WM2008 Conference, February 24 – 28, 2008, Phoenix, AZ

Abstract #8435

Rapid Response Risk Assessment Turnaround System (R3ATS)

Kenneth Redus
Redus and Associates, LLC
189 Lafayette Drive, Suite C
Oak Ridge, Tennessee 37830 USA

Rudolph Escher
Epsilon Systems Solutions, Inc.
601 Gulfwood Rd, Suite 201
Knoxville, TN 37923 USA

ABSTRACT

The Rapid Response Risk Assessment Turnaround System (R3ATS) is a decision support system that can be used for cost and schedule risk assessment as prescribed by the US Department of Energy (DOE) Order 413.3A, Program and Project Management for the Acquisition of Capital Assets. Unlike complex and training-intensive project control and accounting risk systems – or naïve and statistically incorrect risk assessment approaches – employed throughout the DOE complex R3ATS is a powerful and yet simple decision support system for conducting project risk assessments. Output from R3ATS include: (1) establishing a project risk register which can be periodically updated to regularly monitor and assess a dynamic risk picture, (2) producing statistically derived and justifiable cost and schedule contingency probability density functions, and (3) inclusion, via Bayesian updating, of significant trigger events that result in project cost, schedule or technical risk events. During FY2007, R3ATS was used by the Oak Ridge Transuranic (TRU) Waste Processing Center (TWPC) project to examine the FY2008 through FY2009 budget (~ $70 million) and the life cycle budget (over $500 million). In less than eight weeks, Oak Ridge DOE personnel and TWPC project management were trained on – and subsequently incorporated – the R3ATS approach thus demonstrating its significance as a viable and rapid turn-around decision support tool for cost and schedule risk assessment.

INTRODUCTION

In FY 2007, the Oak Ridge Transuranic (TRU) Waste Processing Center (TWPC) project defined the mission need for a defensible risk-oriented decision support system. The objective for such a system is to support US Department of Energy (DOE) Oak Ridge Office (ORO) budget planning efforts associated with the TWPC life cycle from FY2008 through FY 2018.

The top three requirements to meet the mission and the objective are: (1) identify and assess TWPC cost and schedule risks associated with the FY 2008 and FY 2009 budget (~$70 million) and the life cycle budget (over $500 million), (2) include as part of the assessment an examination of trigger (or initiating) events associated with the cost and schedule risks, (3) quantify the cost and schedule risk event and trigger uncertainties. Once the risk items are identified and assessed, two final requirements are to develop risk handling strategies and to implement the risk management strategies that follow DOE Order 413.3A [1, 2].

The Rapid Response Risk Assessment Turnaround System (R3ATS) is developed to meet the above-stated requirements. Desiring a simple and user-friendly cost and schedule risk-oriented decision support

system, TWPC also needs to R3ATS to provide risk-balancing for performance management as a core competency while ensuring that future investment in training results in effective risk management at each level of supervision.

An enterprise risk perspective is the paradigm for the R3ATS. The clear benefit is that cost and schedule risk information can be widely shared among the TWPC senior management team, the TWPC cost account managers, and DOE project management counterparts at all activity and work package levels. An integrated risk profile of the TWPC life cycle is used for combined TWPC and DOE planning and assessment. With R3ATS, TWPC and DOE now have a risk-based decision-making system that follows DOE Order 413.3A and is defensible, reliable, and repeatable.

R3ATS DEVELOPMENT AND IMPLEMENTATION PROCESS

Systems Engineering Approach

R3ATS was developed during FY 2007 using a systems engineering approach consisting of three phases. First, functional and operational requirements were identified. We defined attributes necessary for the R3ATS as illustrated in Table I. We examined existing risk assessment approaches used in the commercial and federal communities [3 – 14] and determined which facets should and should not be included in R3ATS. Next, we created a R3ATS rapid prototype version and provided it to the users to obtain supplemental operational requirements and identify shortcomings in user interfaces. Following their assessments, we refined the prototype and performed functional and system-level testing of R3ATS to validate and verify system performance.

A lesson learned is that while we have the key elements of the R3ATS architecture in place, system operation, maintenance, and refinement are crucial for future success through the FY2018 TWPC life-cycle.

Table I. Attributes Required for a Risk Assessment System

Attribute	R3ATS	DOE and Contractor Risk Assessment Systems
Consistent and concise definition of cost or schedule “risk”	Quantitative definition of risk, likelihood, trigger, and consequence using consistent metrics [3, 4, 5, 7, 8, 9]	Arbitrary definition of risk, likelihood, trigger, and consequence applied that changes depending on risk assessor [3, 4, 7, 10, 11]
Ease in user input and understanding of output	Risk management process following DOE O 431.3 and EM Guidance [1, 2, 3]	
Account for biases and errors in judgment	Prescriptive scaling used to minimize opportunity to anchor on a single risk value and to maximize opportunity to adjust risk values [6, 8, 13, 14]	Not accounted for; no mechanism used to examine biases or errors [3, 4, 7, 10, 11]
Use metrics to measure risk components that are repeatable and reliable	Quantitative metrics used to ensure repeatability (measurement error is small) and reliability (consistency of measurements between raters) [8, 14]	Metrics are pseudo-quantitative which result in reliance on verbal and qualitative expressions of risk events resulting in limited repeatability and no reliability [3, 4,

Attribute	R3ATS	DOE and Contractor Risk Assessment Systems
		5, 7, 10, 11]
Express triggers, likelihoods, and consequences as probability distributions	Each trigger, likelihood, or consequence is expressed as a probability distribution [5, 8, 13, 14]	Assumes triggers occur with certainty; likelihoods are expressed as midpoint of arbitrary ranges; maximum possible value for consequence is usually orders of magnitude greater than expected value [3, 4, 7, 10, 11]
Sees risks as random events	Probability distributions for trigger and risk event likelihoods and consequences explicitly recognize randomness [8, 9]	Statistical analysis of random events cannot be performed due to arbitrary and inconsistent definitions of risk factors and lack of repeatable and reliable measurement approach [3, 4, 7, 10, 11]
Synthesizes individual risks into one risk	Applies Bayes Rule to propagate trigger and risk event consequence uncertainties; use Monte Carlo simulation to add products of multiple probability distributions [8, 12, 14]	Assumes triggers and consequences are independent and additive; use Monte Carlo simulation to add products of multiple probability distributions [3, 4, 7, 10, 11]
Establish a framework that quantitatively examines risks independently and collectively	Consistency in definitions coupled with reliable and repeatable measurement approach ensures sound quantitative examination	Framework is subject to interpretation and external influences to make the answer "what it should be"

R3ATS Architecture

The R3ATS architecture is based on implementation of the elements of the systems engineering approach. Fig. 1. The architecture is simple and transferable to other DOE organizations requiring the capabilities of a defensible risk-oriented decision support system. Each of the components of the R3ATS architecture is discussed in detail.

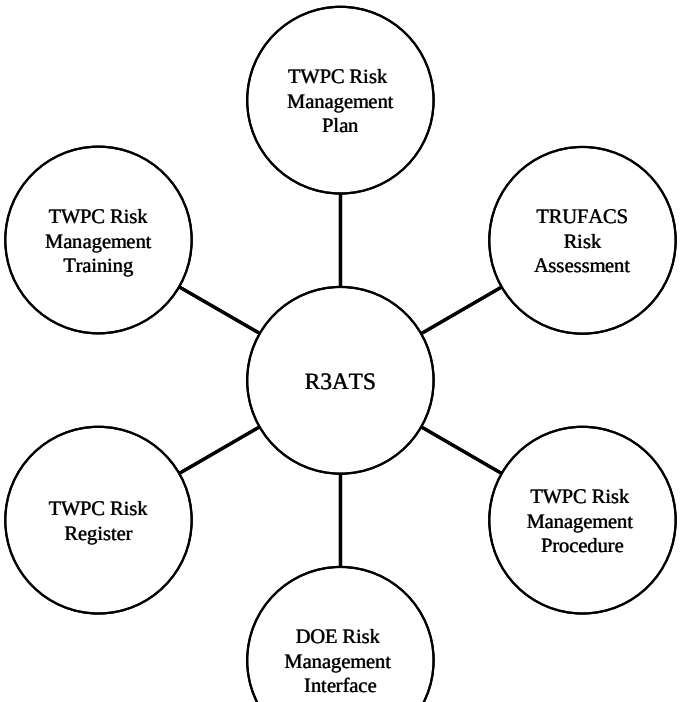

Fig. 1. R3ATS Architecture

The TWPC Risk Management Plan (RMP) describes how risk-balanced decision making for the life cycle Performance Measurement Baseline (PMB) is performed [15]. For technical and disposition facility capacity reasons, the TWPC reflects more than usual project management uncertainty over its life cycle. A less than fully defined Project technical scope has the result that programmatic and policy issues are prominent in the near-term risk profile of the facility. To fit the TWPC planning context, this RMP tailors the conventional approach to forward engineered project risk management. This unique tailoring reflects specific Integrated Safety Management lessons learned about inherent risks to effectiveness of the overall Performance Management System. The RMP addresses all known Project risks and significant opportunities. It ensures integration of bottoms-up analysis of uncertainty about planned work, with a rolling, top-down assessment of how external variability and internal innovation are to be managed. Furthermore, the RMP leads to risk-balanced decisions among the contractor, the client and other TWPC stakeholders. The Plan guides risk handling using a graded approach to the planning process using discrete, progressive levels of work definition rigor.

TRUFACS (TWPC Risk and Uncertainty Forecasting Analysis Capability System) Risk Assessment is the analytical engine for risk identification, risk assessment and analysis, risk handling and mitigation, and risk monitoring. Specific risk documentation is generated from TRUFACS to include the TWPC Risk Register and special studies. TRUFACS propagates uncertainties associated with cost estimates, risk estimates, and risk handling strategy estimates over the timeframe FY 2008 – FY 2012. The platform for TRUFACS is Microsoft Excel [16]. Mathematical (Monte Carlo) simulations in TRUFACS are accomplished using the Excel add-in @Risk [17]. Fig. II illustrates the functional flow of TRUFACS.

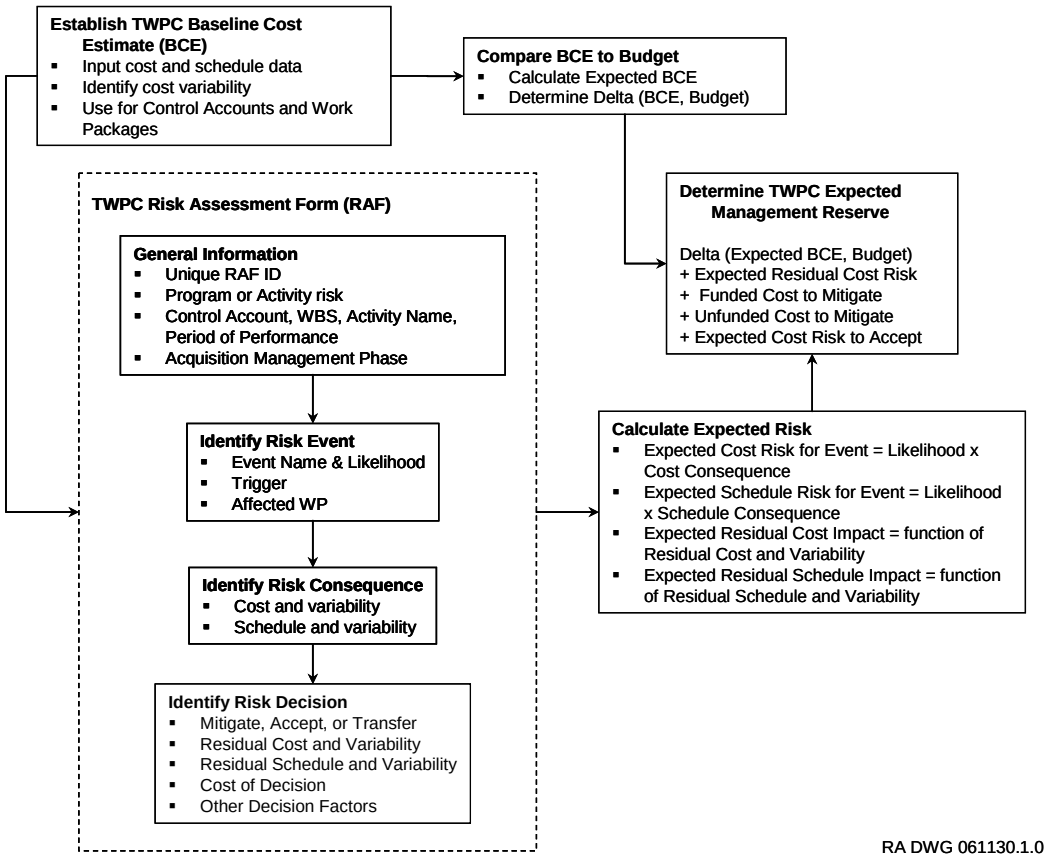

Fig. 2. TRUFACS Decision Logic

- *Establish the TWPV Baseline Cost Estimate (BCE)*. Cost and schedule data, to include the cost budget, are provided from TWPC Project Controls. Cost variability estimates are provided by individual Work Package (WP) managers. Table II provides the definitions for both cost variability and also schedule variability. Deterministic cost data is combined with the cost variability estimates to calculate a probabilistic representation of cost for each WP. This is accomplished using a beta probability function bounded by the minimum and the maximum cost as determined from the variability inputs. The result is the Expected BCE.
- *Compare BCE to Budget*. The difference between the Expected BCE and the budget represents a 50% confidence value of budget exceedance or under-run. This value is used as an element of calculating the TWPC Expected Management Reserve.
- *TWPC Risk Assessment Form (RAF)*. The TWPC RAF is the data collection instrument used to calculate Expected Risk and Cost Risk Avoidance. This information is collected at the work package level.

    - General information included in the form includes (1) a unique RAF identifier used for configuration control, (2) an identification of whether the RAF is providing a program or an activity risk (or both), (3) detailed information associated with the Control Account, WBS, Activity Name, or Period of Performance, and (4) the DOE Acquisition Management Phase associated with the WP system for which the risk is examined.
    - The unique risk event is described in terms of (1) the event name, a qualitative and a quantitative statement for the event likelihood (the probability of occurrence of the event), (2) an identification of specific events that would trigger, or cause, the risk event to occur, and (3) an identification of other WP that would be affected should the risk event occur. Table III provides the scale that quantifies the qualitative statement of the likelihood of the risk event. The risk event consequence is also defined in the RAF in terms of schedule, cost, or technical impact. Quantification of the consequence includes the most likely cost or the schedule consequence and its associated variability. Using the scale in Table II, the minimum and the maximum cost or schedule consequence are calculated using the Confidence in Cost Value (CICV) or the Confidence in Schedule Value (CISV). Similarly, the RAF includes a table look-up to determine a qualitative level of risk for the event.
    - TRUFACS also has a Bayesian updating method that determines a “weighted” likelihood of a risk event based on triggers that have a probability (or likelihood) between zero and one. TRUFACS Bayesian updating accounts for the prior probability that a trigger may occur. Given that the trigger occurs, there is some likelihood the risk event will occur or not occur. Combining these two variables and weighting them by the joint probability that all triggers and all risk events occur provides a posterior likelihood each risk event will occur. As is the case when a trigger is assumed to occur with certainty, the expected risk of the risk event is the sum of the products of the posterior risk event probabilities and their consequences.
    - Based upon whether the risk is medium or high, a decision to mitigate, accept, or transfer the risk event is required. Other decision factors are captured in the RAF. If the decision is to mitigate the risk event, there is a both a residual risk (or some risk left over as

measured in cost and schedule) after mitigation is performed and either a funded or an unfunded cost of performing the mitigation actions. The RAF also identifies recommended actions and potential key impacts associated with accomplishing the mitigation. If the risk is accepted, the residual risk is exactly the risk of event. If the risk is transferred, the risk is reduced to effectively zero.

Table II. TRUFACS Scaling Used to Determine Cost or Schedule Variability Given User Input of Most Likely (ML) Value

ID	Confidence in Cost Value (CICV) or Confidence in Schedule Value (CISV)	Minimum	Maximum	Probability Density Function (PDF) [1,2]	Ratio of Upper 95% Confidence Interval to Most Likely (ML)
L	Low	-50%	100%	Beta (2.33, 3.67, 0.50*ML, 2.0*ML)	1.57
M	Moderate	-25%	50%	Beta (2.33, 3.67, 0.75*ML, 1.50*ML)	1.28
H	High	-10%	15%	Beta (2.6, 3.4, 0.90*ML, 1.15*ML)	1.09
BL	Biased on the low side	-5%	100%	Beta (1.2, 4.8, 0.95*ML, 2.0*ML)	1.47
BH	Biased on the high side	-50%	5%	Beta (4.6, 3.4, 0.50*ML, 0.05*ML)	1.03
A	Known with certainty	0%	0%	Deterministic	NA

[1] For example, if the Most Likely (ML) Cost Value is $10,000 and the CICV is Low (L), then the PDF is Beta (2.33, 3.67, $5,000, $20,000).
[2] For example, if the Most Likely (ML) Schedule Value is 10 months and the CISV is Biased on the low side (BL) then the PDF is Beta (1.2, 4.8, 9.5 months, 20 months).

Table II. TRUFACS Scaling Used to Quantify Likelihood of the Risk Event

ID	Likelihood of Risk Event	Minimum	Most Likely	Maximum	Probability Density Function (PDF)[1]	Expected Likelihood	Ratio of Upper 95% Confidence Interval to Most Likely (ML)
VL	Very low	1%	5%	10%	Beta (2.8, 3.2, 0.01, 0.10)	5%	1.55
L	Low	10%	25%	30%	Beta (4, 2, 0.10, 0.30)	25%	1.22
M	Moderate	30%	50%	70%	Beta (3, 3, 0.30, 0.70)	50%	1.25
H	High	70%	75%	90%	Beta (2, 4, 0.70, 0.90)	75%	1.08
VH	Very high	90%	95%	99%	Beta (3.2, 2.8, 0.90, 0.99)	95%	1.03
A	100% certainty	100%	100%	100%	Deterministic	100%	NA

[1] For example, if the Likelihood for a Risk Event is Very High (VH), then the expected likelihood is 95% and the PDF is Beta (3.2, 2.8, 0.90, 0.99).

- *Calculate Expected Risk.* TRUFACS calculates expected risk for the risk event using the classic risk equation, namely, risk = likelihood x consequence. Since TRUFACS employs a probabilistic risk approach, the risk equation is the product of two probability functions. If the probability functions were "simple," such as uniform or normal, a closed form analytical solution could be determined. Since this is not the case, mathematical simulation is performed. Expected Cost Risk

is determined by the likelihood of the risk event times the cost impact. Expected Schedule Risk is determined by the likelihood of the risk event times the schedule impact. The expected residual cost or schedule impact is determined as function of the residual cost or schedule impact and its variability. Since each WP may have risks over multiple fiscal years, the expected risk of the event and the impact of the risk strategy are proportionally allocated over the relevant fiscal years based upon the WP cost fiscal year allocation.

- *Determine TWPC Expected Management Reserve*. The calculation of the TWPC Expected Management Reserve represents that value such that there is a 50% chance the reserve will meet the risk requirements and there is a 50% chance it will not. The TWPC Expected Management reserve is calculated as Delta (Expected BCE, Budget) plus Expected Residual Cost Risk plus Funded Cost to Mitigate plus Unfunded Cost to Mitigate plus Expected Cost Risk to Accept. The TWPC Expected Management Reserve is presented as a continuous cost curve allowing one to determine (1) the probability a specific value of management reserve will be exceeded, or, equivalently, the chances that the management reserve is insufficient to meet the risk requirements identified from all the RAF and (2) the specific value of the management reserve such that there is a probability of at most 80% the management reserve is sufficient to meet the risk requirements identified from all the RAF.

The TWPC Risk Management Procedure provides detailed guidance and procedures on how risk identification, risk assessment and analysis, risk handling and mitigation, risk monitoring, and risk documentation and communication are performed [16]. It is the implementation document for the TWPC RMP [15], requirements prescribed in DOE Manual 413.3-1 [2], and associated Environmental Management Program Guidance [3]. The workflow process described within the procedure continuously identifies and manages critical technical, performance, schedule and cost risks throughout the TWPC PMB life cycle. Risks are assessed and analyzed based on probability and consequences to develop mitigation strategies and actions needed to minimize adverse impacts to the achievement of key performance parameters. Potential risk events are then evaluated for risk consequence. The TWPC Risk Register Report is issued and maintained in accordance with the RMP. It includes Control Account Manager (CAM) assessments of the uncertainty and confidence intervals in the cost and schedule parameters of the PMB Work Packages. Data from these assessments are then subjected to a Monte Carlo simulation program to identify cumulative PMB confidence levels and forecasts of Management Reserve. The project risks and uncertainty are then evaluated for their impact on required management reserve and recommended DOE - Oak Ridge Operations contingency.

DOE Risk Management Interface is a key component of the R3ATS architecture since it serves as the communication and interface basis between the TWPC management team and the DOE Integrated Project Team (IPT). R3ATS provides the documentary evidence of compliance with the applicable DOE Orders and is also the historical record for all risk management actions related to each identified risk event.

The TWPC Risk Register (RR) provides a current TWPC risk profile. Applying the Risk Management graded approach process, the TWPC issues a RR Report that contains those risk register items that warrant added senior management focus to assure that handling decisions are successfully executed, updated, and closed in a timely fashion. The RR Report includes all risk items screened as high level risks and usually all of the medium level risks as well. These risk events are monitored closely on a continual basis and their status is updated at least monthly in a report to the client. This process ensures that the most likely and relevant risks are monitored at the appropriate level for their potential affect on TWPC performance. The whole population of risk events are monitored continually as well and their status is

updated at least quarterly under the supervision of the TWPC Risk Review Board. Each month the entire risk event population is considered for changes that could elevate the importance or concern associated with the event.

User (including Management) Training is crucial to the success of any project risk management program. It is essential that the executive and senior level managers are supportive champions of the risk management program. It is up to the executives and senior managers on the Risk Review Board to implement, monitor and use the risk management program to ensure a safe, high performing, and sound fiscally managed project. So training is conducted from the top the down using group seminars, workshops and work instruction training classes to impart the needed knowledge and skills from the top down. The Risk Review Board, Control Account Managers and Work Package Managers all have general and specific training goals and requirements. One on one and small group focused follow-up training is given related to specific work package risk development and evaluation. It is understood that risk management is a new concept for many so the training is designed to be given at various maturity levels as risk events and trigger events are being identified and evaluated. As the training maturity level of the associates grows the training can become more technical and more focused on solving particular questions or problems. This training approach serves to get risk identification off to a quick start and to ultimately complete the process in a compressed time frame.

ILLUSTRATIVE OUTPUT

A primary output of R3ATS is the probability density function that describes the TWPC expected cost and expected schedule. The probability density function is determined using a statistical goodness of fit approach for the sum of all the cost or schedule risks. The difference between the expected value (whether cost or schedule) and the budgeted cost or schedule is defined as the management reserve. The TWPC expected cost (or expected schedule) is interpreted as “there is a 50-50 chance the cost (or schedule) will exceed the expected value.” The difference between the “80% confidence value” for the expected cost or schedule and the expected cost or schedule is defined as the Federal Contingency. The interpretation of “80% confidence value” for the expected cost or schedule is “there 20% chance the cost (or schedule) will exceed the expected value.”

An illustration of the TWPC expected cost curve for FY2008 is presented in Figure 3. The expected cost curve is presented as a complimentary cumulative distribution function (CCDF) so that it the probability of exceedance is obvious to the viewer. Various sensitivities on the input conditions that result in the expected cost curve, and the expected cost curve itself, form the basis for detailed interfaces with DOE to assist in budget planning and evaluation.

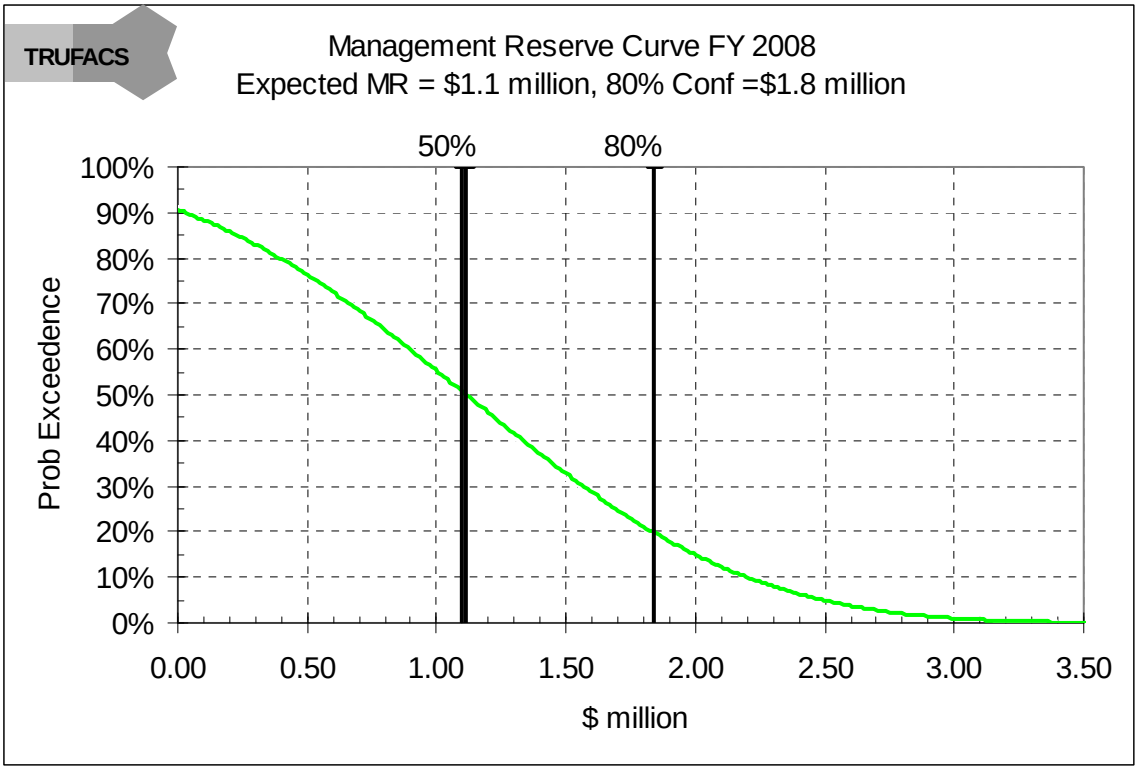

Fig. 3. Illustrative R3ATS Output for FY2008 Management Reserve

CONCLUSION

The R3ATS was developed to meet the mission need for a defensible risk-oriented decision support system. We have demonstrated how R3ATS meets DOE ORO budget planning efforts associated with the TWPC life cycle from FY2008 through FY 2018. We have further identified the critical shortcomings in the entire approach that DOE takes perform risk management. When we realized that DOE guidance for risk management is naïve and can easily produce results are not reliable or repeatable, we applied a defensible systems engineering approach to develop R3ATS. The TWPC approach to risk management offers a risk-balancing approach for performance management and ensures that future investment in training enables all users to use risk management as a tool for successful TWPC mission accomplishment.

REFERENCES

1. U.S. DEPARTMENT OF ENERGY (DOE). DOE Order 413.3A, Program and Project Management for the Acquisition of Capital Assets (2006).
2. U.S. DEPARTMENT OF ENERGY (DOE). DOE Manual 413.3-1, Program and Project Management for the Acquisition of Capital Assets (2003).
3. U.S. DEPARTMENT OF ENERGY (DOE) EM, Risk Management Guide (2007).
4. U.S. DEPARTMENT OF ENERGY (DOE). DOE-ORO-2249, Rev 0, Federal Risk Management Plan, for the Oak Ridge Environmental Management Program Oak Ridge, Tennessee (October 2007).

5. NATIONAL RESEARCH COUNCIL (NRC). The Owner's Role in Project Risk Management, The National Academies Press (2005).
6. A. TVERSKY and D. KAHNEMAN. "Judgment under Uncertainty: Heuristics and Biases," Science Vol. 185. no. 4157, pp. 1124 – 1131 (1974).
7. M. BOLLEX. Programmatic Risk Management Benchmarking of the U.S. Department of Energy, Environmenta1 Management Contractor Sites, CH2M-Hill Hanford Group, Inc., RPP-10932, Revision 0 (2002).
8. L. MERKHOFER, Choosing the Wrong Portfolio of Projects, Lee Merkhofer Consulting, www.prioritysystem.com (accessed December 2007).
9. J. P. KINDINGER. Use of Probabilistic Cost and Schedule Analysis Results for Project Budgeting and Contingency Analysis at Los Alamos National Laboratory, Proceedings of the 30th Annual Project Management Institute 1999 Seminars & Symposium, Philadelphia, Pennsylvania, USA (1999).
10. WASHINGTON SAVANNAH RIVER COMPANY. SRS Risk Summary and Integrated Contingency Estimates, Y-RAR-B-00003 Revision 0 (2006).
11. S. K. SHETE and S. VENKATESH. Application of Risk Management Practices to NNSA Tritium Readiness Subprogram, Y-TRT-G-00002 Rev 2 (2007).
12. D. A. BODNER and W. B. ROUSE. R&D World: Simulation-Based Analysis of R&D Enterprise, Proceedings of the 2005 Industrial Engineering Research Conference, Atlanta, Georgia, USA, (2005).
13. K. S. REDUS. "How Statisticians Speak Risk," Proceedings of the Symposium on Waste Management, Tucson, Arizona, USA (2007).
14. K. S. REDUS. "Incorporating Uncertainties into Waste Volume and Cost Forecasts," FEDRAD II+, Exchange Monitor Publications & Forums, Chicago, Illinois, USA (2006).
15. ENERGX. TRU Waste Processing Center Risk Management Plan, CM-A-AD-021/Rev. 2, Oak Ridge, TN (2007).
16. MICROSOFT CORPORATION. Microsoft Excel 2004, Microsoft Corporation, Redmond, WA (2004).
17. PALLISADE CORPORATION. @Risk, Risk Analysis Add-in for Microsoft Excel, Version 4.5.7, Ithaca, NY (2005).
18. ENERGX. TRU Waste Processing Center Risk Management Procedure, CM-P-PA-004 Rev. 0, Oak Ridge, TN (2007).
19. ENERGX. TRU Waste Processing Center Risk Register Report, CM-R-PA-001/Rev. 1, Oak Ridge, TN (2007).
20. U.S. DEPARTMENT OF ENERGY (DOE). Federal Risk Management Plan for the Oak Ridge Environmental Management Program Oak Ridge, Tennessee, DOE-ORO-2249, Rev 0 (2007).
21. U.S. DEPARTMENT OF ENERGY (DOE). Federal Risk Register for the Oak Ridge Environmental Management Program Oak Ridge, Tennessee, DOE/ORO-2250, Rev 0 (2007).