How Predictive Analytics is Improving Parametric Cost Estimation

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International Cost Estimating & Analysis Association
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Predictive Cost Analytics

- What is it?
- Why now?
- What are the benefits?
- What’s next?
PRICE Systems, L.L.C.

- We improve our customers overall **cost management** to help them increase revenue and save money. By empowering our clients with **proven cost models and predictive cost analytics**, they become better estimators - improving bid success ratios, and achieving tremendous savings in analyzing alternatives. They become confident in their costs, schedules, and risk estimates.

- Headquarters: Mt. Laurel, NJ with additional offices in **DC, OH, VA, UK, France, Germany**

- Partner companies: China, S.Korea, Japan, Australia, Italy, Germany, and elsewhere

- Products: TruePlanning® software, PRICE Models, benchmark databases, integrated processes, and implementation services

- Education: PRICE University, instructor-led training on best estimating practices and product implementation

- 350+ customers & 12,000+ project professionals trained worldwide
- **Parametric Estimating**
  - A cost estimating methodology using statistical relationships between historical costs and other program variables such as system physical or performance characteristics, contractor output measures, or manpower loading. The parametric cost estimation method is one of the four cost estimation methods recommended by the Office of Cost Assessment and Program Evaluation (CAPE).

- **Predictive Analytics**
  - The use of data, statistical algorithms and machine-learning techniques to identify the likelihood of future outcomes based on historical data. Predictive models use known results to develop (or train) a model that can be used to predict values for different or new data (SAS).
History of Parametric Estimating

2004 Anthony A DeMarco, International Society of Parametric Analysts

Operations Research applied to Military Affairs

Operations Research and Statistics applied to Industrial Affairs

Parametric Only Internal

Parametrics US Business Units Formed

Europe Expansion

Asia Expansion

Canada

Parametric Standalone Software

Integrated Software

Analytics

1930
1940
1950
1960
1970
1980
1990
2000
2010
2020

Great Depression
World War II
Severe DoD Project Cost Overruns

Berlin Wall Breached
War on Terrorism
Defense Transformation

RAND Created
PMI Created
OSD CAIG Formed
ISPA Founded
PC Project Mgmt EVM Tools, SEER Launch
Parametric Estimating Initiative
Korean ISPA Chapter
ICEAA = SCEA + ISPA
Canada ICEAA Chapter
The Analytics Big Bang

Predictive analytics reaches critical mass as Big Data and new technologies collide.

Key Innovations
- Monte Carlo simulations
- Computational models for neural networks
- Linear programming
- Non-linear programming
- Computer-based heuristic problem solving
- Real-time analytics
- Prescriptive analytics

Small Businesses & Analytic Experts

Analytic Innovation Accelerates
2000–2009: Production version of R language
for analytic software grows from 0 to 1,000,000 users

21st Century's Sexiest Job
2011–2012: Data scientist job posts increase 5,000%

Buy! Buy! Buy!
2000–2012: Analytics software market grows from $11 billion to $35 billion

21st Century's Sexiest Job
2011–2012: Data scientist job posts increase 5,000%

Hyper-connectivity
2012: 1.7 billion mobile devices sold and 2.8 billion people on social networks add to data explosion

Mid-size Businesses & Tech Startups

Government Agencies

Corporations & Research Institutions

Milestones

1930s–40s
- Dawn of Computer Age
  - 1940s: Turing and Good conduct ground-breaking work with "weights of evidence" to decode German messages in WWII
  - 1940s: Kerrison Predictor automates targeting of anti-aircraft weapons against enemy planes
  - 1944: Manhattan Project team runs computer simulations to predict behavior of nuclear chain reactions

1950s–1960s
- Commercialization of Analytics
  - 1950: ENIAC computer generates first models to forecast weather
  - 1951: First university degree program in Operations Research (Case Institute of Technology)
  - 1956: Analytics solves "shortest path problem," improving air travel and logistics
  - 1958: FICO applies predictive modeling to credit risk decisions
  - 1966: Future SAS Institute starts as research project funded by US Department of Agriculture

1970s–1990s
- Analytics Goes Mainstream
  - 1973: Black-Scholes model created to predict optimal price for stock options over time
  - 1980: First commercial tool for building model-driven Decision Support Systems is marketed
  - 1992: FICO deploys real-time analytics to fight credit card fraud
  - 1995: Amazon and eBay go live; race to personalize online experience is on
  - 1998: Google applies algorithms to web searches to maximize results relevance
  - 1998: Moneyball changes pro sports as Oakland A's use analytics for a competitive edge

2000–Present
- Analytics' Deep Impact
  - Widespread analytic use: dynamic ticket pricing, shopping and movie recommendations, traffic management and much more
  - Natural language processing: unlocks analytic value of unstructured data (e.g., Facebook posts, web pages, PDFs, email, Word docs)
  - Big Data arrives: 2.5 quintillion bytes of data created each day
  - Server farms and low-cost, high-speed processing: make distributed computing and Big Data analytics viable for most organizations
  - Growing demand for talent: 190,000 more analytic experts and 1.5 million more data-literate managers needed in US alone by 2018

Next
- Ubiquitous Analytics
  - Cloud-based analytic exchanges: lead to Collaboration Economy between developers, businesses, researchers, scientists and entrepreneurs
  - Individuals use analytics in everyday decisions: about education, careers, finances, healthcare, peer-to-peer renting and lending ("Share economy")
  - Curing rare diseases: becomes a financial winner
  - Predictive policies: preempt many crimes
  - Anticipatory analytics: makes it nearly impossible to crash a car or burn dinner
  - Mass marketing campaigns are dead: all customer interaction is personal
  - Data licensing trumps data purchasing: in a world where data gets stale in minutes
Parametric can now evolve to leverage the Predictive Analytics Big Bang to speed and lower the cost of Analytics.
Analytics Big Bang causing change!

PEOPLE

PROCESS

TOOLS
People Changes

Phillies hire ex-Google analyst to head baseball research & development

Matt Klentak, in his first winter at the head of a baseball operations department, wanted to learn how companies manage information. The 35-year-old Phillies general manager surveyed people in baseball, other sports, and some with zero connections to the game. How, he asked, do you implement analytics into decisions?

Those talks led him to Andy Galdi, a 30-year-old Google employee who was hired Thursday as the Phillies’ first-ever director of baseball research and development.

PRICE Job Posting

Do you have a passion for excellence? Are you interested in a challenging career with a company that is the best in its field? Do you enjoy working in a collaborative environment with really smart people who are the best at what they do?

Then you should work for PRICE Systems. PRICE Systems specializes in improving our customers’ ability to improve their speed, accuracy and standardization of the foundation of their cost management culture. Our clients are some of the best known Aerospace and Defense organizations on the planet including many of the world’s governments. PRICE Systems employs a small group of highly talented people who live and breathe to add value to our customers. We believe that work must have a high “purpose” factor, and we’re looking for people who share in our passion to create exceptional value.

PRICE Systems wants to hire and develop distinguished scholars interested in a career in Business Intelligence, Predictive Analytics, Cost Estimation and Analysis, Data Mining, Statistical Analysis and Model building. For these positions we are looking for applicants with outstanding academic credentials in Mathematics, Analytics, Applied Mathematics, or Statistics, along with exceptional analytic skills, strong communication skills and the ability to work in a team environment.

Essential Duties and Responsibilities of the position include:

• Perform data collection, mining, categorization, mapping, analysis, normalization, calibration, and database implementation
• Develop, present and defend cost estimating relationships and mathematical cost models using applied mathematical approaches such as probability, statistics, regression analysis, linear algebra, learning curves and data collection
• Performing special cost analysis studies
• Write formal research papers
Process Changes

CSDR Problem Statement

Current CDR Shortcomings
- Subjective Mapping
- Allocation
- Manual
- Inconsistent
- Time Consuming
- No details below the functional labor categories within a WBS element
- Data sampling over time typically limited to once a year

FlexFile Improvements
- Standard WBS
- Raw/Detailed Source Data
- Automated
- Consistent
- Traceable, Repeatable mapping

FlexFiles: Objectives
A Win-Win Government and Industry Partnership

1. Increase Efficiency:
   - Collect data according to the contractor’s management structure
   - Removal of legacy 1921 forms
   - Reduce ad hoc/supplemental government data collection efforts
   - Much easier and less time consuming for Industry – allows them to reduce back end support
   - Automation: data flows directly from contractor systems into ours

2. Improving Data Quality:
   - Eliminate Human Error/Subjectivity
   - Collect raw data, and use technology to eliminate arbitrary allocations and errors
   - Consistent application of Mil-STD-881C to both EV and CSDR data – data Alignment
   - Review and mapping pre-contract award

3. Ensure Completeness:
   - Provides much more insight and analysis flexibility
   - Higher frequency of submissions
   - Receive data over time
   - Include cost and supporting technical data
Tool Changes

“We are entering the Cognitive Era, which demands a powerful combination of tools to evolve your organization into one that thinks and learns from data.”

- IBM
Predictive Cost Analytics

- **Business intelligence (BI)** is the set of techniques and tools for the transformation of raw data into meaningful and useful information for business analysis purposes (Wikipedia 2015)

- **Predictive analytics** encompasses a variety of statistical techniques from modeling, machine learning, and data mining that analyze current and historical facts to make predictions about future, or otherwise unknown, events (Wikipedia 2015)

- **Predictive Cost Analytics** a field of predictive analytics specifically targeting cost and schedule estimating for products, projects, on-going operations, other cost-incurring activities
Predictive Analytics

Seven Reasons You need Predictive Analytics Today
Eric Siegel, PH.D., Prediction Impact, Inc.
Predictive Cost Analytics, if it exists at all, is typically a labor-intensive, Ad Hoc, un-standardized, unrepeatable process using various tools. Predictive cost models are re-created every time. Little information sharing among projects. Only analytical experts can perform the process.
Parametric Estimating without Analytics

Enterprise

Cost & Technical Data
Excel, ERP, PLM, Reports

Data
Data
Data

Math

Business Units

SEER Suite
SLIM
ACE-IT
TruePlanning & the PRICE Models

Business Development (Price-to-Win)
Budgeting
Design Affordability Tradeoffs
Strategic Sourcing
Bid & Proposal

Customers

Parametrics with Predictive Cost Analytics

Enterprise

Data

Business Intelligence

Predictive Analytics

Cost & Technical Data
Excel, ERP, PLM, Reports, SQL, Oracle, etc

“R”
RapidMiner
IBM SAS
MS PowerBI
Tableau
TrueFindings

SEER Suite
SLIM
ACE-IT
TruePlanning &
the PRICE Models

Business Units

Business Development
(Price-to-Win)

Budgeting

Design Affordability Tradeoffs

Strategic Sourcing

Bid & Proposal

Customers


Supervised Data-Mining Speeds the Process
What have we learned from this project? How do I normalize, categorize, and calibrate my measurements?

Is this project possible? What is the rough estimate? What is the ROI? Can we win the job?

Which alternative is the most cost effective? Is our estimate accurate? Will I make a profit? How will I manage costs during this project?

Is the design cost optimized? Does the design meet cost targets?

Am I producing something that will meet operation and support budgets?

Is the prototype confirming our cost estimates? Am I improving my estimate from prototyping?

We have the answers!
Predictive Cost Analytics Process

1. Gather historic cost data in Excel, rows=items / columns=costs, measures

2. Categorize & normalize the data with “supervised” data-mining tools

3. Analyze data with statistics to create item and cost driver “findings” to support future estimates

4. Estimate costs and schedules with your findings as a frame-of-reference for each item and each cost driver

5. Map your estimate to the “customer-language”, alternate WBS’s. Use mappings to prevalent standards

6. Inform your customer so that they can decide with data-driven confidence

7. Capture performance on ongoing and completed projects and add to historic data

8. Repeat
Refreshingly Different

Typically, predictive analytics requires painstaking processes for normalizing data and creating “one-off”, multivariate models to predict outcomes. Tailoring generic predictive analytics tools to estimate costs and schedules is complicated and time consuming.

It is faster and easier to perform “supervised” data-mining and “calibrate” existing, proven models that are tested and supported by experts...

Predictive Cost Analytics

– Specifically designed to predict costs and schedules
– Integrated tools combine to speed the process and lower the cost to predict costs and schedules
– Proven, reusable cost models that capture the common cost drivers of like-items to be estimated
– Subject matter experts know the process, and are available to help you along the way
Parametric Models Ease Data Normalization!

Leveraging Supervised Data-Mining

- How big was it?
- How much of the engineering and manufacturing was new work?
- What was the complexity item and the job?
- How familiar were the people doing the work?
- Was the technology mature?
- When did it take place?
Parametric Models Produce Data-driven Estimates!

- How big *is* it?
- How much of the engineering and manufacturing *is* new work?
- What *is* the complexity item and the job?
- How familiar *are* the people doing the work?
- *Is* the technology mature?
- When *will* it take place?
Case Study

Defense Contractor
United States

*Bid & Proposal* A more efficient DCAA-Compliant estimating system
Predictive Cost Analytics in a DCAA-Compliant Estimating System

Pre-Project Estimate

Project Description Dialog ➔ .xls Input File ➔ DCAA-Compliant Pricing System ➔ Cost Proposal

Support Systems

Project Database ➔ Financial System ➔ Software Estimation Calibration Utility ➔ Analytics for Best Fit Org. Productivity ➔ Calibrated Projects List

Post-Project Data Capture


KEY

Process flow
Data exchange
BF Best Fit

Benefits

Revenue Growth – *higher bid volume and win rates based on management and customer acceptance of estimates*

- **Quality** – standardized methodology across domains
- **Efficiency** – faster cycle time to gather data and estimate costs
- **Credibility** – defendable estimates based on historical data
- **Accuracy** – improved accuracy of cost estimates
- **Compliance** – passed DCAA estimating system audits
Case Study

Major Automobile Manufacturer

*Design Tradeoffs* and *Strategic Sourcing*
Predictive Cost Analytics on Parts & Assemblies

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Benefits

Faster Design Times – Speedier design tradeoffs to meet forecasted market demands

- **Quality** – standardized methodology across domains
- **Efficiency** – faster cycle time to gather data and estimate costs and determine options to be designed
- **Credibility** – defendable estimates based on historical data

Lower Costs – better negotiating position with suppliers by analytically extrapolating from historical data

- **Efficiency** – faster cycle time to gather data and estimate costs
- **Credibility** – defendable “should-costs” based on historical data
Case Study

U.S. Army AMRDEC ADD
United States
Affordability - Rotorcraft Tradeoffs
Predictive Cost Analytics for Rotorcraft Systems and Subsystems
Benefits

Faster Design Times – Speedier design tradeoffs to meet threat analyses and budget constraints

• **Quality** – standardized, thoroughly tested methodology
• **Efficiency** – familiar, comprehensive framework and user interface. Interoperability links with other systems.
• **Credibility** – defendable estimates based on historical data from OEMs

Credible Budget Requests – realistic budgets from the start, little need for exorbitant budget reserve

• **Credibility** – defendable budget estimates based on historical data from OEMs
Case Study

U.S. Army PEO STRI
United States

Budgeting for Simulation and Training Systems
Predictive Cost Analytics for Agile Software Development

Department of the Army

OASA(ALT)
- Plans, Programs, and Resources
  - Pre-Contract
  - Proposal Development

OASA(ALT)
- Principal Military Deputy Chief Integration Officer

OASA(FM&C)
- DASA (Cost & Economics)
  - Acquisition Costing & Cost Review Board

PARC
- Associate Director Contracting Operations (Mr. Ken Tedeschi)

PM ConSim
- Product Manager OneSAF (LTC Wilbur Richburg)

PMG PSG
- Chief Fin. Mgr.- (John Kirsch)
  - Associate Chief FM Cost (Jim Golden)

RFP
CDRL
SSR Form
Prime Contractor

Data Calibration & Model Validation Process
Data Validation Process

Cost Models
- Monthly CDRL/CPR Reports
- Historical Cost Database

Key and Notes:
- Information Flow
- Oversight & Control Data Flow
- PARC: Principal Assistant Responsible for Contracting PSG: Project Support Group
- Excel Spreadsheet
- Form/Template

Historically Informed Capability Based Estimating
Benefits

Cost Savings

• Program cost savings of over $90M indicated by pilot
  • Across six years – life cycle usually full operational capability +20
  • Using only a 15% reduction in growth factor – actual reduction higher
  • Pilot looked at only eight software-intensive programs
• Cost savings on program life cycle costs significantly reduced
• Cost savings can be reinvested in new technology and to reduce funding requests
• Revenue generation increases as PEO STRI lowers cost to take on more work
• Effective measurement of the productivity of contractors’ software development efforts for future pricing/cost estimates.

Qualitative Benefits

• Compliance – valid software cost estimate IAW policy
• Quality – standardized methodology across domains
• Efficiency – faster cycle time to gather data and estimate
• Credibility – defendable estimates based on historical data
• Accuracy – improved accuracy and funding requests
• Improved contractor software data collection process
Case Study

Thales Group
International – HQ France
Bid & Proposal
Data-driven Bid Validation
Predictive Cost Analytics for Bid Validation

Top Down approach

- Parametric estimation
- Cost Consolidation Quotation Data Base
- Financial Data
- Cost Library
- Cost models
- Historical Data
- Price & Cash Sheet
- Project Cost Baseline
- Forecast workload

Bottom-Up approach

- WBS
- CONSOLIATION QUOTATION DATA BASE
- Parametric estimation
- Financial Data
- Cost Library
- Cost models
- Historical Data
- Price & Cash Sheet
- Project Cost Baseline
- Forecast workload

Reliable Forecast for Efficient & Accurate Decisions
## Main Use Cases

<table>
<thead>
<tr>
<th></th>
<th>Top Down Approach</th>
<th>Bottom-Up Approach</th>
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<tbody>
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<td>Target Cost definition, ROM, quick estimates</td>
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<tr>
<td>Firm Fixed Price</td>
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<tr>
<td>Cost Challenging &amp; Optimization</td>
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<td>✓ Together</td>
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<tr>
<td>External Benchmark</td>
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<tr>
<td>Complex solution or organization, low maturity</td>
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</tr>
<tr>
<td>Business as usual / Product lines</td>
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<tr>
<td>Easy comparison of various scenarios</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Detailed risk analysis</td>
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<tr>
<td>Commitments</td>
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Complementary Approaches to Improve Estimates Challenging and Confidence
Benefits

- **Improved Win Rate** - Consistent use of Bid Verification/Validation methodologies avoids over optimism
  - Unbiased metrics from measured benchmarks
  - Provides consistent and credible link to Price-to-Win

- **Accuracy** - Persistent link between “as built” Product Breakdown Structure (PBS) and “reporting” Work Breakdown Structure (WBS)
  - Reveals missing or inconsistent estimates
  - Reconciles Data-Driven estimates with grassroots estimates
  - Mitigates Risk

- **Team Unity** - Unifies “Top Down” Parametric Estimating with “Bottom Up” Grassroots estimating
  - Creates “buy-in” across the organization
  - Minimizes errors and omissions
Predictive Cost Analytics

- **What is it?**
  - Leveraging over 40 years of parametric estimating experience with the predictive analytics big bang

- **Why now?**
  - To speed and lower the cost of predictive cost analytics to expand its reach

- **What are the benefits?**

- **What’s next?**
What’s next?

**Predictive Cost Analytics for Everyone**

- **More and improved Models**
  - Model improvements
  - New models
  - Analytical findings

- **More automation of tasks**
  - Automatic analytics
  - Seamless tool integration
  - Seamless data integration

- **More widespread use**
  - Modeling simplification and automation with Business Process Management (BPM)

*Provider objectives are to speed and lower the cost of predictive cost analytics for everyone!*
Questions?

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