGMA" LINES ARE PLOTTED.
- THESE ARE MONITORED AGAINST A SIGMA LINE (SHOWN IN RED) DEVELOPED FROM THE RESULTS OF AN EVMS EVALUATION.

RACM

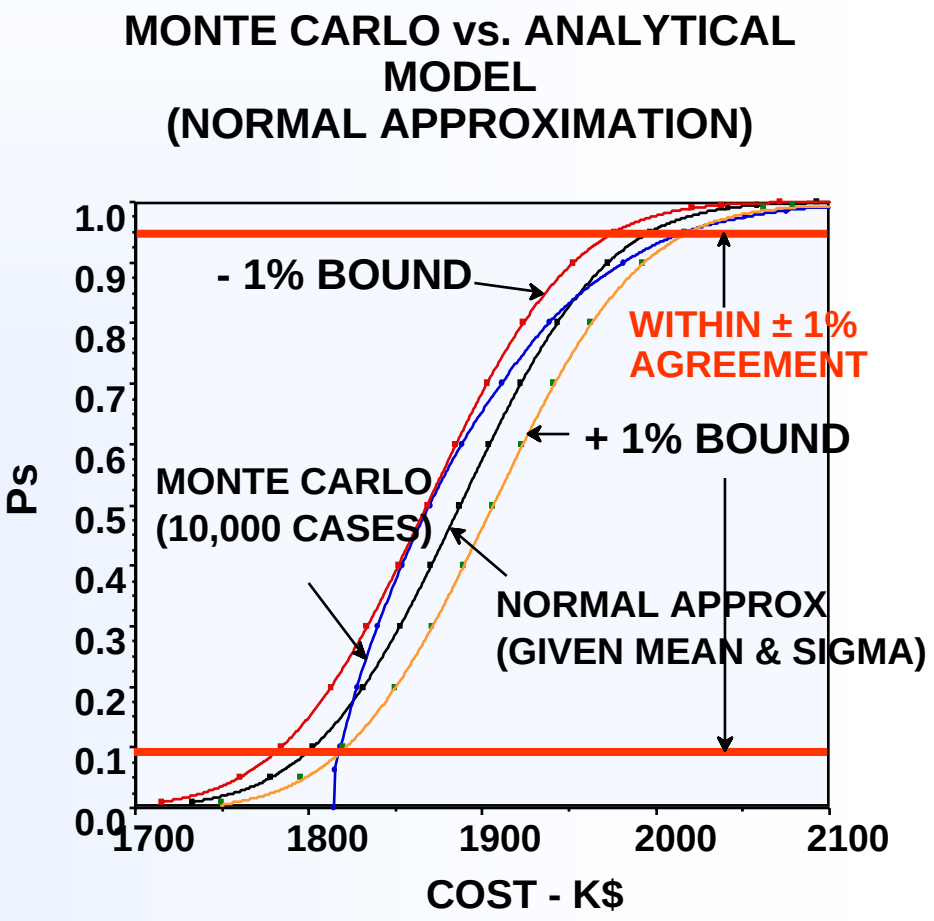
THANK YOU

HIGHLIGHTS OF THE RACM PROCESS

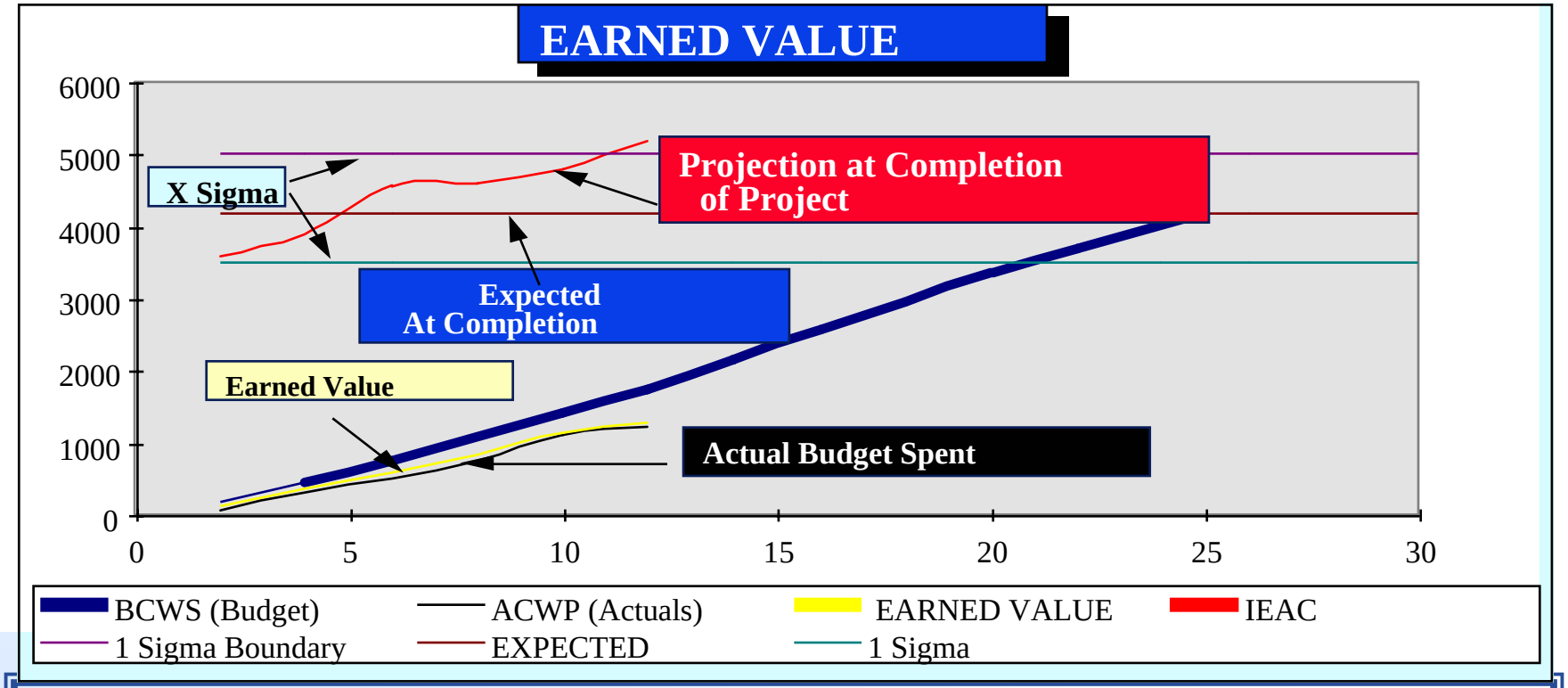
PREVIEW OF RACM PROCESS

RIGOROUS TESTING OF MAJOR ASSUMPTIONS

- RACM PROCESS USES AN ANALYTICAL APPROACH (INSTANT RESPONSE)
- MONTE CARLO TECHNIQUES
  - ✓ MAY INHIBIT A THOROUGH ANALYSIS AND A "WHAT-IF" CAPABILITY (SLOWER RESPONSE TO EACH QUERY)
  - ✓ MAY INTRODUCE A RANDOM SAMPLING ERROR



COMPLEMENTARY TO EVM
ONE EXAMPLE



- NO VARIANCE REPORTING WITHIN X SIGMA BOUNDS
- ALLOW PERIODIC REDISTRIBUTION OF BUDGET IN ORDER TO ADJUST FOR UNDERRUNS AND OVERRUNS

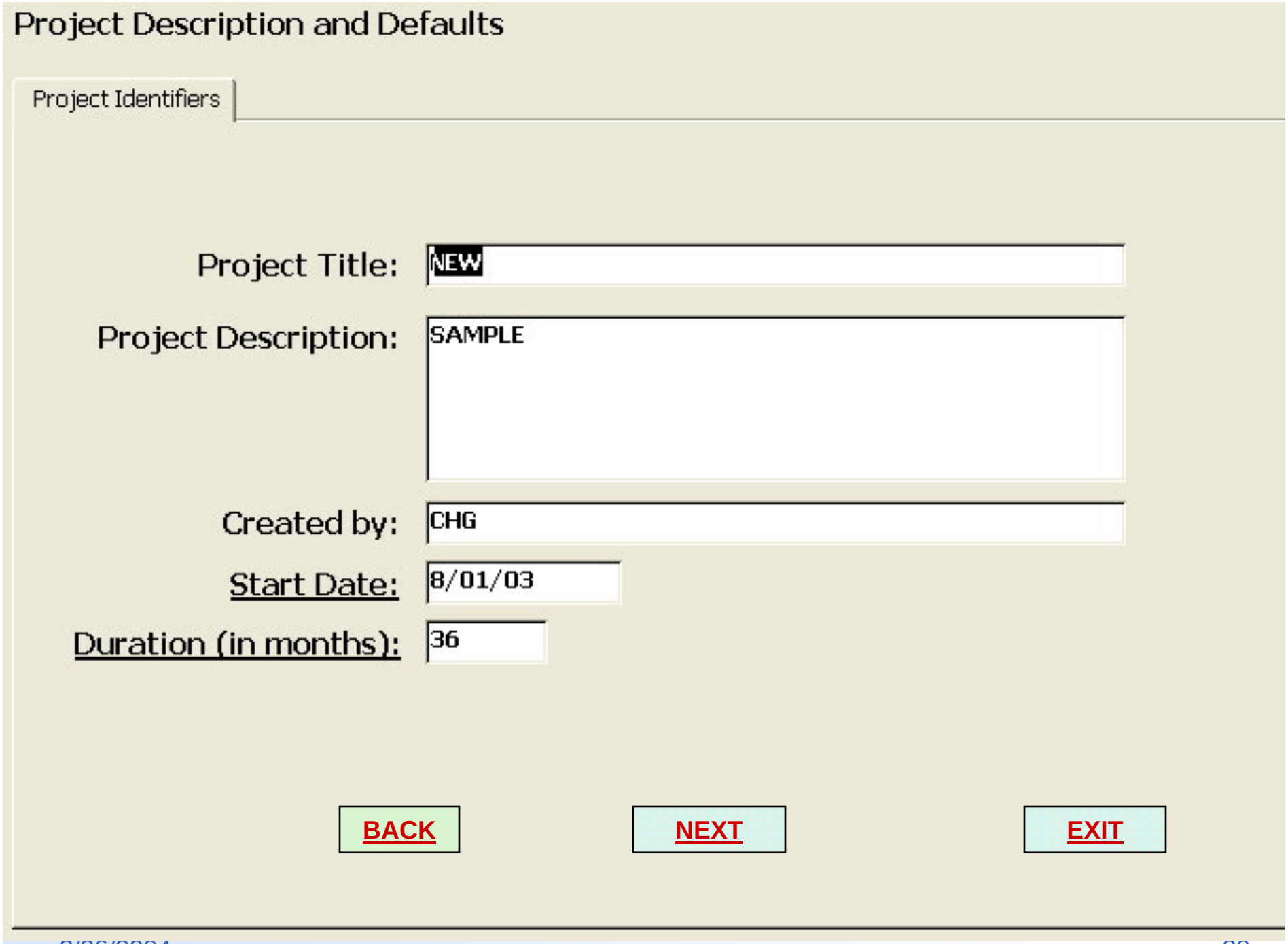
RACM Cost Estimating Steps

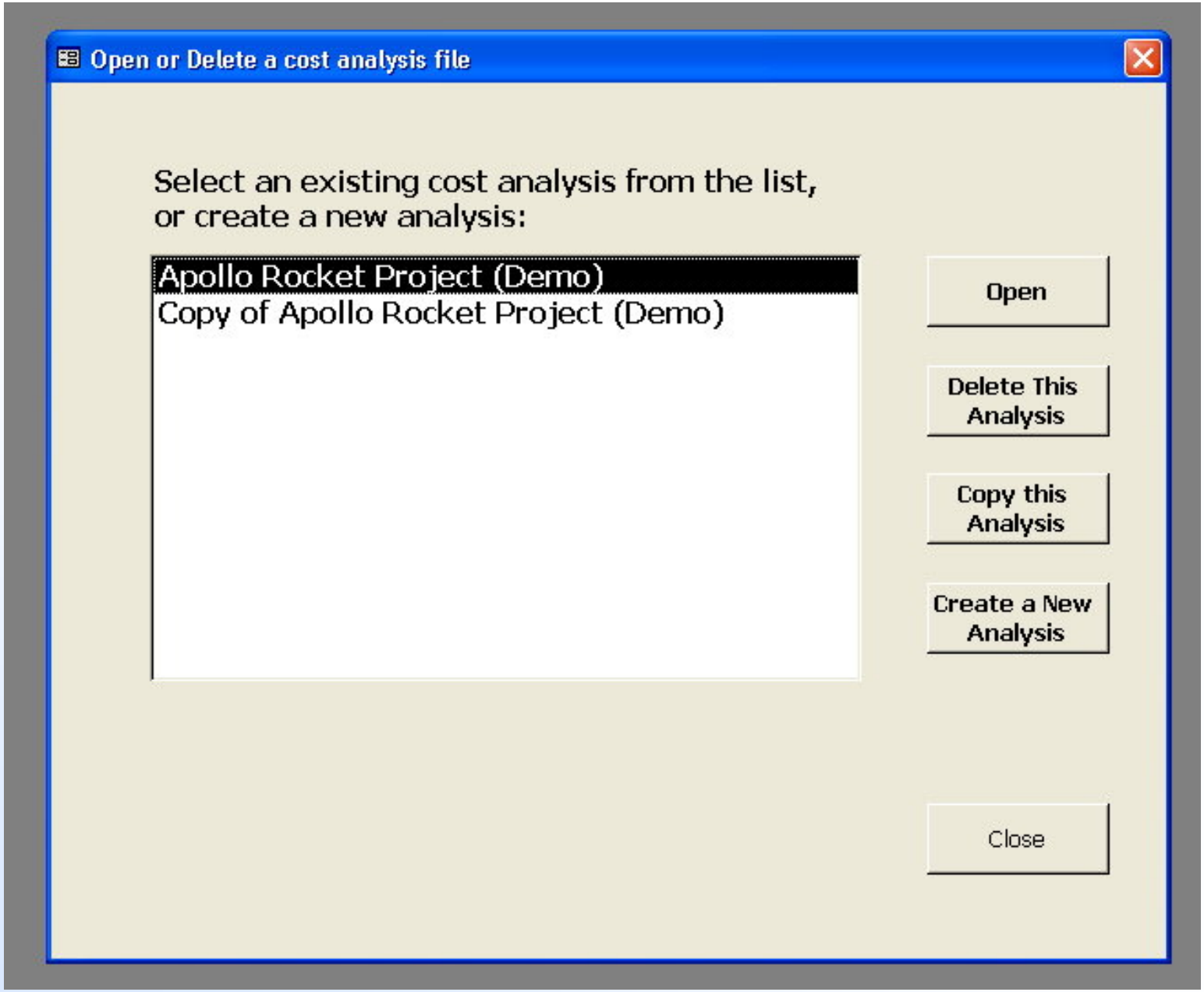
(This program works best with a screen resolution of 1024 x 768 and small fonts)

Initial Settings		**Describe Project and Set Defaults**
Provide "Account Level" Estimates	**Step 1**	**Baseline Data (Initial Unaltered Estimates)**
	Step 2	**Element-level Schedule Effects**
	Step 3	**Potential Cost Improvements**
	Step 4	**Potential Cost Increases**
Provide "Program Level" Estimates	**Step 5**	**Program-level Schedule Effects**
	Step 6	**Unforeseen Problem Effects**
"Management"	**Step 7**	**Management Policy Effects**
	Step 8	**Earned Value**

NOTE: THROUGHOUT THE PROGRAM, HELP TEXT CAN BE ACTIVATED BY CLICKING ON ANY UNDERLINED WORDS

Begin | Tutorial | Exit





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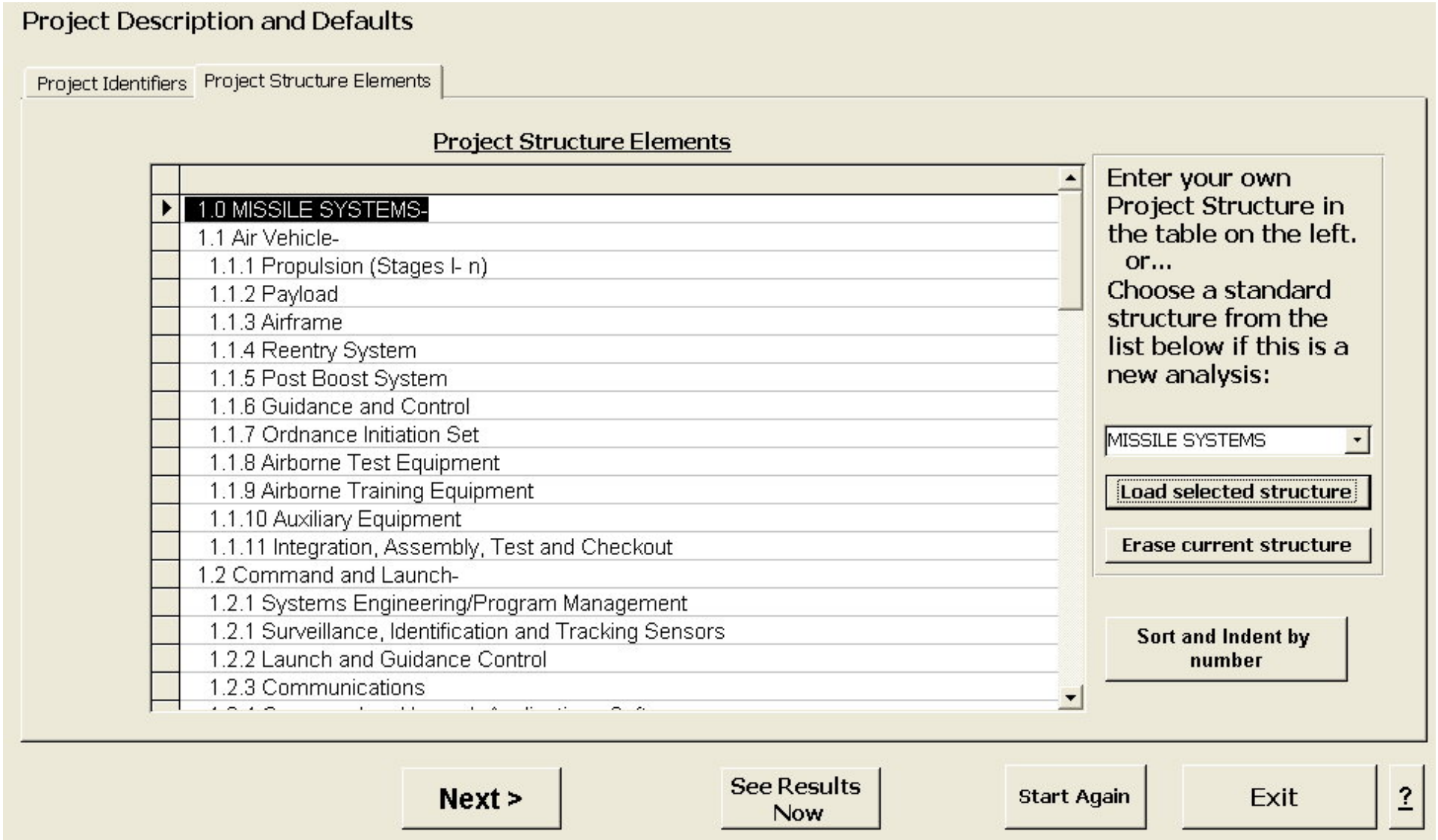

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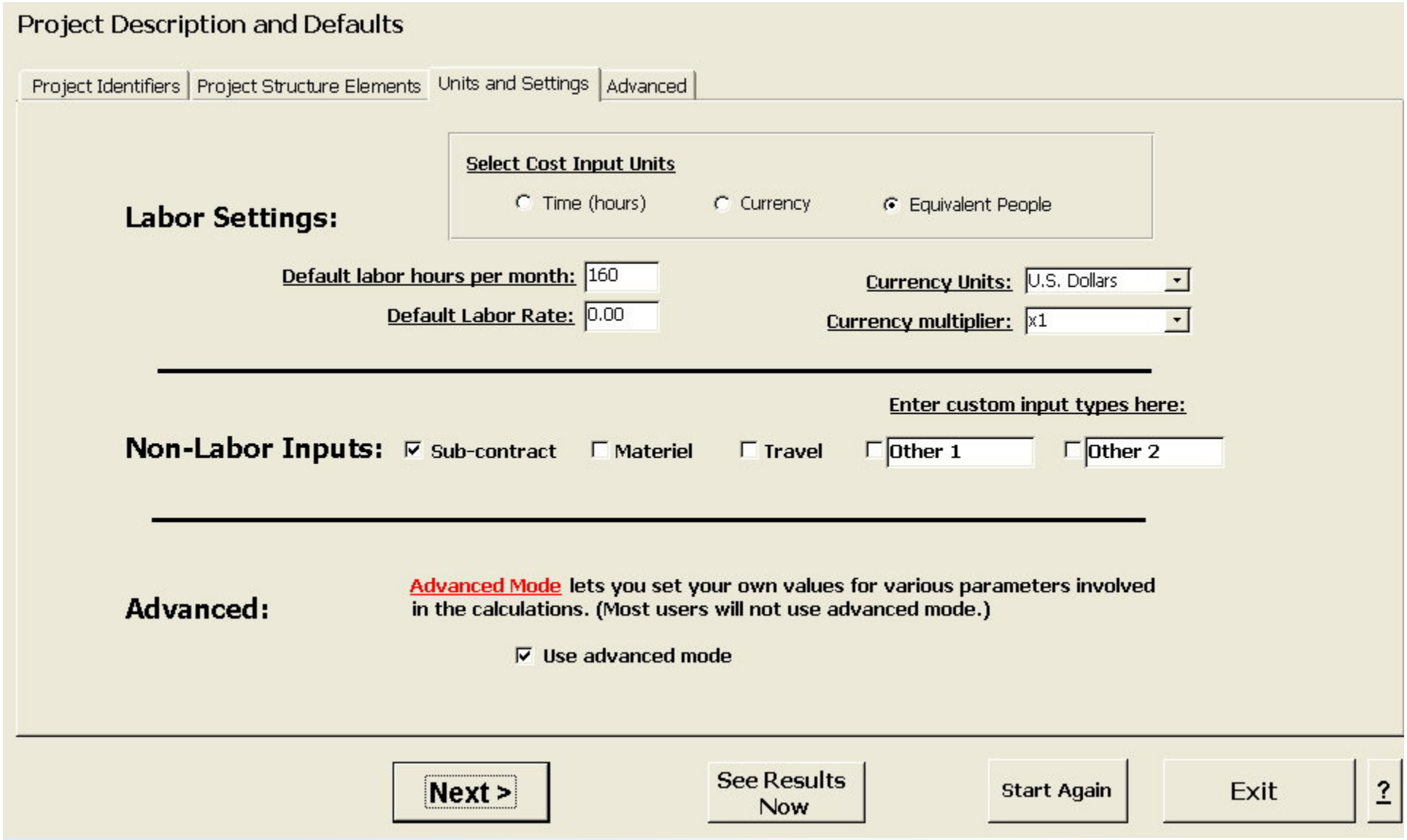

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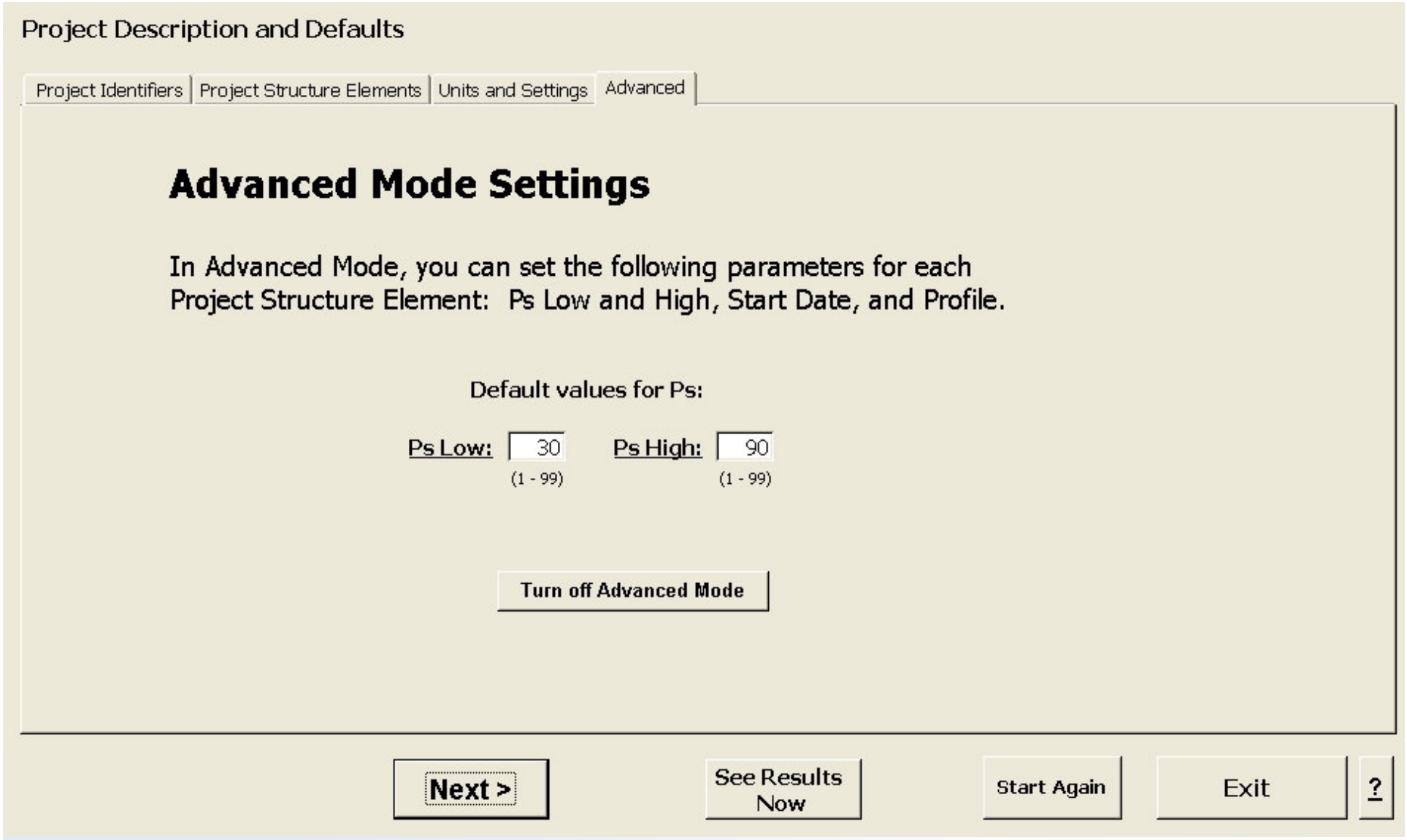

BACK NEXT EXIT

1. Baseline Data | 2. Element Schedule | 3. Improvements | 4. Potential Cost Increases | 5. Program Schedule | 6. Unforeseen Problems | 7. Management Policy | 8. EVM Analysis

Baseline Data

Labor | Sub-Contracts

Apollo Rocket Project (Demo)

Labor

	Hours per Month	Duration in Months	Labor Rate US Dollars	Time Hours Low	Time Hours High	Cost US Dollars x 1 Low	Cost US Dollars x 1 High	Equivalent People Low	Equivalent People High	Ps Low	Ps High	Start Date	Profile
1.0 Saturn Rocket-													
1.1 Missile-													
1.1.1 Propulsion	151	24	110.00	7,248	28,992	797,280	3,189,120	2.0	8.0	20	98	4/1/2002	1
1.1.2 Payload	151	18	110.00	5,436	13,590	597,960	1,494,900	2.0	5.0	20	98	4/1/2002	1
1.1.3 Reentry	151	24	110.00	1,812	10,872	199,320	1,195,920	0.5	3.0	10	98	4/1/2002	1
1.1.4 G&C	151	12	110.00	3,624	10,872	398,640	1,195,920	2.0	6.0	50	98	4/1/2002	1
1.1.5 IA&T	151	18	110.00	2,718	8,154	298,980	896,940	1.0	3.0	10	98	4/1/2002	1
1.2 S/W Eng'g	151	30	110.00	13,590	54,360	1,494,900	5,979,600	3.0	12.0	10	90	4/1/2002	1
1.3 Program Mngmnt	151	36	110.00	10,872	54,360	1,195,920	5,979,600	2.0	10.0	30	95	4/1/2002	1
1.4 Systems Eng	151	36	110.00	21,744	81,540	2,391,840	8,969,400	4.0	15.0	30	95	4/1/2002	1
1.5 ST&E	151	18	110.00	2,718	16,308	298,980	1,793,880	1.0	6.0	10	95	4/1/2002	1
1.6 Training	151	24	110.00	1,812	10,872	199,320	1,195,920	0.5	3.0	10	95	4/1/2002	1
1.7 Data	151	36	110.00	10,872	38,052	1,195,920	4,185,720	2.0	7.0	50	98	4/1/2002	1
1.8 Support Equip	151	24	110.00	7,248	14,496	797,280	1,594,560	2.0	4.0	50	98	4/1/2002	1
1.9 Initial Spares	151	12	120.00	2,718	5,436	326,160	652,320	1.5	3.0	20	98	4/1/2002	1

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BACK | NEXT | EXIT

1. Baseline Data | 2. Element Schedule | 3. Improvements | 4. Potential Cost Increases | 5. Program Schedule | 6. Unforeseen Problems | 7. Management Policy | 8. EVM Analysis

Element Level Schedule Effects

Labor | Sub-Contracts

Labor

Apollo Rocket Project (Demo)

	Schedule Slippage (months)	# of Potential Causes	% Labor Force
1.0 Saturn Rocket-			
1.1 Missile-			
1.1.1 Propulsion	4	4	100
1.1.2 Payload	2	1	100
1.1.3 Reentry	2	1	100
1.1.4 G&C	2	3	100
1.1.5 IA&T	2	1	100
1.2 S/W Eng'g	5	8	100
1.3 Program Mngmnt	3	1	100
1.4 Systems Eng	3	1	100
1.5 ST&E	3	1	100
1.6 Training	3	1	100
1.7 Data	3	1	100
1.8 Support Equip	3	1	100
1.9 Initial Spares	3	5	100

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1. Baseline Data | 2. Element Schedule | 3. Improvements | 4. Potential Cost Increases | 5. Program Schedule | 6. Unforeseen Problems | 7. Management Policy | 8. EVM Analysis

Potential Cost Improvements

Labor | Sub-Contracts

Labor

Apollo Rocket Project (Demo)

	% Improvement	Uncertainty Range (+/-)
1.0 Saturn Rocket-		
1.1 Missile-		
1.1.1 Propulsion	20	30
1.1.2 Payload	10	20
1.1.3 Reentry	10	20
1.1.4 G&C	30	20
1.1.5 IA&T	10	20
1.2 S/W Eng'g	10	20
1.3 Program Mngmnt	20	30
1.4 Systems Eng	20	30
1.5 ST&E	20	30
1.6 Training	25	30
1.7 Data	20	10
1.8 Support Equip	20	10
1.9 Initial Spares	20	10

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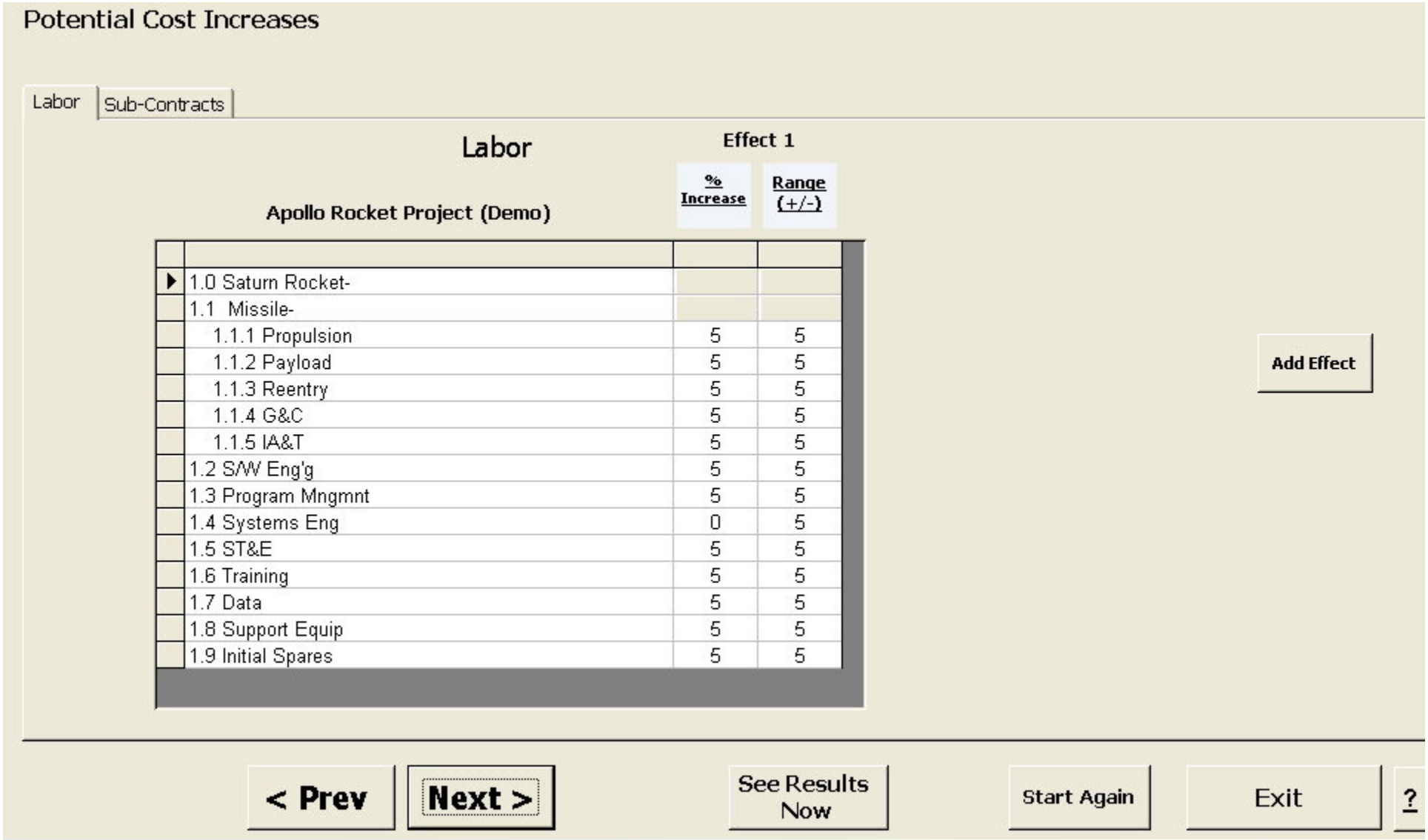

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Program-level Schedule Effects

Apollo Rocket Project (Demo)

Program Level Schedule Slippage (in months):	4
Maximum # of Slippage Causes:	5
Percent Impact on Total Labor Force:	100

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Unforeseen Problem Effects: Global

Apollo Rocket Project (Demo)

		Description of Event	Magnitude of Impact U.S. Dollars	Probability of Occurrence
▶	1	Program Design Review	160000	0.1
	2	Customer Design Review	800000	0.15
	3	Flight Test Demonstration & Verification	1500000	0.5
	4			

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Management Policy Effects

Apollo Rocket Project (Demo)

Desired Operational Probability of Success: 90 % (1 - 99)

Percentage of Max Reserve to Initially Distribute: 0 % (0 -100)

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1. Baseline Data | 2. Element Schedule | 3. Improvements | 4. Potential Cost Increases | 5. Program Schedule | 6. Unforeseen Problems | 7. Management Policy | 8. EVM Analysis

Results - Probability of Successful Completion Within Cost

Summary Info | 1. Baseline Data | 2. Element Schedule Effects | 3. Potential Improvements | 4. Potential Cost Increases

5. Program Level Schedule Effects | 6. Unforeseen Problem Effects | 7. Management Policy Effects

Apollo Rocket Project (Demo)

Select a title from the list to display a particular summary chart.

Standard Information:

> Suggested Allocation
Cost Distribution
Sensitivity Analysis
Profit Distribution
User Allocation Example

Advanced Information:

Monthly Budget ($)
Cumulative Budget ($)
Cumulative Budget (% Total)
EVM Analysis

Suggested Initial Allocation for 90% Probability of Success

Project Element	Total-Dist	Labor-K$	EP Level	NonLbr - K$	Ps Labor	Ps NonLbr
1.0 Saturn Rocket-						
1.1 Missile-						
1.1.1 Propulsion	3263	1365	3.4	1897	50	50
1.1.2 Payload	1096	831	2.8	265	50	50
1.1.3 Reentry	1766	560	1.4	1206	50	50
1.1.4 G&C	2015	316	1.6	1699	50	50
1.1.5 IA&T	608	512	1.7	96	50	50
1.2 S/W Eng'g	3922	3917	7.9	5	50	50
1.3 Program Mngmnt	2025	2013	3.4	12	50	50
1.4 Systems Eng	3260	3245	5.4	15	50	50
1.5 ST&E	885	831	2.8	55	50	50
1.6 Training	586	515	1.3	71	50	50
1.7 Data	1025	1023	1.7	2	50	50
1.8 Support Equip	737	688	1.7	49	50	50
1.9 Initial Spares	473	404	1.9	69	50	50
Total Initial Allocation:	21661	16220		5441		
Reserves:	10532					
Total Project Cost:	32193					

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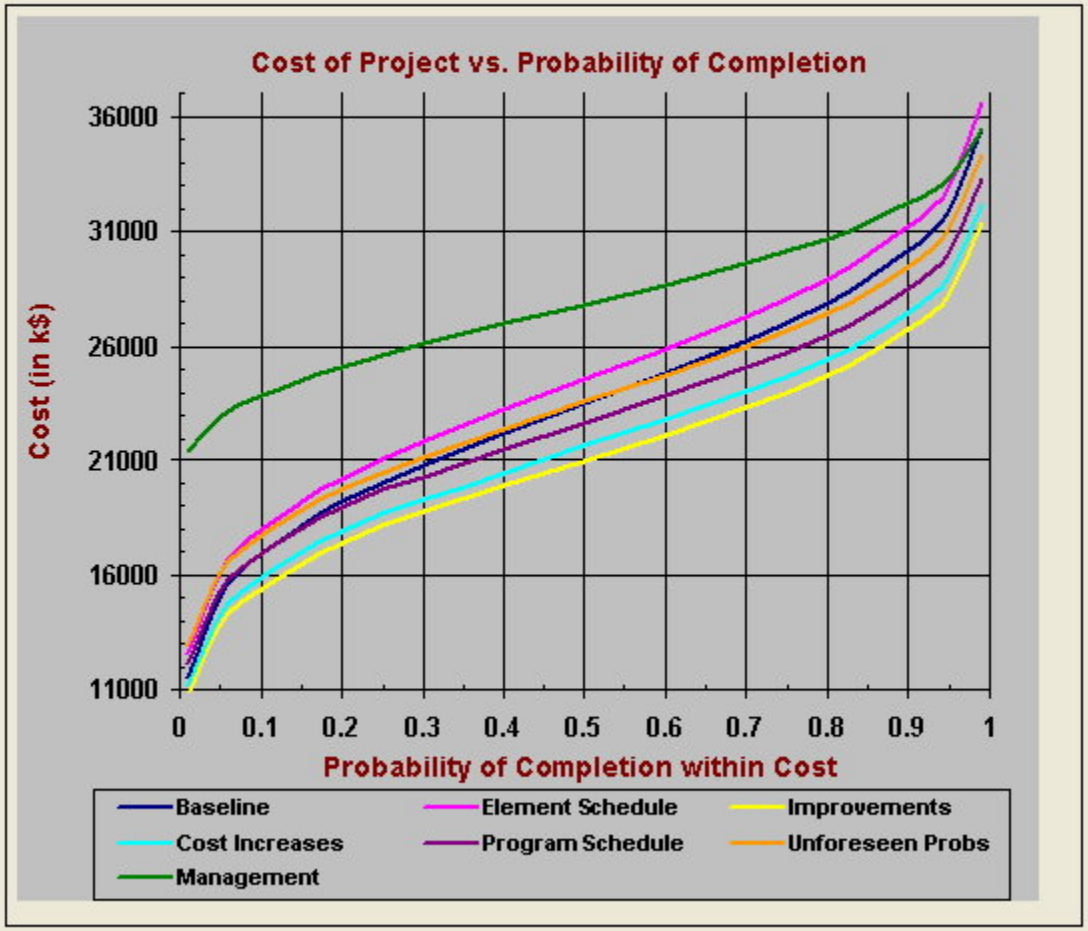
Results - Probability of Successful Completion Within Cost

Summary Info | 1. Baseline Data | 2. Element Schedule Effects | 3. Potential Improvements | 4. Potential Cost Increases

5. Program Level Schedule Effects | 6. Unforeseen Problem Effects | 7. Management Policy Effects

Apollo Rocket Project (Demo)

Probability	Unforeseen Problems	Management	Impact
0.01	12874	21429	8555.8
0.05	16010	22917	6907.7
0.1	17682	23856	6174.2
0.2	19706	25114	5407.8
0.3	21166	26092	4926.5
0.4	22413	26967	4553.7
0.5	23579	27810	4230.5
0.6	24745	28670	3924.7
0.7	25993	29601	3609.0
0.8	27452	30695	3242.8
0.9	29477	32193	2715.9
0.95	31149	33390	2241.0
0.99	34285	35473	1188.2



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Results - Probability of Successful Completion Within Cost

Summary Info | 1. Baseline Data | 2. Element Schedule Effects | 3. Potential Improvements | 4. Potential Cost Increases

5. Program Level Schedule Effects | 6. Unforeseen Problem Effects | 7. Management Policy Effects

Apollo Rocket Project (Demo)

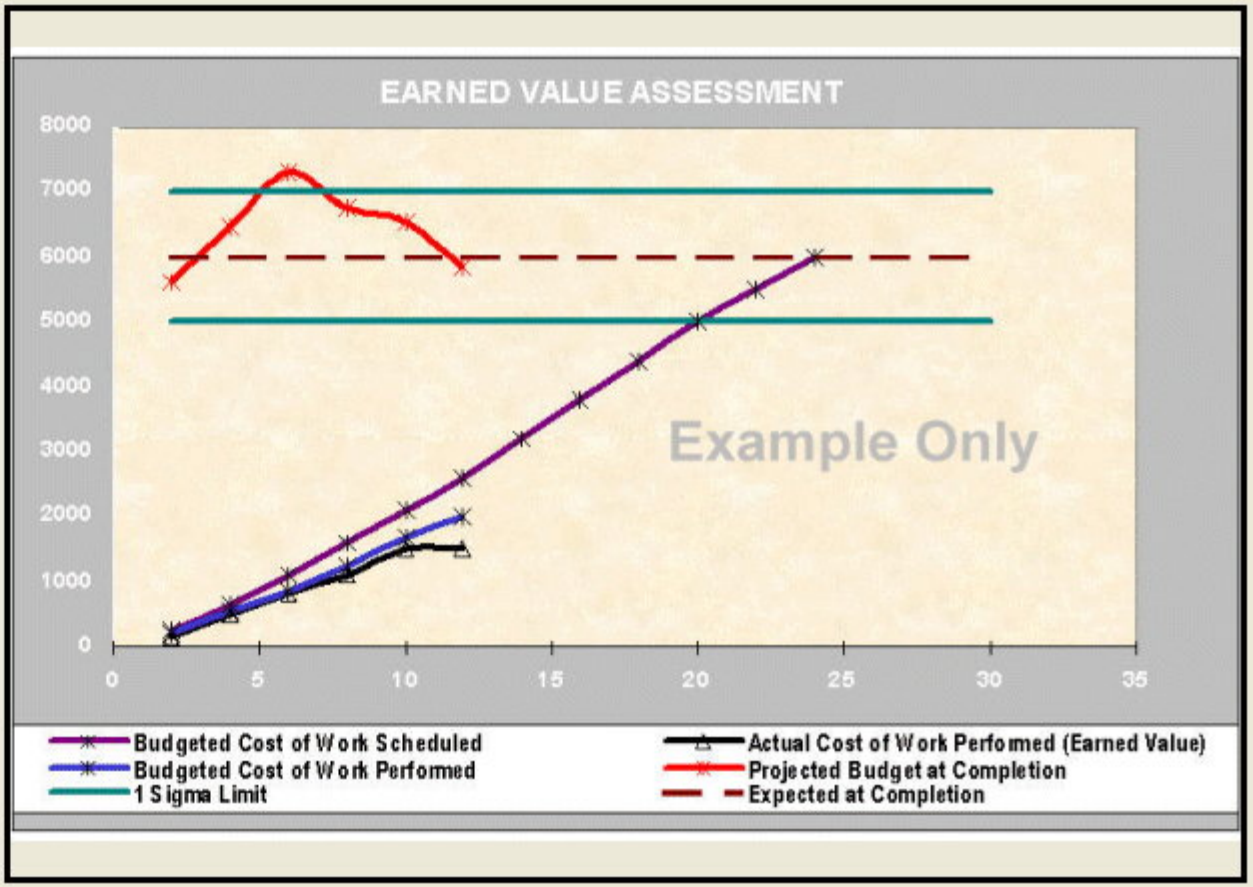
Select a title from the list to display a particular summary chart.

Standard Information:

- Suggested Allocation
- Cost Distribution
- Sensitivity Analysis
- Profit Distribution
- User Allocation Example

Advanced Information:

- Monthly Budget ($)
- Cumulative Budget ($)
- Cumulative Budget (% Total)
- > EVM Analysis



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Results - Probability of Successful Completion Within Cost

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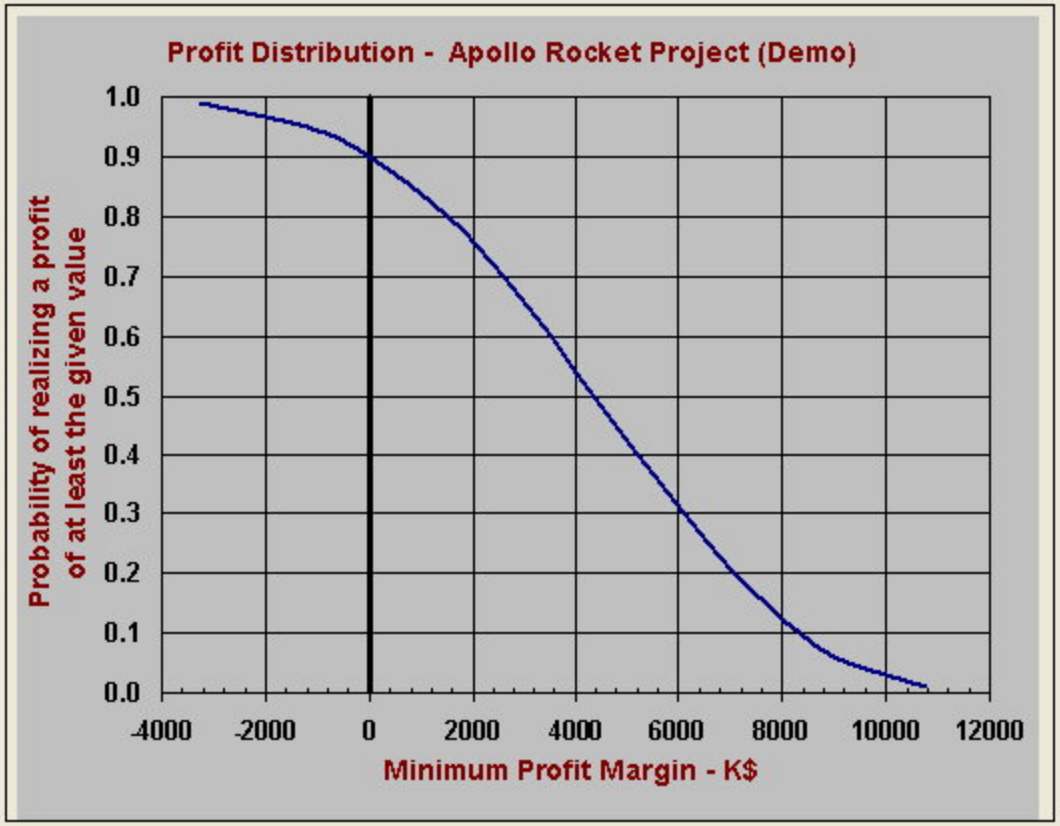

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Results - Probability of Successful Completion Within Cost

Summary Info | 1. Baseline Data | 2. Element Schedule Effects | 3. Potential Improvements | 4. Potential Cost Increases

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Apollo Rocket Project (Demo)

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Standard Information:

- Suggested Allocation
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- Sensitivity Analysis
- Profit Distribution
- > User Allocation Example

Advanced Information:

- Monthly Budget ($)
- Cumulative Budget ($)
- Cumulative Budget (% Total)
- EVM Analysis

User Supplied Allocation
SATURN ROCKET PROJECT

Example Only

PROJECT ELEMENTS	TOTAL - DIST	LABOR - K$	EP LEVEL	NONLBR - K$	Ps - LABOR	Ps - NONLBR
1.1 Missile	–	–	–	–	–	–
1.1.1 Propulsion	2,723	1273	3.2	1450	45%	40%
1.1.2 Payload	1,522	1019	3.4	503	73%	96%
1.1.3 Reentry	1,985	452	1.1	1533	35%	77%
1.1.4 G&C	1,879	499	2.5	1380	74%	40%
1.1.5 IA&T	814	663	2.2	151	81%	74%
1.2 SW Eng'g	3,317	3305	6.6	12	36%	100%
1.3 Program Mngmnt	1,979	1955	3.3	24	49%	98%
1.4 Systems Eng	3,081	3058	5.1	23	47%	96%
1.5 ST&E	1,012	959	3.2	53	61%	48%
1.6 Training	549	495	1.2	54	47%	34%
1.7 Data	1,280	1275	2.1	5	58%	99%
1.8 Support Equip	1,032	844	2.1	188	68%	84%
1.9 Initial Spares	488	423	1.9	65	58%	49%
TOTALS	21,661 (K$)	16,220 (K$)	974.4 (MAN-MOS)	5,441 (K$)		
RESERVES:	10,799				Overall Project Ps = 90%	
TOTAL PROGRAM:	32,460	DELTA COST = 267 K$				

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Results - Probability of Successful Completion Within Cost

Summary Info | 1. Baseline Data | 2. Element Schedule Effects | 3. Potential Improvements | 4. Potential Cost Increases

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Apollo Rocket Project (Demo)

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- Cumulative Budget (% Total)
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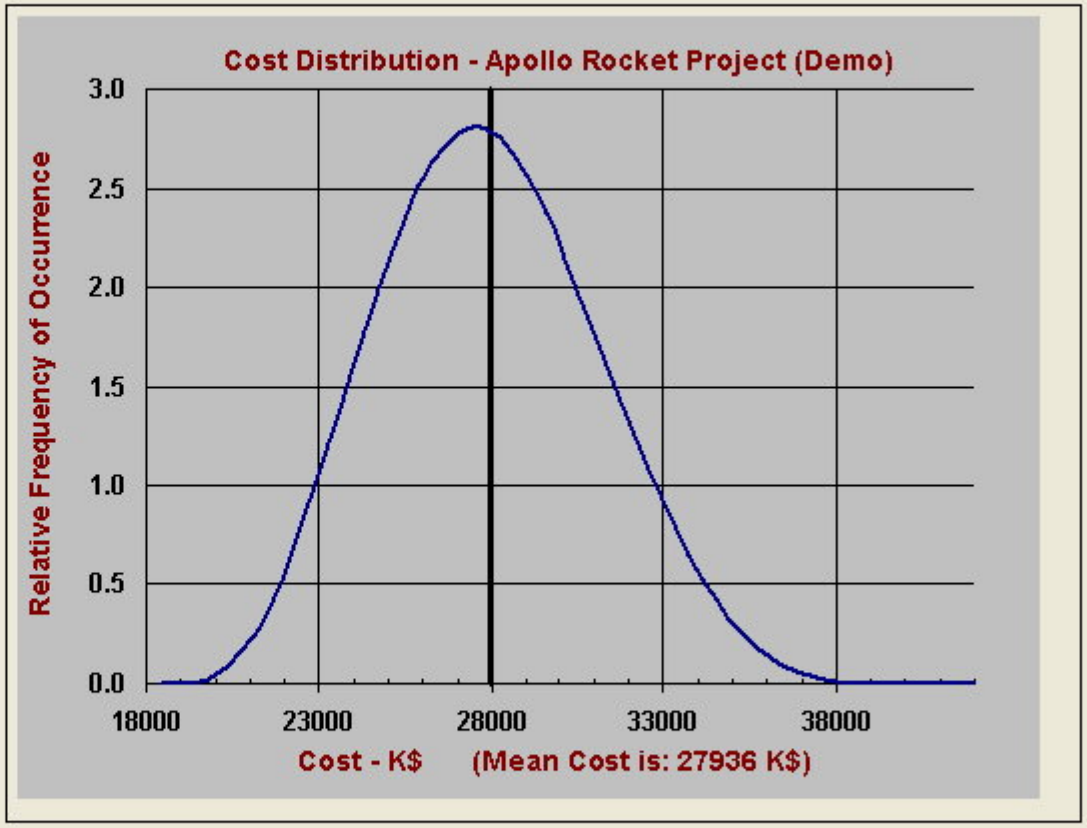

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Results - Probability of Successful Completion Within Cost

Summary Info | 1. Baseline Data | 2. Element Schedule Effects | 3. Potential Improvements | 4. Potential Cost Increases

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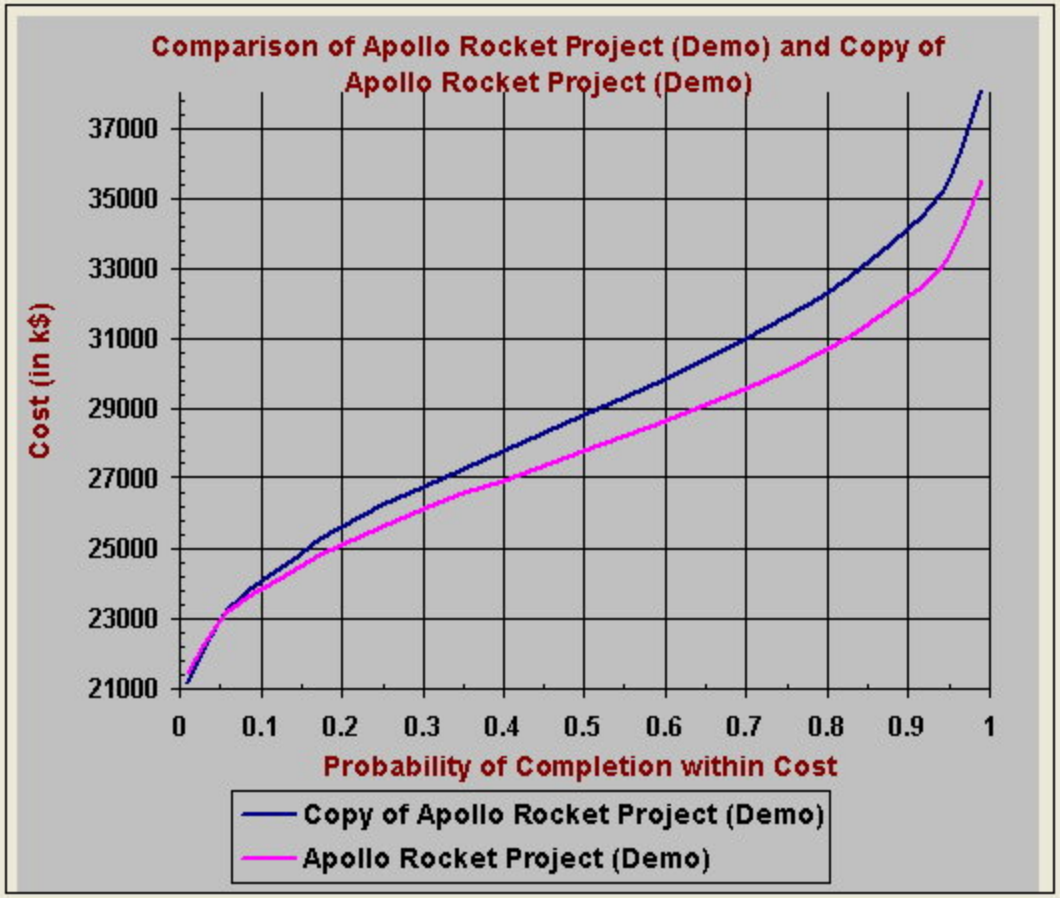
- Cumulative Budget (% Total)
- EVM Analysis



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EXPLANATION

For the illustration, assume that we start with 25 independent, identical, normal distributions of mean = 0 & sigma =1. There is no need to refer to some random set without these parameters & then standardize/Z score transform them all into that form. It's only an example & it's easiest just to start with the simple N(0,1) distributions because of the math (numbers) involved. The values are automatically expressed in sigma units just like Z score transformed variables so that we can reference the tables directly. Being identical certainly isn't the typical situation, but it suffices for illustration of the principle (& it is the worst case scenario so it produces a nice drastic impact on the results). In the real world (& the model), where the sigma's are all different, a more complicated solution exists to achieve the equi-risk allocation values - can't simply divide by the number of elements. But the same principle exists - simple arithmetic summation of xx% confidence points do not produce an xx% confidence point for the sum of all the variables. They over estimate just like the pitch example demonstrates

BACK

MODEL RESULTS

Pitch for 10 units

Probability	Baseline
0.01	0.330
0.05	0.401
0.1	0.440
0.2	0.486
0.3	0.519
0.4	0.548
0.5	0.574
0.6	0.601
0.7	0.629
0.8	0.663
0.9	0.709
0.95	0.747
0.99	0.819