Acquisition Research Program:
Creating Synergy for Informed Change

Dynamic Cost-Contingency Management

A Method for Reducing Project Cost While Increasing Probability of Success

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Cost-overrun problem: Déjà-vu

"Their judgment was based more on wishful thinking than on sound calculations of probabilities."

Thucydides, 431 B.C.E.

- Thucydides' observation is very insightful and still appropriate today

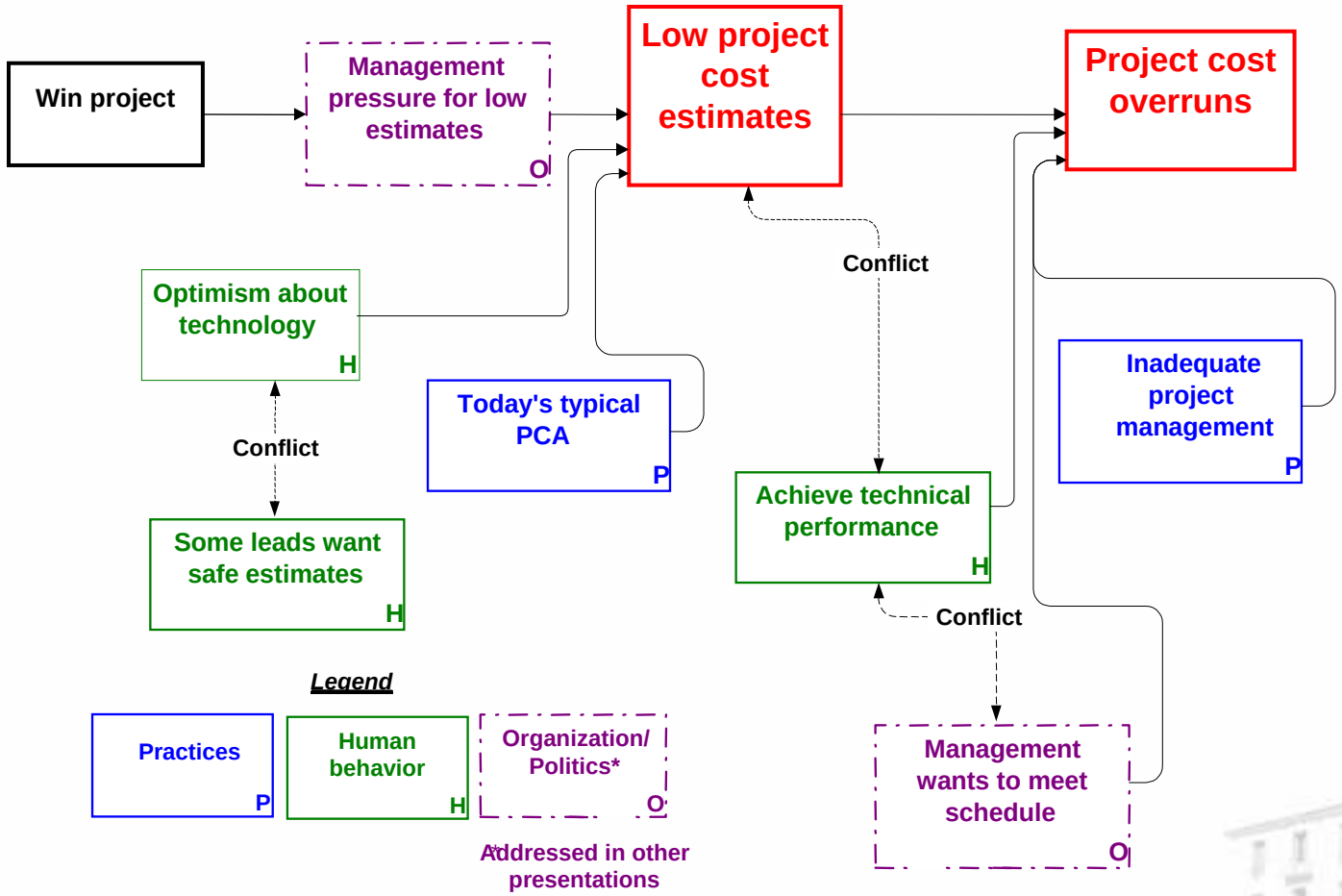
- Projects that come-in under cost do not necessarily deserve kudos
  - They may have carried excessively safe budgets!

Cost overrun causes "Top 10" list

Common threads among "top 10" lists

- Institutional and organizational culture
  - Procurement process, management pressure, poor project definition…
- Real Vs. idealized human behavior
  - Psychology is relevant to economics, decision-making, management,…
  - The "100% rational" person is a theoretical model that differs from reality
- Inadequate analysis - Today's typical Probabilistic Cost Analysis
  - Ad-hoc data elicitation, improper distributions, omitted and/or limited dependencies, omitted high-risk events & decision points
  - Shift from deterministic to probabilistic approach is NOT silver bullet
    - Monte Carlo simulation is only a mathematical tool: *GIGO*
- Poor management practices
  - Lack of appreciation of probabilistic concepts and psychological influences in budget allocation and control of management reserve

Current project reality leads to cost overruns

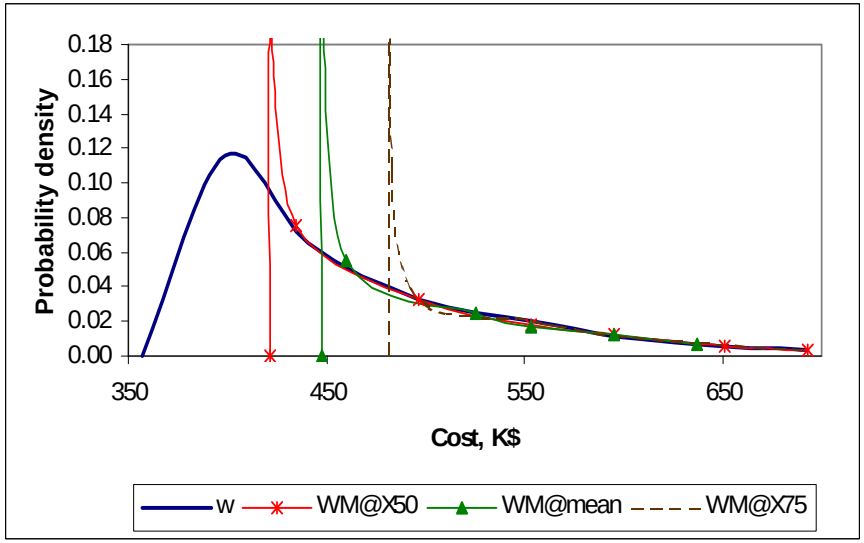


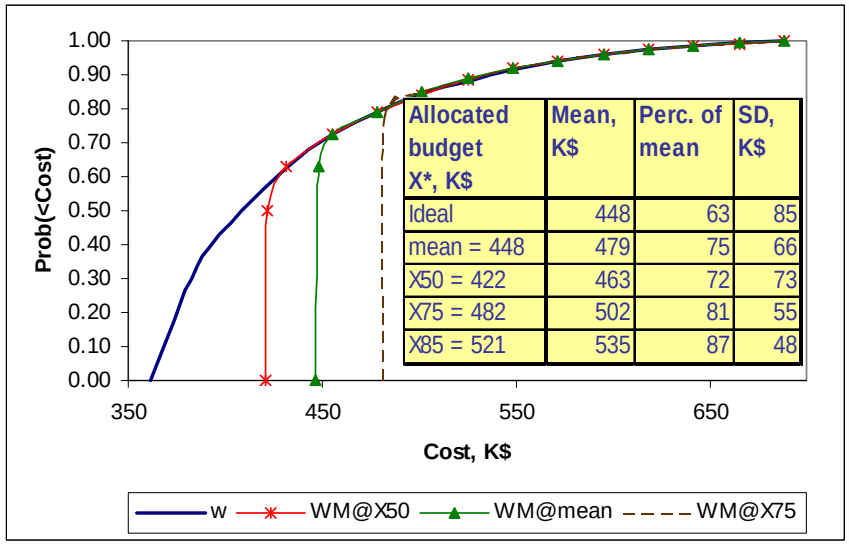
Psychology can teach us much about cost overruns

- Overconfidence
  - R&D folks are intrinsically optimistic about new technologies
    - ☞ *"For heaven's sake, spread those fractiles! Be honest with yourselves! Admit what you don't know!"* *[Alpert and Raiffa, 1982]*
- Negative human behavior – MAIMS Principle
  - *"Money Allocated Is Money Spent." [C. Gordon, 1997]*
  - Task underruns are rarely available to protect against tasks overruns. Task overruns are passed on to the total project.
- Mistakes of reason
  - *"Too many details tend to cloud the big picture."*
  - Total project cost is not simply the sum of cost elements. Project risks are likely to affect multiple elements.
    - ☞ *"Implicitly trusting the most readily available information or anchoring too much on convenient facts."* *[Russo and Schoemaker, 1990]*

Realistic cost analysis requires a systems perspective
Integrate psychological influences, valid mathematical models, and sound management techniques

MAIMS significantly impacts project cost





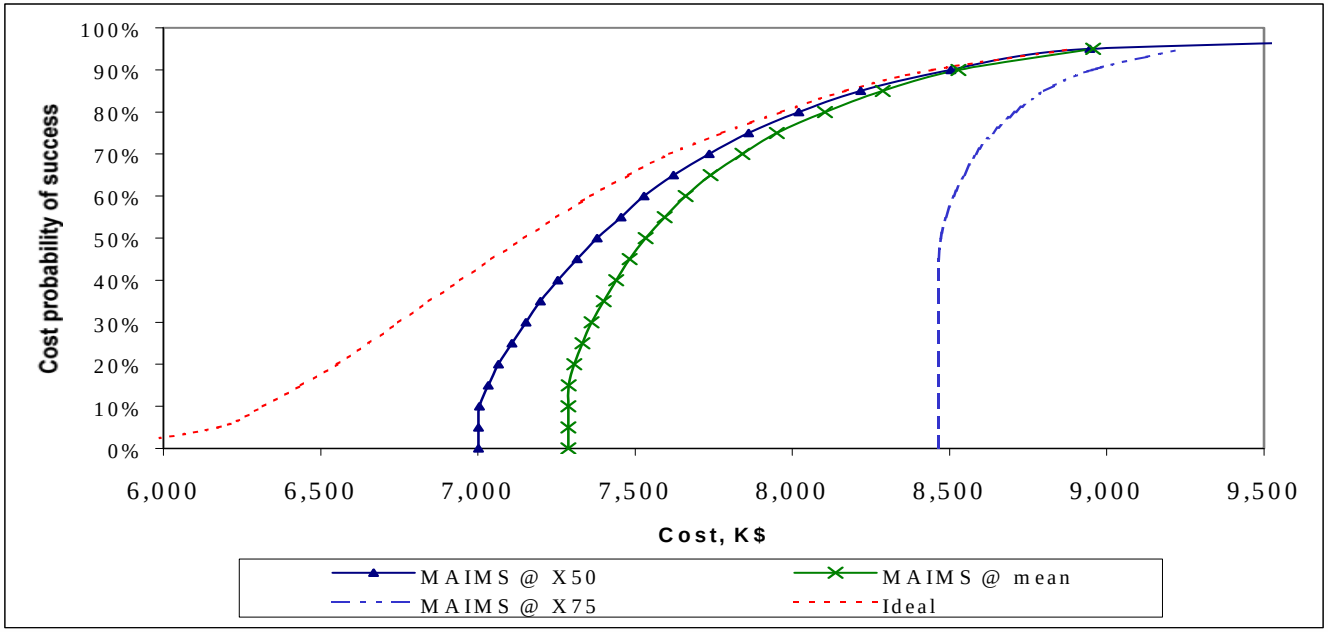
Allocated budget X*, K$	Mean, K$	Perc. of mean	SD, K$
Ideal	448	63	85
mean = 448	479	75	66
X50 = 422	463	72	73
X75 = 482	502	81	55
X85 = 521	535	87	48

Properties of MAIMS - Modified probability distributions

- Minimum value: allocated budget, x*
- Spike (Dirac delta function) at x*
- Identical to original cost element for values > x*

MAIMS impact increases with increased budget allocation

Budget allocation impacts project cost and probability of success



Mythical Project

- "100% Rational" team
- Each cost manager spends only as necessary to satisfy requirements
- Actual cost may be less than budgeted costs

Real Project

- Human & organizational influences
- MAIMS principle: No cost manager spends less than his/her budget
- Actual cost increases with higher allocated budget

It's NOT your textbook contingency anymore!

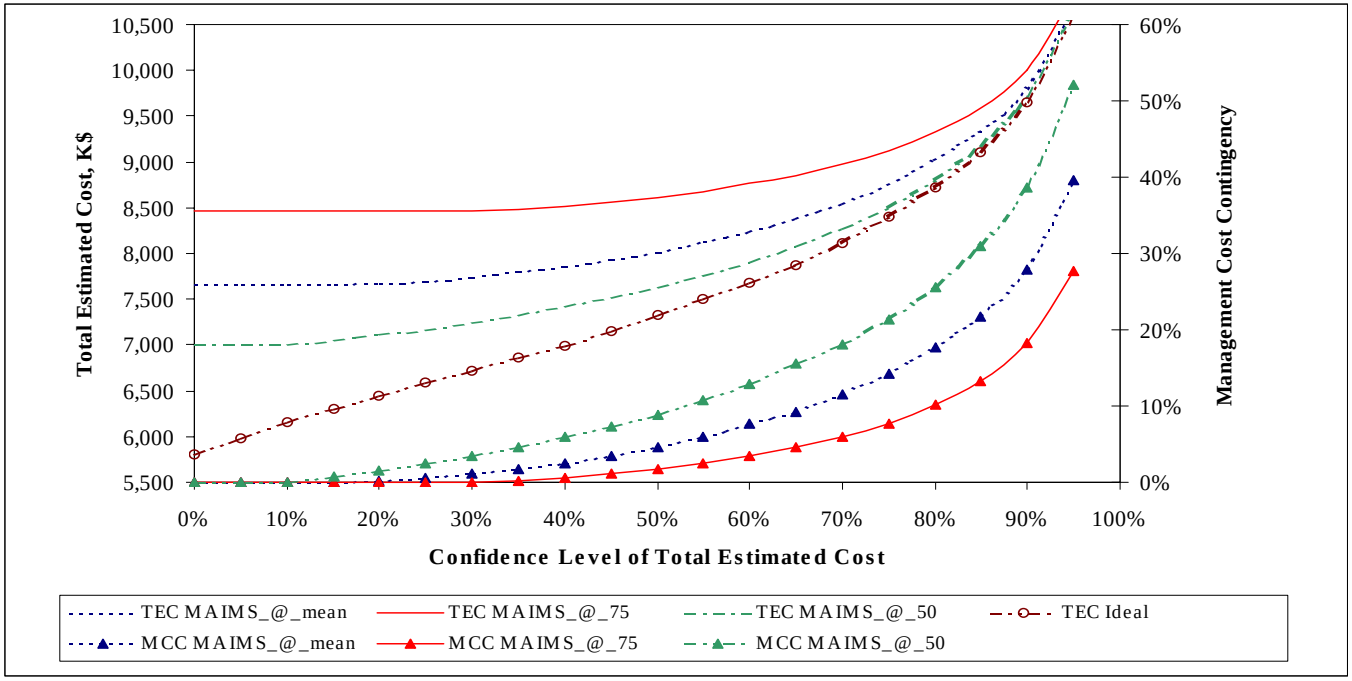
- Cost contingency depends on desired probability of success and cost management strategy

  $MCC(PoS, PBC_1,\ldots,PBC_n) = TEC(PoS, PBC_1,\ldots,PBC_n) - PBC$

  - MCC: Management Cost Contingency
  - TEC: Total Estimated Cost
  - PoS: Probability of Success
  - PBC_i: Baseline Budget for Cost element C_i
  - PBC: sum over all cost elements

- Major differences with both deterministic practice and today's typical PCA
  - MCC is not a fixed percentage of PBC
  - MCC incorporates depends on the management strategy
  - MCC is an interactive and iterative process
    - Analysts, engineers, managers

Contingency, cost, & success are NOT directly related



- High cost NEED NOT provide (1) high PoS or CL and/or (2) high contingency
- Low contingency DOES NOT necessarily equate to low cost
- High contingency DOES NOT necessarily equate to high cost and/or padding

Realistic budget allocation, adequate contingency, and dynamic allocation are critical to optimal cost and probability of success.

Fable of a project cost overrun

- ➢ Agency X issues a RFP
- Requests cost at 50% CL
- ➢ Contractor A prepares bid
- Possesses limited sophistication; not cognizant of MAIMS principle
- Performs today's typical PCA
  - P50: 7,348 K$
  - Min: 5,633 K$
- ➢ Cont. A submits bid of 7,348 K$
- Confident of success. Thinks cost estimate has a 30% margin.
- ➢ Contractor A is winner
- ➢ Project starts & budgets allocated
- Cost element baseline at mean: 7,665 K$

- ➢ Much time is spent reallocating and prorating budgets
- Budget cost elements at 50% CL
  - Baseline cost: 7,002 K$
  - Management reserve: ~ 5%

The outcome

Everybody works very hard. But the project runs out of budget and is cancelled

- ➢ Epilogue
- Another project has succumbed to the MAIMS principle
- Today's typical PCA models a mythical project
- Contracting agencies & contractors use proposed approach

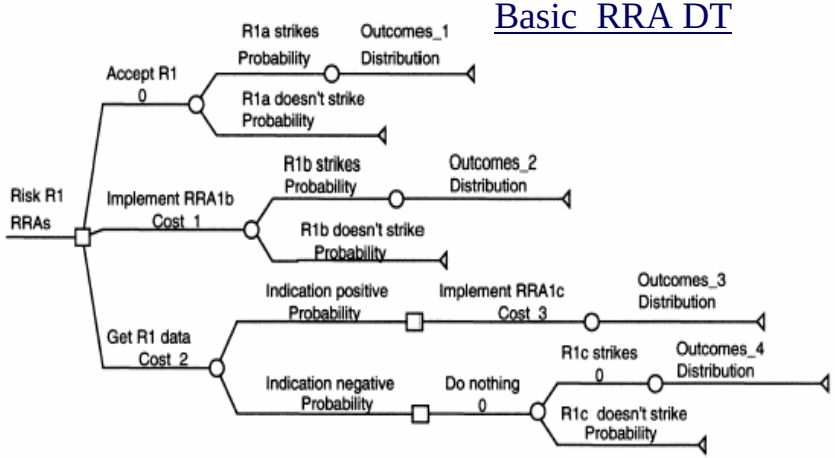
High technical risks require individual risk mitigation plans

☞ Technical risks often associated with high-consequence events

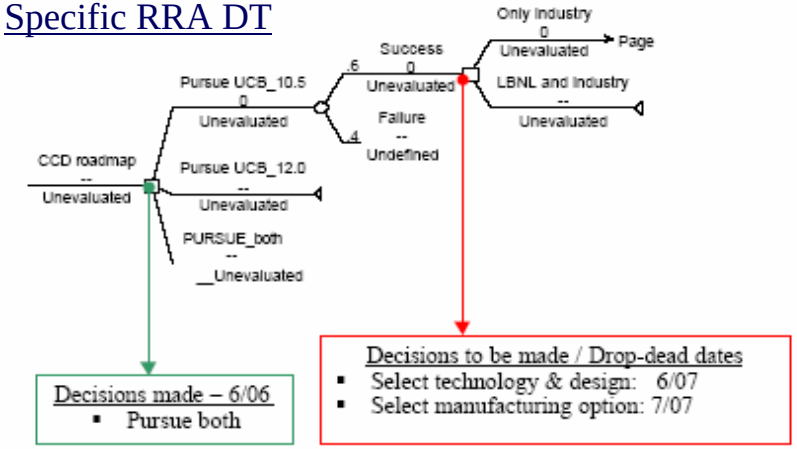
➢ Detailed engineering analysis more suitable than statistical analysis

- Identify possible Risk Response Actions (RRA)
  - Accept risk as is, Immediately implement RRA, Obtain addition information
- Develop risk-specific RRAs including critical decision points
  - Scenarios and Decision Trees (DT)
- Assess risk reduction profile
  - Technical performance parameters, Cost and Schedule earned-value system

Basic RRA DT

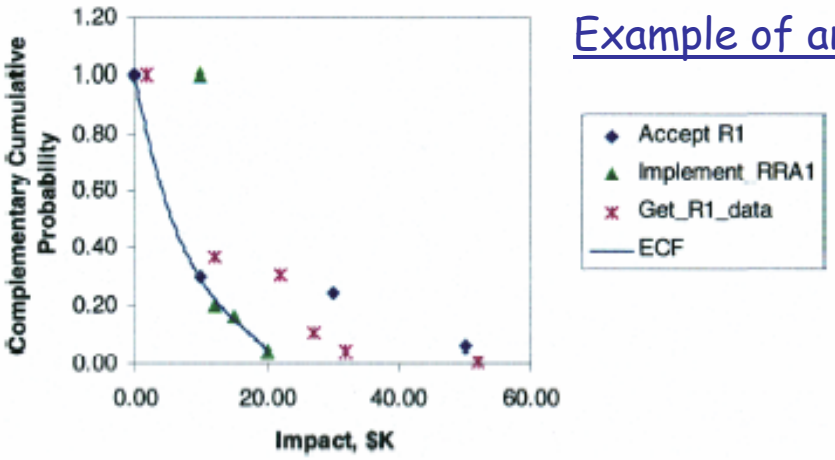


Specific RRA DT



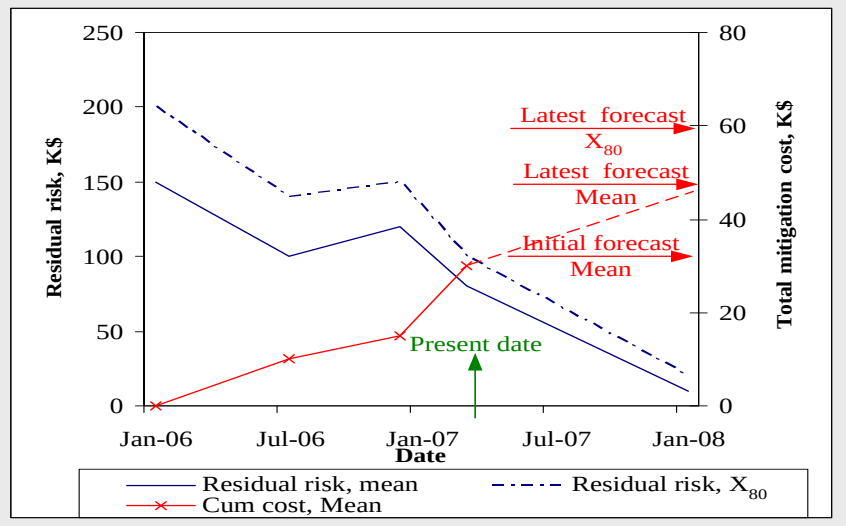
The efficient management of technical risks requires a portfolio approach

- ☞ Proposed approach based on Markowitz' s efficient portfolio selection principle
- ➢ The PMO manages high technical risks as a whole rather than focus on the individual risks per se
  - Systematic development and implementation of Efficient RRA Set
    - Lowest total project cost for a given probability of success
  - System-level oversight
  - Dynamic allocation of contingencies for RRAs
- ➢ Contingencies held and managed at the project-wide level
  - Protection against MAIMS principle



Example of an Efficient Contingency Frontier

Risk monitoring & reserve analysis avert surprises



- Risk exposure metric
  - Baseline risk (unmitigated)
  - Residual risk over time (mitigated)
  - Cost of mitigation over time
- Clearly reveals progress and value of RM effort

- Risk metrics track RM effectiveness and value throughout LC
  - Risk exposure metric - one of many useful quantitative risk metrics
  - Technical Performance Measurements (TPM) for KPPs
- Risk monitoring and metrics should be produced continually
  - Integrated with other PM activities and databases
- Reserve analysis compares contingency reserves to residual risk
  - Assures adequate contingency reserves for remaining risks

Implementation is the challenge!

- Efficient project cost management requires a rigorous framework supported by probabilistic risk analysis and decision-making under uncertainty.

- Some R&D is required
  - Integrated analysis of performance, cost, and schedule
  - Tool for dynamic budget allocation.

- The greatest challenge is the implementation of systems thinking at the personnel, organizational, and institutional levels.

Dynamic cost-contingency management is well worth the additional effort.
The benefits are likely to be significant.